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CONTENTS

Notes on the fungal diversity in the Botanical Garden of the National Museum of Bosnia and Herzegovina

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Abstract: Over the past three years, initial mycological studies have been carried out in the Botanical Garden of the National Museum of Bosnia and Herzegovina. As a result of these sporadic surveys, 22 different species of fungi were found, including *Octospora pseudoampezzana, Xylaria oxyacanthae, Orbilia carpoboloides* and *Calathella eruciformis*, which were recorded for the first time in Bosnia and Herzegovina. The aim of this study is to initiate scientific research on fungal occurrence and diversity in this urban floral oasis and thus also to improve national knowledge about the fungal species that inhabit such anthropogenic habitats. This work can also serve as an additional argument to emphasise the importance of botanical gardens in urban areas, and their contribution to the diversity of mycobiota in anthropogenic habitats in general.

Key words: mycobiota, urban areas, botany, Sarajevo

INTRODUCTION

Although man-made green spaces in the urban environment are mostly represented by parks and other landscaped green areas, whose primary functions are to provide quality space for recreation and relaxation, without any particular interest for maintaining a high level of biodiversity, there are also botanical gardens formed with the opposite intention, i.e. designed to create small biodiversity oases deep within urban centres.

Botanical gardens have multiple purposes in everyday life: They can represent important refuges for the survival of certain highly endangered endemic and/or rare plant species; they provide great opportunities for multidisciplinary scientific research that could provide a better understanding of phyto-diversity in general; they are a great place for education *in situ*; they provide a perfect setting for daily relaxation, which is beneficial for both physical and mental health. They can also be a useful tool in biosecurity research by serving as sentinel monitoring sites to detect threats from pathogens and pests (Wondafrash et al., 2021). Their high biological and conservational importance is indicated by the fact that 31% of the total number of accepted and currently known plant species grow in botanical gardens all over the world (Antonelli et al., 2020).

Alongside trees and plants, botanical gardens are home to other closely associated organisms that are usually much less investigated than the flora itself. Such other organisms occasionally become subject of inventory primarily on the initiative of employed scientists or in the context of regular institutional project activities (see, for example, Glushakova & Kachalkin, 2017 for yeasts; Matveev et al., 2018 for slime moulds; Wilkie, 2020 for lichens; Cathrine et al., 2022 for arachnids, etc.).

The real value of inventory studies within botanical gardens largely lies in the fact that they help us to determine the true magnitude of biodiversity in these urban oases, which brings us one step closer to *ex situ* conservation of endangered and rare organisms, while at the same time allowing us to closely monitor structural changes in biodiversity levels through temporal observation and analysis of the diversity of certain species.

Fungi, as an inevitable and crucial component of the biodiversity of botanical gardens, had largely remained under-studied in the past. With the exception of isolated earlier individual studies (for example Currey, 1874), only recently have significant efforts been undertaken in terms of the mycological research of botanical gardens (Eckstein & Eckstein, 2009; Folcz & Börcsök, 2015; Kartika et al., 2018; Watling et al., 2019; Kruse et al., 2020; Bradshaw et al., 2022). In Bosnia and Herzegovina, to date there has been no evidence of mycological studies being carried out in botanical gardens. On the other hand, the presence of taxonomic studies of relative significance in similar anthropogenic habitats in urban areas are worthy of note (Moravec, 1971; Jukić et al., 2018).

The Botanical Garden of the National Museum of Bosnia and Herzegovina is located near the centre of Sarajevo, in the oldest cultural and scientific institution in the state. The garden itself is an object of special educational purpose, and represents an important monument of natural and botanical heritage.

Although it occupies a significantly smaller area in comparison to other European botanical gardens (14,270 m^2 according to Bečić et al. (2011)), the diversity of the plant fund has gradually increased over the years, having reached a maximum number of 3,000 different plant species (Šilić, 1988). Currently, however, official sources list much smaller number of the plants (1,700 according to the National Museum's own website).

The Botanical Garden was founded by the famous Austrian botanist Karl Malý at the beginning of the 20th century, and has undergone certain structural and physiognomic changes over time. However, its main role as an invaluable and an effective instrument of *in situ* teaching at different levels of education remained unchanged.

A detailed overview of and insight into the diversity and abundance of living plants in the Botanical Garden of the National Museum of Bosnia and Herzegovina has been provided by Šilić (1988) and Bečić & Ljujić-Mijatović (2010). However, no other systematic and comprehensive inventories of other taxonomic groups – including fungi – have been conducted to date.

To (partially) address this issue, the authors conducted such research, with the preliminary results presented here representing the first real insight into the diversity of fungi in botanical gardens in Bosnia and Herzegovina.

MATERIAL AND METHODS

Six field studies were carried out between 2021 and 2023 in the Botanical Garden of the National Museum of Bosnia and Herzegovina, Sarajevo. The main focus of the research was ascomycetous fungi, their ecology and diversity. At the same time, seven species from the phylum Basidiomycota were also recorded, mainly those that are easy to identify *in situ* by recognizing relevant macro-characters.

The ascomata and basidiomata of the registered fungi species were photographed both *in situ* and *ex situ* using photographic equipment and a stereomicroscope. Macrophotographs *in situ* were taken with a Canon 700D camera, a 100mm f/2.8L Macro IS USM lens, a tripod and a Canon Macro Ring Lite MR-14EX II, while *ex situ* macrophotographs were taken with a Nikon SMZ445 stereo zoom microscope. A

Nikon SE type 102 compound light microscope was used for laboratory analyses and observation of micromorphological characters. Photomicrographs were taken with a Sony DSC-H2 camera.

Samples for microscopy were prepared by cutting fresh fungal apothecia by hand using a razor blade, and, in the case of very small apothecia, samples were taken with a teasing needle.

The descriptions of macro- and micromorphological characters are mainly based on the analysis of living structures of fresh collections (Baral, 1992) from the Botanical Garden of the National Museum of Bosnia and Herzegovina, and are combined with relevant literature data where indicated.

All measurements were carried out in a tap water mount. For each species analysed, 20 ascospores were measured to determine their average length and width. The extreme values of measured ascospores and other structures are given in parentheses. The ornamentation of the ascospores was stained with lactophenol cotton blue (LCB); the presence or absence of an iodine reaction in the apical part of the asci was checked using Lugol's solution (IKI); cresyl blue (CRB) was used to highlight cytoplasmic inclusions such as spore bodies in *Orbiliomycetes* and for staining the nucleus and nucleolus in *Sclerotiniaceae*.

In order to define the simple spore shape in accordance with the Q value (length:width ratio of ascospores) the geometric delimitation criteria from Kušan et al. (2014) were used.

The abbreviation "FAMU" and the corresponding database codes are given for each material deposited in the Fungarium of the Mycological Society MycoBH.

RESULTS

1. ***Arrhenia spathulata*** (Fr.) Redhead
   Fig. 1 – j)
   Among shoots of *Tortula ruralis* covering rocks, 20 Feb 2021.

2. ***Octospora gyalectoides*** Svrček & Kubička
   Fig. 2 - d), f)
   Rocky and base-poor site, probably on shoots of *Crossidium squamiferum*, 14 Feb 2021, 07 Jan 2023, N.J./070123-Y2; FAMU – 0959.

3. ***Octospora pseudoampezzana*** (Svrček) Caillet & Moyne
   Figs. 1 - b), d); 3 - i), o), p), q)
   Description: Ascomata apothecial, 1–4 (5) mm in diam., yellow-orange, orange to brown-orange; margin conspicuous and quite pronounced, first whitish and silky, later getting darker, finally in mature specimens becoming blackish; hymenium finely granulose. Asci cylindrical, *250–340 × 22–28.7 µm, 8-spored, uniseriate. Ascospores *(19.7) 20.2–23.8 × (14.3) 14.5–15.9 (16.9) µm, ellipsoid to broadly ellipsoid, containing one large oil droplet, usually eccentric; ornamentation consists of roundish isolated warts, evenly scattered over the spore surface and of more or less the same diam. (0.5–1.0–1.2 µm). Paraphyses cylindrical, barely exceeding asci, slightly enlarged in the upper part, *7–10 µm wide in the apical part, containing light orange pigmentation.
   Material examined: On shoots of *Schistidium crassipilum/ S. helveticum complex* covering limestone rocks, 14 Feb 2021, 20 Feb 2021 & 07 Jan 2023, N.J./070123-Y1; FAMU – 1389.
   Notes: As stated in Eckstein & Eckstein (2009) and Németh et al. (2022), host species is almost always *Schistidium crassipilum*. Rare cases with *Racomitrium heterostichum* as a host moss were reported in Eckstein et al. (2020). First record for Bosnia and Herzegovina.

4. ***Ciboria amentacea*** (Balb.) Fuckel
   Figs. 1 - e), g); 3 - b), c), g), h), l) r), s)
   On fallen and buried male catkins of *Corylus avellana*, apparently emerging from thali of *Marchantia polymorpha*, 20 Feb 2021, 28 Feb 2021 & 07 Jan 2023.

5. ***Auricularia mesenterica*** (Dicks.) Pers.
   On the dead *Ulmus* sp. trunk, 20 Mar 2021 & 07 Jan 2023.

6. ***Xylaria oxyacanthae*** **Tul. & C. Tul.**
   Fig. 1 – k)
   Description: Stromata usually slender, simple or rarely branched, 2–5 cm in height and up to 2–4 mm wide, cylindrical, slightly enlarged in the upper part and often laterally compressed. Apices finely pronounced, sometimes mammiform, pinkish-orange to orange-brown. Middle part more whitish or greyish, while lower part of stromata remains black or greyish-black
   Material examined: On partially buried and mummified *Crataegus monogyna* fruits probably mixed with excrements of *Columba palumbus*, 20 Mar 2021.
   Notes: First record for Bosnia and Herzegovina. The material was identified on the basis of the description of relevant macro and micro characteristics from Kujawa & Karasiński (2007) and Himani & Krishnappa (2020).

7. ***Piceomphale bulgarioides*** (Rabenh.) Svrcek
   Figs. 1 - c); 3 - m), n)
   On fallen *Picea omorika* cones, 20 Mar 2021. First record of *P. bulgarioides* on *Picea omorika* in Bosnia and Herzegovina.

Figure 1. Some fungal species registered in the Botanical Garden of the National Museum of Bosnia and Herzegovina: **a)** ***Geopora sumneriana*** under ***Cedrus libani***; **b), d)** ***Octospora pseudoampezzana***, bryophilous species on shoots of ***Schistidium crassipilum/ S. helveticum complex;*** **c)** ***Piceomphale bulgarioides*** on cones of ***Picea omorika***; **e), g)** ***Ciboria amentacea*** ascomata seemingly emerging from the liverwort ***Marchantia polymorpha*** thalli; **f), i)** ***Ciboria coryli*** sharing the same habitat type with ***C. amentacea***; **h)** ***Ciboria rufofusca*** on fallen ***Abies alba*** cones; **j)** ***Arrhenia spathulata***, bryophilous species; **k)** ***Xylaria oxyacanthae*** (anamorph) on buried seeds of ***Crataegus*** sp.

8. ***Ciboria coryli*** (Schellenb.) N.F. Buchw.
Fig. 1 - f), i)
On fallen and partially buried male catkins of *Corylus avellana*, 28 Feb 2021.

9. ***Ciboria rufofusca*** (O. Weberb.) Sacc.
Fig. 1 - h)
On lying cone scales of *Abies alba*, 08 May 2022.

10. ***Geopora sumneriana*** (Cooke) M. Torre
Figs. 1 - a); 3 - j), k)
Under *Cedrus libani*, among the litter of needles, 08 May 2022.

11. ***Orbilia aurantiorubra*** Boud.
Figs. 2 - a); 3 - a), e)
On dead dry semi-decorticated twigs of *Fraxinus* sp.?, 08 May 2022.

12. ***Orbilia carpoboloides*** (P. Crouan & H. Crouan) Baral
Figs. 2 – b), c); 3 - d), f)
Description: Ascomata apothecial, 0.5–1.5 (1.8) µm wide., light rose-carneous, light ochraceous, yellow-ochraceous or orange-ochraceous, sometimes slightly reddish, irregularly rounded or broadly elliptical, concave, with conspicuous margin usually made of whitish "teeth" or fimbriate hair tufts (Baral et al., 2020). Asci cylindrical, *(62.4) 65.4–78.8 (79.7) × (4.9) 5.6–6.4 (6.7) µm, 8-spored, bi- or triseriate. Ascospores *(12.4) 12.5–15.6 (15.9) × (2.3) 2.3–2.8 (2.9) µm, fusiform to fusoid, rarely straight, more often slightly curved at the base; spore body vermiform, barely enlarged at the base, 4.2–7 µm in length. Paraphyses septate, quite straight, or slightly flexuous, mammiform to spathulate (Baral et al., 2020), with more or less pronounced apical narrowed part.
Material examined: On corticated part of dead twig of undetermined deciduous tree, 08 May 2022.
Notes: First record for Bosnia and Herzegovina.

13. ***Propolis farinosa*** (Pers.) Fr.
Fig. 2 - i)
On dead deciduous twigs, 08 May 2022.

14. ***Pyrenopeziza rubi*** (Fr.) Rehm
Fig. 2 - h), j)
On dead *Rubus* sp. twig, 08 May 2022.

15. ***Xylaria carpophila*** (Pers.) Fr.
On fallen dead beechmasts, 08 May 2022.

16. ***Dacrymyces capitatus*** Schwein.
Fig. 2 - e)
On dead twigs of unknown deciduous tree, 08 May 2022.

17. ***Calathella eruciformis*** (P. Micheli ex Batsch) D.A. Reid
Description: Basidiomata cyphelloid, tubular in shape, sometimes distinctly narrowed at the base or campanulate, 0.5–1.5 mm wide and up to 2 mm high; outer side and marginal region densely covered in long whitish hairs, later becoming more ochre, grey to ochre-brownish, surface more brownish; hymenial inner part smooth, pale cream to ochre cream.
Material examined: On dead *Populus* sp. twigs, 07 Jan 2023, N.J./070123-Y3; FAMU – 1391.
Notes: First record for Bosnia and Herzegovina. The material was identified based on the description of relevant macro and micro characteristics from Halama et al. (2019).

18. ***Xylaria longipes*** Nitschke
On remnants of unknown deciduous tree, 07 Jan 2023.

19. ***Schizophyllum commune*** Fr.
On dead *Populus alba* remnants, 07 Jan 2023.

20. ***Auricularia auricula-judae*** (Bull.) Quél.
On living *Berberis* sp. branches, 07 Jan 2023.

21. ***Candolleomyces typhae*** (Kalchbr.) D. Wächt. & A. Melzer
Fig. 2 - g)
On decaying dead stem and/or leaves of *Typha angustifolia*, 25 Jun 2023, N.J./250623-Y1; FAMU – 1390.

22. ***Psilachnum inquilinum*** (P. Karst.) Dennis
On dead partially inundated stem of *Equisetum hiemale*, 25 Jun 2023, N.J./250623-Y2; FAMU – 1392.

Figure 2. Some fungal species registered in the Botanical Garden of the National Museum of Bosnia and Herzegovina: **a)** *Orbilia aurantiorubra* on dead *Fraxinus* sp.,? twig; **b), c)** *Orbilia carpoboloides* on dead twig of undetermined deciduous tree; **d), f)** *Octospora gyalectoides* on shoots of *Crossidium squamiferum*; **e)** *Dacrymyces capitatus* on dead twigs of undetermined deciduous tree; **g)** *Candolleomyces typhae* on decaying stem of *Typha angustifolia*; **h), j)** *Pyrenopeziza rubi* on dead *Rubus* sp. stem; **i)** *Propolis farinosa* on undetermined deciduous twigs.

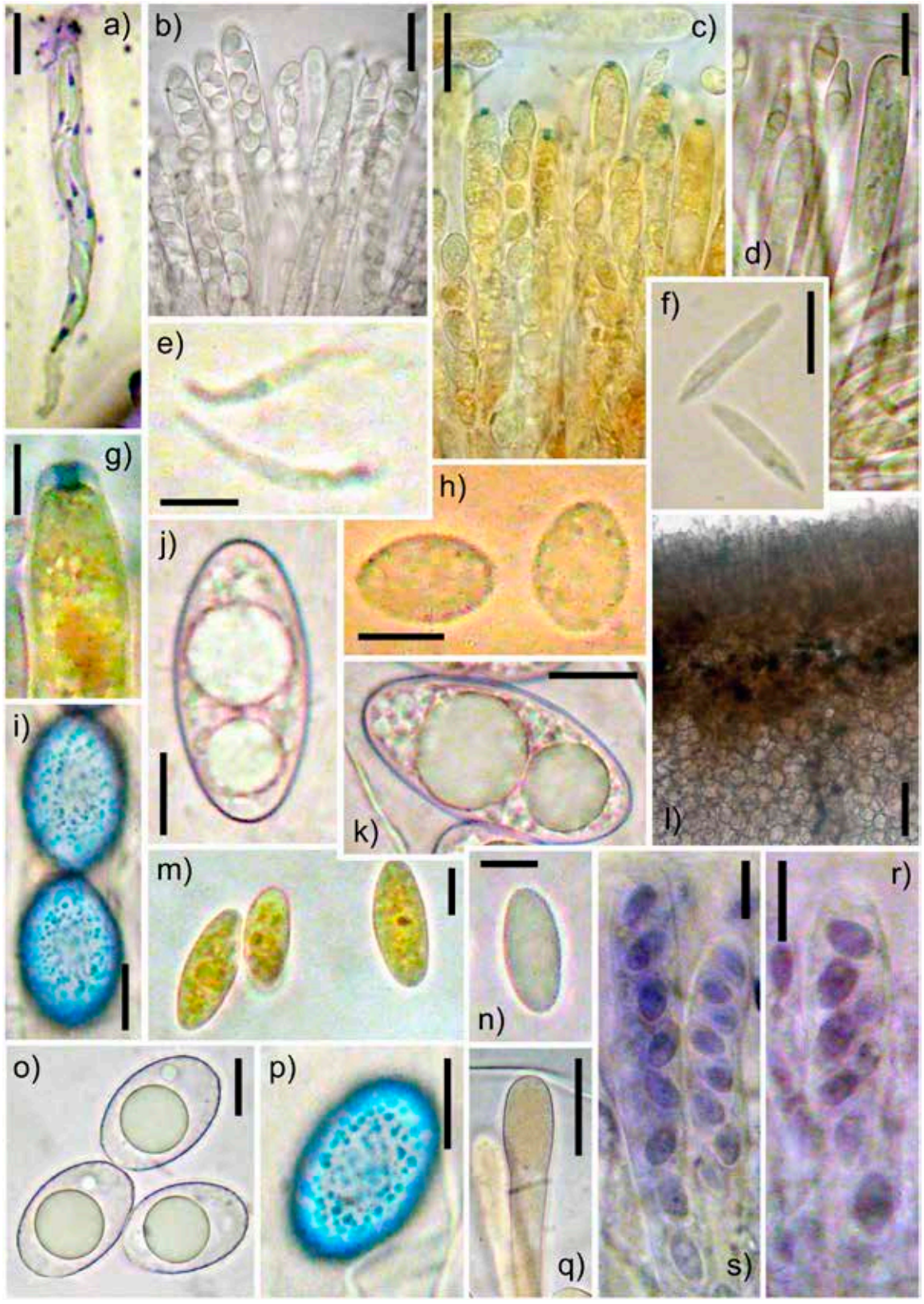

Figure 3. Micro characters of some fungal species registered in the Botanical Garden of the National Museum of Bosnia and Herzegovina: **a), e)** *Orbilia aurantiorubra* – a) asci and ascospores in CRB mount, e) *mature ascospores; **b), c), g), h), l) r), s)** *Ciboria amentacea* – b) *immature ascospores and asci, c) *asci and ascospores in IKI mount, g) *apical apparatus of the asci in IKI mount, h) – *mature ascospores, l) *vertical section of the apothecia, r), s) asci and ascospores in CRB mount; **d), f)** *Orbilia carpoboloides* – d) *apical part of the paraphyses and asci, f) *mature ascospores; **j), k)** *Geopora sumneriana* – *mature ascospores; **m), n)** *Piceomphale bulgarioides* – m) *mature ascospores in IKI mount, n) *mature ascospores; **i), o), p), q)** *Octospora pseudoampezzana* – o) *immature ascospores, i), p) *mature ascospores in LCB, q) *apical part of the paraphyses. Bars: l) – 50 µm; b), c), q) - 20 µm; a), d), f), i), j), k), o), p), r), s) – 10 µm; e), h), g), m), n) – 5 µm.

DISCUSSION

Botanical gardens in urban areas should be considered unique sources of biodiversity enrichment. These small areas represent a profound substitutional link between human and natural environments, especially in the modern and accelerated lifestyles of today.

Diverse floristic components and structures, the heterogeneity of the flora, the vegetation of different bioclimates, the combination of normally incompatible components, and the special care and treatment of the plants are the cause of the great and highly specific biodiversity in these small "oases" and are also the main reasons for botanical gardens' need to be one of the highest priorities in urban planning.

This short and narrowly focused mycological study clearly shows that botanical gardens are highly interesting and intriguing man-made habitat types, and should be recognized as fungal diversity hotspots within contemporary urban areas. This has also been argued by other mycologists in the past (Eckstein & Eckstein, 2009; Folcz & Börcsök, 2015; Kartika et al., 2018; Kruse et al., 2020; Bradshaw et al., 2022). A number of long-term studies and corresponding results, such as those of Folcz & Börcsök (2015) are quite impressive and show the true value of botanical gardens and their importance for the biodiversity of fungi, and the conservation of fungi in general.

Although botanical gardens are usually very limited in space and may seem somewhat irrelevant factors in terms of fungal diversity (or overall biodiversity) at the national, regional and global level, it is quite the contrary. These islands of biodiversity play a significant role in enriching fungal heterogeneity, on national and regional scales in particular. Also, botanical gardens are the only locations where certain species of fungi (or other organisms) with natural habitats that are very distant from one another can be found living together. As a result, they provide a great opportunity for scientists around world to closely study and monitor different types of organisms, but such studies should also be taken with caution, due to the negative effects of outbreeding depression on population persistence (Chen & Sun, 2018). They can, however, provide ideal conservation environments for *ex situ* conservation of fungi (Folcz & Börcsök, 2015), with the results presented here going some way to support this hypothesis. In addition, botanical gardens provide a wide range of mycological interpretation and educational activities, including those aimed at preserving fungal diversity (Hu & Zhang, 2008).

Collections of *Octospora pseudoampezzana*, *Xylaria oxyacanthae*, *Orbilia carpoboloides* and *Calathella eruciformis* from the Botanical Garden of the National Museum of Bosnia and Herzegovina represent the first registered findings of these species in Bosnia and Herzegovina, and provide solid arguments for emphasizing the important role that botanical gardens can potentially play in modern science. This preliminary checklist of fungi from the Botanical Garden of the National Museum of Bosnia and Herzegovina is arguably only partial in nature, and minute projection of the overall level of fungal diversity within this man-made habitat. It is for this reason that the authors strongly outline the (largely self-implied) need for continuation of this mycological research.

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SAŽETAK

Botanički vrtovi općenito predstavljaju vrlo značajne oaze bioraznolikosti koje je stvorio čovjek i obično su prostorno smještene unutar same jezgre urbanih sredina. Njihova uloga danas je višestruka i nezamjenjiva. Oni prije svega služe za edukaciju različitih interesenih grupa, pomažu pri *ex situ* konzervaciji ugroženih vrsta biljaka i drugih organizama te u značajnoj mjeri obogaćuju biodiverzitet u urbanim zonama, gdje on inače, ne dolazi do izražaja. Botanički vrtovi su interesantna staništa i s aspekta mikologije, prvenstveno zbog prisustva obilja vaskularne, ali i nevaskularne flore, odnosno brojnih biljnih vrsta koje učestvuju u različitim tipovima interakcija s gljivama. O tome svjedoče pojedini naučni radovi u okviru kojih su obrađene različite taksonomske skupine gljiva: Eckstein & Eckstein (2009) – briofilne vrste, Folcz & Börcsök (2015) – više različitih skupina, Kartika et al. (2018) – više različitih skupina, Watling (2019) – nelihenizirane vrste, Kruse et al. (2020) – više različitih skupina, Bradshaw et al. (2022) – gljive porodice *Erysiphaceae* i dr. Ovim istraživanjem utvrđeno je prisustvo pojedinih vrlo značajnih i rijetkih vrsta gljiva te je valorizovana pretpostavljena važna uloga botaničkih vrtova u raznolikosti gljiva u modernim urbanim zonama. S druge strane, premda postoji više od 100 godina i sadrži izuzetno vrijedne zbirke briofita, viših biljaka i dendroflore, Botanički vrt Zemaljskog muzeja Bosne i Hercegovine do danas nije bio predmet mikoloških istraživanja. U ovom radu su prvi put prezentovani rezultati istraživanja diverziteta gljiva Botaničkog vrta Zemaljskog muzeja Bosne i Hercegovine koja su realizovana u posljednje dvije godine. Kratka istraživanja su provođena u zimskim, proljetnim i ljetnim dijelovima godine, a ukupno je u periodu februar 2021. – juni 2023. realizovano 7 istraživanja. Predmet ovih istraživanja bile su gljive odjeljka Ascomycota, ali su uporedo, u manjem obimu, registrovane i neke karakteristične i značajne vrste odjeljka Basidiomycota. Sav prikupljeni materijal je naknadno laboratorijski obrađen u skladu s principima vitalne taksonomije, a radi ispravne determinacije vrsta i registrovanja najbitnijih specijskih obilježja. U okviru provedenog seta istraživanja determinisane su 22 vrste gljiva, od čega 15 vrsta iz odjeljka Ascomycota i 7 iz odjeljka Basidiomycota. Vrste ***Octospora pseudoampezzana, Xylaria oxyacanthae, Orbilia carpoboloides*** i ***Calathella eruciformis*** zabilježene su prvi put u Bosni i Hercegovini. Za navedene vrste je u okviru rada dat kraći deskriptivni opis koji sadrži podatke o najbitnijim morfološkim i mikrokarakteristikama.

New data and the overview of dragonfly fauna (Insecta: Odonata) of Nevesinjsko polje

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Abstract: This paper provides the first overview of the dragonfly fauna of Nevesinjsko polje – one of the largest karst poljes in Bosnia and Herzegovina – and two small adjacent poljes, Lukavačko and Slato. Field surveys undertaken from 2012 to 2020 resulted in 40 species being recorded (63% of all Odonata fauna species recorded in the country). Of these, 12 species are reported for the first time for the study area. The most significant is the first record of *Coenagrion ornatum* (Selys, 1850), a species of European conservation concern, upon Nevesinjsko polje. The collected data represents an important contribution to the knowledge of the dragonfly fauna of karst poljes, which themselves represent biodiversity hotspots of the Dinaric Karst region.

Key words: Bosnia and Herzegovina, *Coenagrion ornatum*, distribution, karst poljes

INTRODUCTION

The Dinaric karst region that extends from Italy, over a large part of Slovenia, Croatia, Bosnia and Herzegovina, and Montenegro, and ending in Kosovo and northern Albania, is characterized by a high diversity of geomorphological, hydrological and ecological karstic phenomena (Bonacci, 1987; Mihevc et al., 2010; Redžić et al., 2011; Sket, 2012; Zupan Hajna, 2019). Within this area, karst poljes are one the most characteristic hydro-geomorphic phenomena. They are large depressions characterized by a flat floor, surrounded by steep slopes and covered with deposition that allows surface runoff (Gams, 1978; Prohić et al., 1998). Many of the poljes are oases in dry karstic landscapes, each with their own hydrological system, seasonal floodings, and watercourses that flow only within the poljes themselves, disappearing underground at their margins (Redžić et al., 2008; Bonacci, 2013). Of more than 130 poljes that exist in the Dinaric Alps, 57 are situated within Bosnia and Herzegovina (Sackl et al., 2014), including some of the largest and best-preserved ones (Redžić et al., 2008; Milanović, 2017). They are distributed from sea level up to 1,200 m AMSL (Stumberger et al., 2014).

Karst poljes are also habitats of international biodiversity value, and part of the so-called 'Mediterranean Basin biodiversity hotspot', characterized by a high variety of freshwater habitats, including wetlands, peat bogs, permanent and temporary lakes, ponds, rivers, streams and underground waterflows (Redžić et al., 2008; Sackl et al., 2014; Milanović, 2017). The biodiversity of karst poljes in Bosnia and Herzegovina has been the subject of many studies (e.g. Ritter-Studnička, 1974; Francuski et al., 2019; Matočec et al., 2019) attesting to these habitats being biodiversity hotspots for the region (e.g. Sket, 2012; Sackl et al., 2014; Reier et al., 2022; Delić et al., 2023). However, the biodiversity and ecological importance of many still remains insufficiently known (Stumberger et al., 2014).

For a long time, dragonfly fauna of Bosnia and Herzegovina remained only scarcely studied, but in the past 15 years the knowledge of Odonata in the country has been significantly improved, with many new studies resulting in important data and new records of species for the country (e.g. Jović et al., 2010; Bedjanič, 2011; Kulijer, 2012, 2014, 2015a, 2015b, 2017; Kulijer et al., 2012, 2013, 2016; Kulijer & Topić, 2013; Kulijer & Miljević, 2015). Currently, 64 Odonata species are known for Bosnia and Herzegovina (Kulijer & Miljević, 2015), and the most comprehensive overview of the country's dragonfly fauna has been provided by Kulijer et al. (2013).

Although numerous papers on dragonflies from karst waters in the Dinaric region have been published in recent years, many of these have focused on lotic waters (e.g. Pešić et al., 2017; Vilenica, 2017; Vilenica et al., 2022a, 2022b), while dragonfly studies that explore poljes as a whole, i.e. including the entire complex of habitats that occur in them, are few and far between (see, for example, Kulijer, 2012, 2013). A number of studies have confirmed the importance of karst poljes as important habitats for dragonflies in Bosnia and Herzegovina, including several species which are threatened or protected in Europe *Coenagrion ornatum* (Sélys, 1850), *Lindenia tetraphylla* (Vander Linden, 1825) and *Cordulegaster heros* Theischinger, 1979 (Kulijer, 2012, 2013, 2014, 2015b; Vilenica et al., 2021). However, the dragonfly fauna of these habitats is still scarcely known, and only a limited number of poljes in Bosnia and Herzegovina have been systematically investigated (Livanjsko polje, Hutovo blato, Ljubuško polje), with detailed data having only been published for Livanjsko polje (Kulijer, 2012, 2013, 2015b). The first data on dragonfly fauna of Nevesinjsko polje was published only recently. This was collected via several nationwide dragonfly field studies, particularly within the scope of the Balkan Odonatological Meeting (Jović et al., 2010; Kulijer et al., 2016; Tratnik et al., 2020).

The aim of this study was to compile all available data and to present the first overview of the dragonfly fauna of Nevesinjsko polje, one of the largest high-altitude karst poljes in Bosnia and Herzegovina.

MATERIALS AND METHODS

STUDY AREA

The study area is located in the north-eastern part of the Herzegovina region of Bosnia and Herzegovina (Fig. 1). In addition to Nevesinjsko polje (77.53 km^2), it also includes two small poljes to the southeast that are closely connected to Nevesinjsko polje – Lukavačko (3.3 km^2) and Slato (4.1 km^2) – as well as the hilly area that surrounds these poljes. Nevesinjsko polje is one of the largest periodically flooded karst poljes in Bosnia and Herzegovina, and is situated at an altitude of approximately 850 m AMSL. The northern part of the polje is under the strong influence of the mountain climate from the nearby high mountains of Velež, Prenj and Crvanj (Redžić et al., 2008; Stumberger et al., 2014). Administratively, the whole area belongs to the Republika Srpska entity.

DATA COLLECTION

The data was collected sporadically from a wide range of habitats (Fig. 2) during field excursions conducted between 2012 and 2020 (Tab. 1 & 2). It was previously partially published within the results of the Balkan Odonatological Meetings held in 2014 & 2020 (Kulijer et al., 2016; Tratnik et al.,

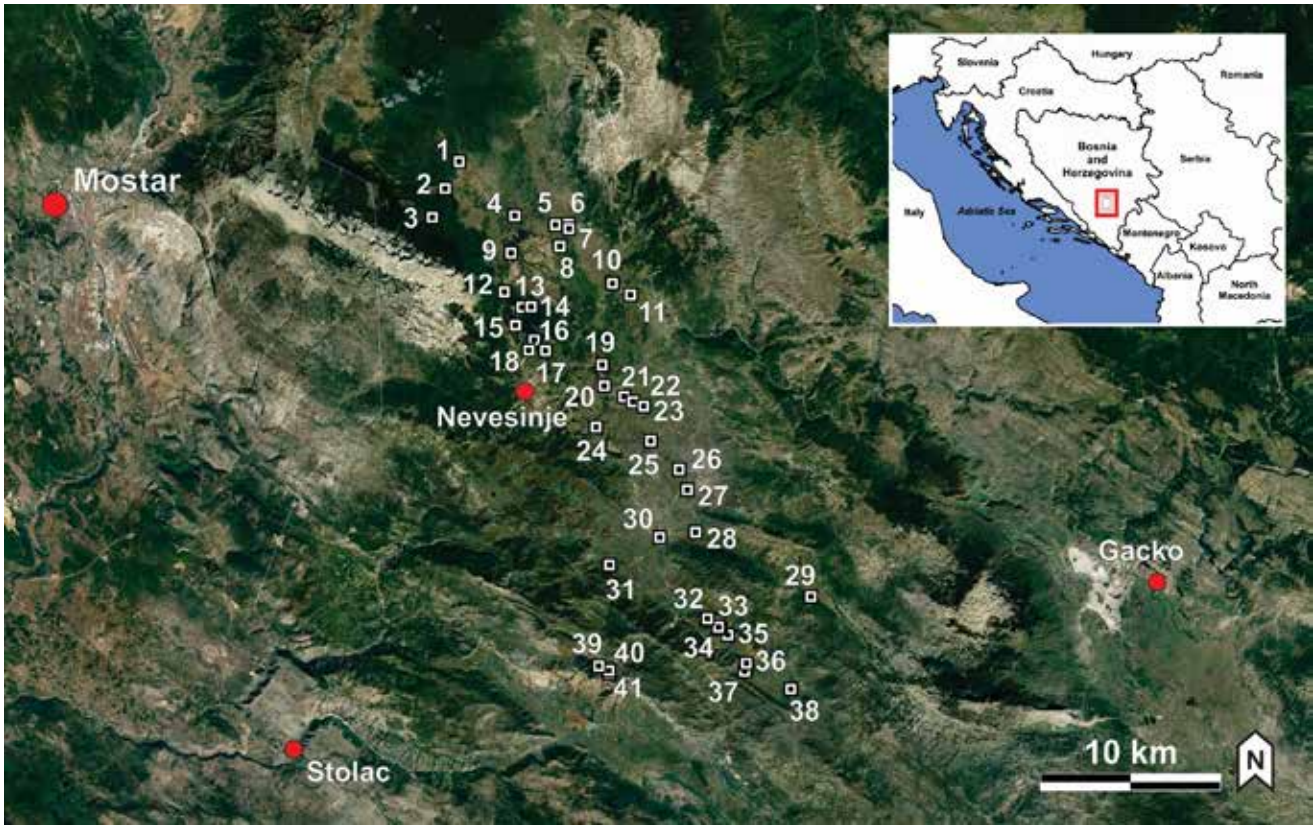

Figure 1. Geographical position of the Nevesinjsko polje study area and locations with dragonfly records.

2020). The study also incorporates the data collected within the International Biology Camp "Rujište 2017", the diploma thesis of Radenka Đurasović, as well as several other publications (Jović et al., 2010; Kulijer, 2015a), as well as data from the entomological collections of the National Museum of Bosnia and Herzegovina.

The data was mainly collected from adult specimens that were visually observed or caught with a hand net and identified in the field. Several voucher specimens were collected and deposited in the entomological collections of the National Museum of Bosnia and Herzegovina and the private collection of R. Đurasović. Larvae and exuviae were sampled sporadically, and identified in the laboratory afterwards.

RESULTS

A total of 293 records of 40 species were collected from 41 sites (Fig. 1, Tab. 1). This includes 181 unpublished records of 37 species, out of which 12 species are reported for the first time for the area. These are: *Calopteryx splendens* (Harris, 1780), *Calopteryx virgo* (Linnaeus, 1758), *Lestes barbarus* (Fabricius, 1798), *Coenagrion ornatum* (Selys 1850), *Ischnura pumilio* (Charpentier, 1825), *Aeshna isoceles* (Müller, 1767), *Aeshna mixta* Latreille, 1805, *Anax parthenope* (Selys, 1839), *Brachytron pratense* (Müller, 1764), *Cordulia aenea* (Linnaeus, 1758), *Libellula fulva* (Müller, 1764) and *Orthetrum brunneum* (Fonscolombe, 1837).

The oldest data on dragonflies of Nevesinjsko polje is to be found in the entomological collection of Viktor Apfelbeck, a small but historically significant dragonfly collection housed at the National Museum of Bosnia and Herzegovina (Kulijer & Marinov, 2010; Kulijer & Boudot, 2013; Kulijer et al., 2013). Three species from this region, *S. fusca*, *S. flaveolum* and *S. striolatum*, were found in the collection. The last two were collected in 1890, and represent the oldest known specimens from this area, and are among the oldest from Bosnia and Herzegovina in general. The list of all recorded species with locality numbers where they were recorded is presented in Tab. 2.

SYSTEMATIC ACCOUNT

Abbreviations used: M - male(s), F - female(s), MA - mature adult(s), Juv/Ten - juvenile(s)/teneral(s), Lar - larva(e), Cop - copula(e)/tandem(s), Ovip - ovipositing. The locality numbers correspond to those given in Tab. 2, as well as small letters in brackets used for new observations in cases of multiple dates per locality. The name(s) of the collector and determiner are given (if known) only in instances where specimens were not collected by the authors. References are only provided for published records.

Table 1. List of all locations with dragonfly records within the Nevesinjsko polje study area. References are only given for published data.

	Locality	Date	Latitude	Longitude	Altitude [m]
1	Lakat Police	1890	43.371667	18.068333	884
2	Tijesno, road to Veleško Lake	12.vi.2012	43.358889	18.058611	949
3	Veleško Lake	(a) 1986, (b) 30.vii.2017, Kulijer et al. (2016)	43.344722	18.05	1040
4	Pridvorci	12.vi.2012	43.345556	18.105833	864
5	Prijehode	30.iv.2012	43.341111	18.133333	840
6	Zlatac	12.vi.2012	43.341389	18.142222	843
7	Pokrivenik	12.vi.2012	43.339167	18.1425	839
8	Smrdan	12.vi.2012	43.330556	18.136389	846
9	Babova j., Sopilja	29.vi.2019	43.327222	18.103333	835
10	Duge njive, Postoljani, two small cattle ponds	Tratnik et al. (2020)			
11	Vrbovača pond, Krekovi	12.vi.2012, Tratnik et al. (2020)	43.306667	18.184167	904
12	Ristovina (Zlatac) ponds	(a) 15.v., (b) 15.vi., (c) 15.vii., (d) 17.vii., (e) 25.vii., (f) 10.viii., (g) 30.viii., (h) 07.ix.2015, (i) 30.vii.2017, Kulijer et al. (2016)	43.308056	18.098889	845
13	Nevesinjsko Lake, NE side	Kulijer et al. (2016), Tratnik et al. (2020)			
14	Srednja voda	(a) 15.vii., (b) 06.viii., (c) 07.ix.2015	43.300833	18.116944	843
15	Nevesinjsko Lake	(a) 15.vi., (b) 05.viii., (c) 15.viii., (d) 30.viii.2015, Jović et al. (2010)	43.291667	18.106389	846
16	Nevesinjsko Lake, SE side	Tratnik et al. (2020)			
17	Alagovac stream, Pomakovci	Tratnik et al. (2020)			
18	Logor	Jović et al. (2010)			
19	Kovačica pond, Batkovići	Tratnik et al. (2020)			
20	Bare, Batkovići, ponds	(a) 13.vi.2012, (b) 29.vi.2019	43.261944	18.166389	863
21	Boljkovače, ponds and wet meadows	(a) 13.vi.2012, (b) 29.vi.2019	43.256667	18.179722	849
22	Veljkovača, Šumački Stream	(a) 13.vi.2012, (b) 29.vi.2019	43.254167	18.185833	846
23	Bratački lug, Zalomka River	(a) 08.viii., (b) 11.viii.2015	43.251944	18.193056	845
24	Jezero, Žiljevo, small cattle pond	Tratnik et al. (2020)			
25	Zalužje, small cattle pond	Tratnik et al. (2020)			
26	Donje Budisavlje, stream near Zalomka River (both almost dry)	13.vi.2012, Tratnik et al. (2020)	43.220833	18.216944	832
27	Budisavlje, Zalomka River at the bridge (almost dry)	13.vi.2012	43.210833	18.2225	829
28	Donji Dražanj, pond beside the road to Slato polje	13.vi.2012	43.19	18.228056	881
29	Slato polje, pond	13.vi.2012	43.158333	18.305833	1037
30	Puddle beside the road near Donji Dražanj	13.vi.2012	43.1875	18.203889	841
31	Gornji Biograd, small water reservoir	28.0vi.2019	43.173889	18.17	860
32	Zavodka River, Ključani, Lukavačko polje	(a) 13.vi.2012, (b) 28.vi.2019	43.1475	18.235833	853
33	Udbina, small spring, Lukavačko polje	28.vi.2019	43.143348	18.243568	860
34	Zavodka River, Udbina, Lukavačko polje	13.vi.2012	43.142778	18.244722	862
35	Zavodka Stream, Lukavačko polje	28.vi.2019	43.139444	18.249722	865
36	Kljen stream, Lukavačko polje	13.vi.2012	43.125556	18.262222	891
37	Kljen, pond, Lukavačko polje	13.vi.2012	43.121667	18.261111	877
38	Donji Lukavac, Lukavačko polje, ponds and marshy meadows	13.vi.2012	43.112778	18.292222	869
39	Trusina, spring	28.vi.2019	43.124167	18.162778	947
40	Trusina, pond with vegetation	29.vi.2019	43.121944	18.169722	1010
41	Trusina, almost dry puddle	(a) 25.iv.2019, (b) 29.vi.2019	43.120556	18.169722	990

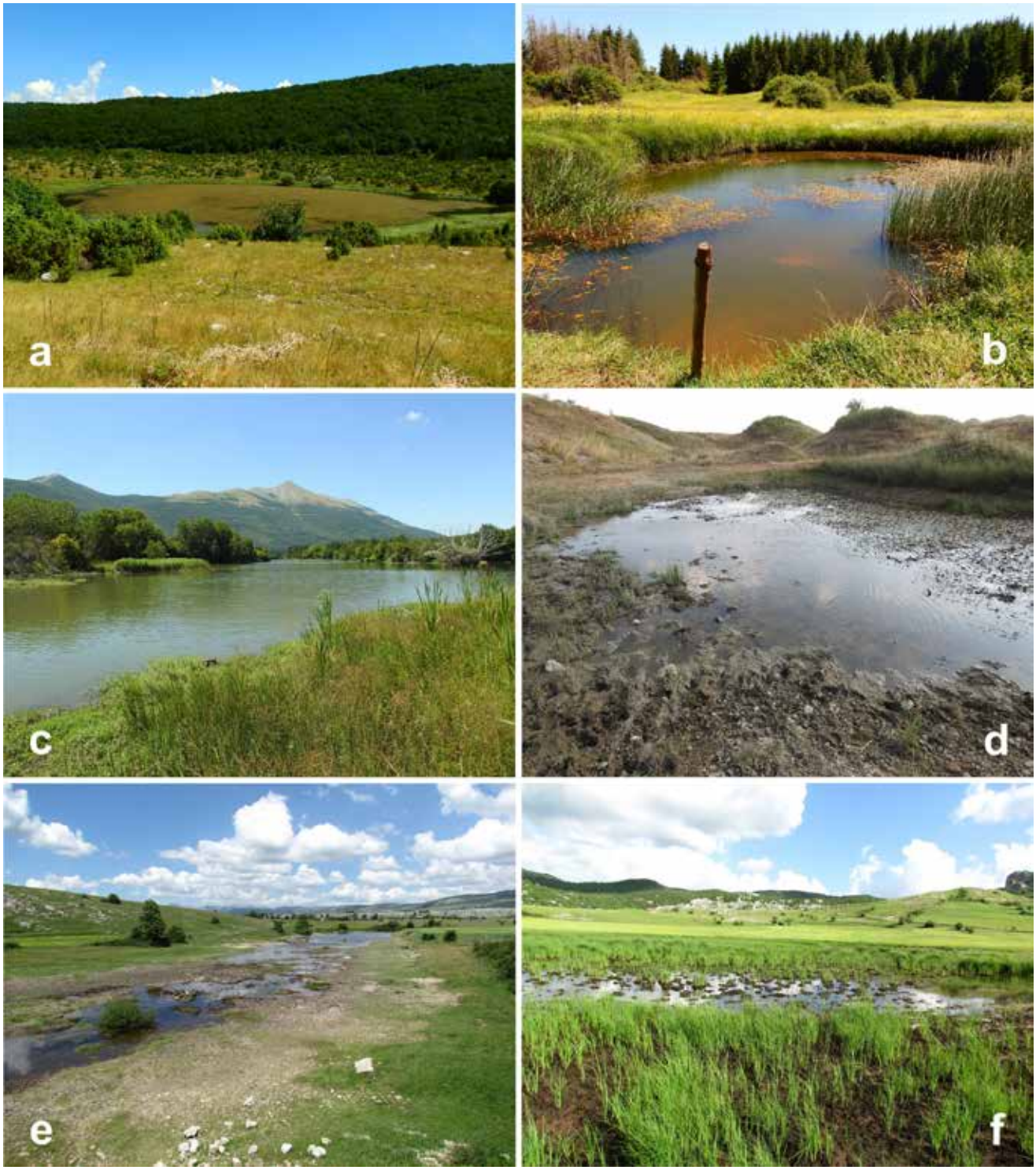

Figure 2. Surveyed habitats in the Nevesinjsko polje study area: a) Loc. 3. Veleško Lake (30.vii.2017), b) Loc. 9. Babova j., Sopilja (29.vi.2019), c) Loc. 16. Nevesinjsko Lake, SE side (02.viii.2020), d) Loc. 25. Zalužje (01.viii.2020), e) Loc. 27. Budisavlje, Zalomka River (13.vi.2012) f) Loc. 38. Donji Lukavac, Lukavačko polje (13.vi.2012) (photo: D. Kulijer).

Table 2. The checklist of Odonata species from the Nevesinjsko polje study area with reference to observation sites. The locality numbers correspond to those given in Table 1. The names of new species for the area are given in bold.

	Species	Localities	Total
CALOPTERYGIDAE			
1	***Calopteryx splendens*** (Harris, 1782)	9	1
2	***Calopteryx virgo*** (Linnaeus, 1758)	9, 14(a)	2
LESTIDAE			
3	*Chalcolestes viridis* (Vander Linden, 1825)	12(d), 16	2
4	***Lestes barbarus*** (Fabricius, 1798)	3(b), 12(g,i), 22(b), 37	4
5	*Lestes dryas* Kirby, 1890	3(b), 7, 8, 9, 10, 12(a), 13, 16, 17, 19, 20(b), 21(a,b), 22(a,b), 26, 32(b), 35, 38	17
6	*Lestes sponsa* (Hansemann, 1823)	3(b), 12(c,i), 13, 23(a)	4
7	*Lestes virens* (Charpentier, 1825)	12(g), 13	2
8	*Sympecma fusca* (Vander Linden, 1820)	1, 3(b), 13, 14(b), 16	5
COENAGRIONIDAE			
9	***Coenagrion ornatum*** (Sélys, 1850)	8	1
10	*Coenagrion puella* (Linnaeus, 1758)	3(b), 7, 8, 9, 10, 11, 12, 15, 16, 18, 20(a,b), 21(a,b), 22(a,b), 26, 27, 31, 32(b), 36, 38, 40	20
11	*Coenagrion scitulum* (Rambur, 1842)	10, 19, 20(b), 31	4
12	*Enallagma cyathigerum* (Charpentier, 1840)	3(b), 12(c,i), 13, 15, 20(b), 29, 30, 32b	8
13	*Erythromma lindenii* (Selys, 1840)	9, 13, 15, 16, 22(b)	5
14	*Erythromma viridulum* (Charpentier, 1840)	16	1
15	*Ischnura elegans* (Vander Linden, 1820)	3(b), 10, 11, 12(b), 13, 15, 16, 17, 18, 19, 20(b), 24, 25, 32(a,b), 37	15
16	***Ischnura pumilio*** (Charpentier, 1825)	8, 11(a), 29, 32(b), 35, 38	6
17	*Pyrrhosoma nymphula* (Sulzer, 1776)	8, 9, 12, 15, 18, 32, 33, 36	8
PLATYCNEMIDIDAE			
18	*Platycnemis pennipes* (Pallas, 1771)	9, 13, 15(b), 16, 17, 22(b)	6
AESHNIDAE			
19	*Aeshna affinis* Vander Linden, 1820	2, 9, 13, 16, 19, 32(b)	6
20	*Aeshna cyanea* (Müller, 1764)	12(d,i), 13, 14(c)	3
21	***Aeshna isoceles*** (Müller, 1767)	9	1
22	***Aeshna mixta*** Latreille, 1805	3(b)	1
23	*Anax imperator* Leach, 1815	3(b), 9, 11, 12(e,i), 13, 15(a), 16, 19, 20(a,b), 22(a,b), 23(b), 32(b)	12
24	***Anax parthenope*** Selys, 1839	22(b)	1
25	***Brachytron pratense*** (Müller, 1764)	8	1
CORDULIIDAE			
26	***Cordulia aenea*** (Linnaeus, 1758)	3(b)	1
27	*Somatochlora flavomaculata* (Vander Linden, 1825)	9, 13, 16	3
28	*Somatochlora meridionalis* Nielsen, 1935	9, 12(d), 15(b), 16	4
LIBELLULIDAE			
29	*Libellula depressa* Linnaeus, 1758	3(b), 4, 6, 7, 8, 9, 10, 11, 12(f,i), 13, 15, 16, 17, 18, 19 20(a,b), 21(a,b), 22(a,b), 23(b), 26, 28, 30, 31, 32(b), 34, 35, 36, 37, 38, 40, 41(a,b)	31
30	***Libellula fulva*** (Müller 1764)	9, 12(d)	2
31	*Libellula quadrimaculata* Linnaeus, 1758	3(a,b), 12(d), 13, 21(a), 22(b), 32(b), 38	7
32	***Orthetrum brunneum*** (Fonscolombe, 1837)	8, 15(b), 22(b), 39	4
33	*Orthetrum cancellatum* (Linnaeus, 1758)	3(b), 13, 15, 16, 19	5
34	*Orthetrum coerulescens* (Fabricius, 1798)	9, 15,	2
35	*Sympetrum flaveolum* (Linnaeus, 1758)	1, 3(b), 9, 13, 17, 22(b), 26, 32(a,b), 34, 37, 38	11
36	*Sympetrum fonscolombii* (Selys, 1840)	5, 11, 12(h), 15(d), 20(a), 22(b), 30	7
37	*Sympetrum meridionale* (Selys, 1841)	16	1
38	*Sympetrum sanguineum* (Müller, 1764)	3(b), 9, 12(i), 13, 15, 16, 17, 26, 31, 34, 40	11
39	*Sympetrum striolatum* (Charpentier, 1840)	1, 3(b), 12(f), 15(c)	4
40	*Crocothemis erythraea* (Brullé, 1832)	3	1

Family CALOPTERYGIDAE

Calopteryx splendens (Harris, 1782)
Loc. 9: >10MA;
Calopteryx virgo (Linnaeus, 1758)
Loc. 9: >10MA; **Loc. 14(a)**: 1M;

Family LESTIDAE

Chalcolestes viridis (Vander Linden, 1825)
Loc. 12(d): 1M; **Loc. 16**: Tratnik et al., 2020;
Lestes barbarus (Fabricius, 1798)
Loc. 3(b): 2M; **Loc. 12(g)**: 1M, **(i)**: 1M; **Loc. 22(b)**: 1M; **Loc. 37**: 3Juv/Ten;
Lestes dryas Kirby, 1890
Loc. 3(b): 1M,1F, Kulijer et al., 2016; **Loc. 7**: <10MA,>10Juv/Ten; **Loc. 8**: 3Juv/Ten; **Loc. 9**: >100MA; **Loc. 10**: Tratnik et al., 2020; **Loc. 12(a)**: 1F, Tratnik et al., 2020; **Loc. 13**: Kulijer et al., 2016, Tratnik et al., 2020; **Loc. 16**: Kulijer et al., 2016; **Loc. 17**: Kulijer et al., 2016; **Loc. 19**: Kulijer et al., 2016; **Loc. 20(b)**: >20MA,<Juv/Ten; **Loc. 21(a)**: 1F, **(b)**: >10MA; **Loc. 22(a)**: 1F, **(b)**: >10MA; **Loc. 26**: 1F; **Loc. 32(b)**: 2M,1F; **Loc. 35**: 1M; **Loc. 38**: >10MA,>Juv/Ten;
Lestes sponsa (Hansemann, 1823)
Loc. 3(b): >100MA, Tratnik et al., 2020; **Loc. 12(c)**: 1M, **(i)**: 3M,1F, Kulijer et al., 2016; **Loc. 13**: Tratnik et al., 2020, Tratnik et al., 2020; **Loc. 23(a)**: 1M;
Lestes virens (Charpentier, 1825)
Loc. 12(g): 1M; **Loc. 13**: Kulijer et al., 2016;
Sympecma fusca (Vander Linden, 1820)
Loc. 1: 2M leg. Apfelbeck, 2F leg. unknown; **Loc. 3(b)**: 2Juv/Ten; **Loc. 13**: Kulijer et al., 2016; **Loc. 14(b)**: 1M; **Loc. 16**: Tratnik et al., 2020;

Family COENAGRIONIDAE

Coenagrion ornatum (Selys, 1850)
Loc. 8: 2M,2F,2Cop;
Coenagrion puella (Linnaeus, 1758)
Loc. 3(b): >10MA,>10Cop, Kulijer et al., 2016; **Loc. 7**: 2M; **Loc. 8**: 1M; **Loc. 9**: >10M,<10Cop,<10Ovip; **Loc. 10**: Tratnik et al., 2020; **Loc. 11**: >100MA,>10Cop,>10Ovip, Tratnik et al., 2020; **Loc. 12**: Kulijer et al., 2016; **Loc. 15**: Jović et al., 2010; **Loc. 16**: Tratnik et al., 2020; **Loc. 18**: Jović et al., 2010; **Loc. 20(a)**: >10MA,>10Cop,>10Ovip, **(b)**: >10MA; **Loc. 21(a)**: >10MA,>10Cop,>10Ovip, **(b)**: <10MA; **Loc. 22(a)**: >10MA,>10Cop,>10Ovip, **(b)**: >10MA,<10Cop,<10Ovip; **Loc. 26**: 5M,3F; **Loc. 27**: 1M; **Loc. 31**: <10MA,<10Cop; **Loc. 32(b)**: >10MA,>10Cop; **Loc. 36**: 2M; **Loc. 38**: 1F; **Loc. 40**: 1M;
Coenagrion scitulum (Rambur, 1842)
Loc. 10: Tratnik et al., 2020; **Loc. 19**: Tratnik et al., 2020; **Loc. 20(b)**: 3M; **Loc. 31**: >10MA,>10Cop,>10Ovip;
Enallagma cyathigerum (Charpentier, 1840)
Loc. 3(b): >100MA,>10Cop,<10Juv/Ten, Kulijer et al., 2016; **Loc. 12(c)**: 1F, **(i)**: 1M,1Cop, Kulijer et al., 2016; **Loc. 13**: Kulijer et al., 2016; **Loc. 15**: Jović et al., 2010; **Loc. 20(b)**: 3MA; **Loc. 29**: 1M; **Loc. 30**: 1M,1Cop; **Loc. 32(b)**: >10M;
Erythromma lindenii (Selys, 1840)
Loc. 9: <10MA; **Loc. 13**: Kulijer et al., 2016, Tratnik et al., 2020; **Loc. 15**: Jović et al., 2010; **Loc. 16**: Tratnik et al., 2020; **Loc. 22(b)**: 5M;
Erythromma viridulum (Charpentier, 1840)
Loc. 16: Tratnik et al., 2020;
Ischnura elegans (Vander Linden, 1820)
Loc. 3: Kulijer et al., 2016; **Loc. 10**: >10MA; **Loc. 11**: Tratnik et al., 2020; **Loc. 12(b)**: 1F, Kulijer et al., 2016; **Loc. 13**: Kulijer et al., 2016, Tratnik et al., 2020; **Loc. 15**: Jović et al., 2010; **Loc. 16**: >10MA,>10Juv/Ten; **Loc. 17**: >10MA; **Loc. 18**: Jović et al., 2010; **Loc. 19**: >100MA; **Loc. 20(b)**: 5MA; **Loc. 24**: 8MA; **Loc. 25**: 1MA; **Loc. 32(a)**: 1M, **(b)**: 3MA; **Loc. 37**: 2M;
Ischnura pumilio (Charpentier, 1825)
Loc. 8: 1M,1Juv/Ten; **Loc. 11(a)**: 2M,<10MA,5Cop; **Loc. 29**: 1M; **Loc. 32(b)**: 7MA,1Ovip; **Loc. 35**: 1M; **Loc. 38**: 1M;
Pyrrhosoma nymphula (Sulzer, 1776)
Loc. 8: 30MA; **Loc. 9**: 2M,1F; **Loc. 12(c)**: 1M; **Loc. 15**: Jović et al., 2010; **Loc. 18**: Jović et al., 2010; **Loc. 32(b)**: 1M; **Loc. 33**: 1M,1F; **Loc. 36**: 1M;

Family PLATYCNEMIDIDAE

Platycnemis pennipes (Pallas, 1771)
Loc. 9: >100MA,>10Cop,>100Ovip; **Loc. 13**: Kulijer et al., 2016, Tratnik et al., 2020; **Loc. 15(b)**: 1F; **Loc. 16**: Tratnik et al., 2020; **Loc. 17**: Tratnik et al., 2020; **Loc. 22(b)**: 1M;

Family AESHNIDAE

Aeshna affinis Vander Linden, 1820
Loc. 2: 1M; **Loc. 9**: 3M; **Loc. 13**: Tratnik et al., 2020; **Loc. 16**: Tratnik et al., 2020; **Loc. 19**: Tratnik et al., 2020; **Loc. 32(b)**: 1M;
Aeshna cyanea (Müller, 1764)
Loc. 12(d): 1M,1F, **(i)**: 4M, Kulijer et al., 2016; **Loc. 13**: Kulijer et al., 2016; **Loc. 14(c)**: 1M,1F;
Aeshna isoceles (Müller, 1767)
Loc. 9: 15MA;
Aeshna mixta Latreille, 1805
Loc. 3(b): 1M;
Anax imperator Leach, 1815
Loc. 3(b): 5M,2Ovip, Kulijer et al., 2016; **Loc. 9**: 12M; **Loc. 11**: 1Ovip, Tratnik et al., 2020; **Loc. 12(e)**: 1M, **(i)**: 2M, Kulijer et al., 2016; **Loc. 13**: Tratnik et al., 2020; **Loc. 15(a)**: 1M, Jović et al., 2010; **Loc. 16**: Tratnik et al., 2020; **Loc. 19**: Tratnik et al., 2020; **Loc. 20(a)**: 1M, **(b)**: 1M; **Loc. 22(a)**: 3M,1Ovip **(b)**: 4M,1F; **Loc. 23(b)**: 1M; **Loc. 32(b)**: 5M,2F,2Ovip;
Anax parthenope (Selys, 1839)
Loc. 22(b): 1M;
Brachytron pratense (Müller, 1764)
Loc. 8: 2M;

Family CORDULIIDAE

Cordulia aenea (Linnaeus, 1758)
Loc. 3(b): 2M;
Somatochlora flavomaculata (Vander Linden, 1825)
Loc. 9: 3M; **Loc. 13**: Tratnik et al., 2020; **Loc. 16**: Tratnik et al., 2020;
Somatochlora meridionalis Nielsen, 1935
Loc. 9: 10M,1Ovip; **Loc. 12(d)**: 1M, Kulijer et al., 2016; **Loc. 15(b)**: 1M; **Loc. 16**: Tratnik et al., 2020;

Family LIBELLULIDAE

Crocothemis erythraea (Brullé, 1832)
Loc. 3: Kulijer et al., 2016;
Libellula depressa Linnaeus, 1758
Loc. 3(b): 1M; **Loc. 4**: 5M,2Cop; **Loc. 6**: 1M; **Loc. 7**: 1M; **Loc. 8**: 1M,1F; **Loc. 9**: 10M; **Loc. 10**: Tratnik et al., 2020; **Loc. 11**: 5M, Tratnik et al., 2020; **Loc. 12(f)**: 1M,1F, **(i)**: 2M, Kulijer et al., 2016; **Loc. 13**: Kulijer et al., 2016; **Loc. 15**: Jović et al., 2010; **Loc. 16**: Tratnik et al., 2020; **Loc. 17**: Tratnik et al., 2020; **Loc. 18**: Jović et al., 2010; **Loc. 19**: Tratnik et al., 2020; **Loc. 20(a)**: 2M, **(b)**: 3M; **Loc. 21(a)**: 10M,2F,1Cop,1Ovip, **(b)**: 5M,1F; **Loc. 22(a)**: 20M, **(b)**: 10M,2F; **Loc. 23(b)**: 1M,1F; **Loc. 26**: 1M; **Loc. 28**: 1M,1Ovip; **Loc. 30**: 2M; **Loc. 31**: 3M; **Loc. 32(b)**: 13M,2F,2Cop; **Loc. 34**: 1M; **Loc. 35**: 1M; **Loc. 36**: 1M; **Loc. 37**: 2M; **Loc. 38**: 2M; **Loc. 40**: 1F; **Loc. 41(a)**: 1Lar, **(b)**: 1Lar;
Libellula fulva (Müller, 1764)
Loc. 9: >100MA,>10Cop; **Loc. 12(d)**:1F;
Libellula quadrimaculata Linnaeus, 1758
Loc. 3(a): 1Juv/Ten leg. Paštar R., **(b)**: 5MA; **Loc. 12(d)**: 1F; **Loc. 13**: Kulijer et al., 2016; **Loc. 21(a)**: 2M; **Loc. 22(b)**: 1M; **Loc. 32(b)**: 1M; **Loc. 38**: 1F;
Orthetrum brunneum (Fonscolombe, 1837)
Loc. 8: 3M; **Loc. 15(b)**: 1M; **Loc. 22(b)**: 1M; **Loc. 39**: 1M;
Orthetrum cancellatum (Linnaeus, 1758)
Loc. 3(b): 5M; **Loc. 13**: Kulijer et al., 2016; **Loc. 15**: Jović et al., 2010; **Loc. 16**: Tratnik et al., 2020; **Loc. 19**: Tratnik et al., 2020;
Orthetrum coerulescens (Fabricius, 1798)
Loc. 9: 12M,1Juv/Ten; **Loc. 15**: Jović et al., 2010;
Sympetrum flaveolum (Linnaeus, 1758)
Loc. 1: 1F leg. et det. unknown; **Loc. 3(b)**: 50MA,10Cop,2Ovip, Kulijer et al., 2016; **Loc. 9**: >10MA; **Loc. 13**: Kulijer et al., 2016, Tratnik et al., 2020; **Loc. 17**: Tratnik et al., 2020; **Loc. 22(b)**: 2Juv/Ten; **Loc. 26**: Tratnik et al., 2020; **Loc. 32(a)**: 1F, **(b)**: 10MA; **Loc. 34**: 5MA; **Loc. 37**: 10Juv/Ten; **Loc. 38**: Kulijer, 2015a;
Sympetrum fonscolombii (Selys, 1840)
Loc. 5: <10MA leg. Dervović I.; **Loc. 11**: 1M; **Loc. 12(h)**: 1M,1F, Kulijer et al., 2016; **Loc. 15(d)**: 1M,1F; **Loc. 20(a)**: 1M; **Loc. 22(b)**: 1M; **Loc. 30**: 1M;
Sympetrum meridionale (Selys, 1841)
Loc. 16: Tratnik et al., 2020;
Sympetrum sanguineum (Müller, 1764)
Loc. 3(b): 2M, Kulijer et al., 2016; **Loc. 9**: 1M; **Loc. 12(i)**: 3M, Kulijer et al., 2016; **Loc. 13**: Kulijer et al., 2016, Tratnik et al., 2020; **Loc. 15**: Jović et al., 2010; **Loc. 16**: Tratnik et al., 2020; **Loc. 17**: Tratnik et al., 2020; **Loc. 26**: 1M; **Loc. 31**: 1M; **Loc. 34**: 1F; **Loc. 40**: 1F,1MA;
Sympetrum striolatum (Charpentier, 1840)
Loc. 1: 1M leg. et det. unknown; **Loc. 3(b)**: 5MA, Kulijer et al., 2016; **Loc. 12(f)**: 1M, Kulijer et al., 2016; **Loc. 15(c)**: 1M, Jović et al., 2010;

DISCUSSION

Local faunal studies are important in gaining better knowledge of species' distribution, their biology and ecology, and especially for the assessment of threats and the establishment of an effective system for the protection of their populations and habitats. Although it was not possible to cover all habitats in this large and diverse area – nor all seasonal aspects of many sites – through this study, the number of 40 recorded species (63% of all dragonfly species of the country) (Kulijer & Miljević, 2015) represents a valuable contribution to the knowledge of species distribution in these specific and sensitive karst habitats, as well as throughout the country. The most important such contribution is arguably the first record of *Coenagrion ornatum* (Selys 1850) for Nevesinjsko polje. This is a species of European conservation concern, protected by the European Habitats Directive (Annex II) and a near threatened (NT) species in the European Red List of Dragonflies (Kalkman et al., 2010). As the species is already known to occur across the karst poljes of Herzegovina and southwest Bosnia, this finding is of little surprise (Kulijer, 2012, 2014; Kulijer et al., 2013). As *C. ornatum* is mainly found in May & June, becoming scarce or disappearing altogether by or during early July (Boudot & Kulijer, 2015) and the main investigations were conducted later in the year (Tab. 1; Jović et al., 2010; Kulijer et al., 2016; Tratnik et al., 2020), we believe the species may well have a much wider presence throughout Nevesinjsko polje. Additional surveys focused on *C. ornatum* should be carried out, particularly in the northern part of the polje, where a greater number of potentially favourable habitats exist (Fig. 3). The species is known to inhabit both natural streams and artificial canals in many karst poljes in Bosnia and Herzegovina (Kulijer, 2012, 2014; Kulijer et al., 2013), with sound knowledge of its distribution being important for the identification of Natura 2000 protected areas for this species in Bosnia and Herzegovina.

The majority of recorded species are widespread throughout the country (Kulijer et al., 2013). The most frequent were *L. depressa* (31 sites), *C. puella* (20), *L. dryas* (17) and *I. elegans* (15) (Tab. 2). Three of them, *C. puella*, *I. elegans* and *L. depressa*, are habitat generalists, present in wide range of stagnant and slow flowing water habitats (Boudot & Kalkman, 2015), while *L. dryas* is the second most common species of the genera in the country, being particularly

Figure 3. *Coenagrion ornatum* (Selys 1850) habitat in Nevesinjsko polje, Loc. 8 (12.vi.2012).

abundant at higher altitudes (Kulijer et al., 2013). It is also a summer species abundant in temporary waters that are widely represented among the surveyed locations.

During the study, ten species were recorded at only a single location, namely: *C. splendens, C. ornatum, E. viridulum, A. mixta, A. isosceles, A. parthenope, B. pratense*, *C. aenea, S. meridionale* and *C. erythraea*. The low representation of these species, which are in general very common and widespread throughout the country (Kulijer et al., 2013), can be explained by a number of factors: The first is a lack of fieldwork in the early spring and autumn seasons – all surveys were conducted from mid-June to mid-August (Tab. 1; Jović et al., 2010; Kulijer et al., 2016; Tratnik et al., 2020). The largest freshwater habitat in the study area, the Nevesinjsko Lake was mostly investigated in late summer, when most spring species were no longer present. A second reason is the lack of permanent flowing waters in the study area. Finally, these results also demonstrate that the data on the dragonfly fauna of this large and diverse area is still insufficient, and that further research is needed.

The records were gathered from 41 localities distributed between altitudes of 829 and 1,040 m AMSL (Tab. 1, Fig. 1 & 2). The site at the lowest elevation in the study area is Zalomka River near Budisavlje, Loc. 27 (829 m AMSL), while the highest point is at Veleško Lake, Loc. 3 (1,040 m AMSL). In terms of species richness, the following locations had the highest species diversity: Loc. 9: Babova j., Sopilja (18 species); Loc. 12: Ristovina (18); Loc. 3: Veleško Lake (17); Loc. 13: Nevesinjsko Lake, NE side (17); Loc. 16: Nevesinjsko Lake, SE side (16) and Loc. 15: Nevesinjsko Lake (15). All of these locations are situated in the north-western part of the study area, where the most important dragonfly habitats are concentrated. For Nevesinjsko Lake itself (Locs. 13, 15 & 16), a total of 27 species was reported (66% of all the species found in the study area). Due to their large size and rich and diverse vegetation, Nevesinjsko and Veleško lakes support significant dragonfly communities. Many rivers and streams in karst poljes are only temporary, drying out in the summer period (Bonacci, 2015; Bonacci et al., 2019), and this is precisely the case for the Zalomka river, the largest watercourse in the study area. As a result, the presence of dragonfly fauna is limited, and mainly restricted to small ponds and pools that remain in the riverbed. A considerable number of small bodies of water – like many cattle ponds in the poljes – are also temporary and not suited to sustaining significant dragonfly communities (e.g. Fig. 2d).

We compared our results with those of studies of the dragonfly fauna of Livanjsko polje, the only other karst polje in Bosnia and Herzegovina for which significant data on Odonata fauna are published, with this polje also being situated at a higher altitude, as with Nevesinjsko polje (Kulijer, 2012, 2013). This comparison showed major similarities in terms of the number and composition of species. In Livanjsko polje, 42 species were found (Kulijer, 2012, 2013), compared to 40 in Nevesinjsko (with 98% of species from Nevesinjsko polje also being found in Livanjsko polje). The most common species in Nevesinjsko polje (Tab. 2) were also among the most common in Livanjsko polje (Kulijer, 2012), with the only notable differences in species composition being *Lestes sponsa* (Hansemann, 1823) found only in Nevesinjsko polje, and *Gomphus vulgatissimus* (Linnaeus, 1758), *Onychogomphus forcipatus* (Linnaeus, 1758) and *Orthetrum albistylum*

(Selys, 1848), which were only observed in Livanjsko polje. *Lestes sponsa* is common in mountain areas in southern Europe, including Bosnia and Herzegovina, where it inhabits wide range of standing and well-vegetated unshaded waters (Boudot & Raab, 2015). The habitats in Nevesinjsko polje, situated at higher altitudes and under stronger influence of the mountain climate, are quite suitable for this species, which is expected to be present in Livanjsko polje as well. The absence of *G. vulgatissimus* and *O. forcipatus* from Nevesinjsko polje can be explained by the scarcity of permanent flowing waters, while for *O. albistylum* the reasons could be the altitude and water temperature, particularly as the larger stagnant water habitats are situated in the colder north-western part of the polje, and the species is known to be less tolerant to cold water (Kalkman & Ambrus, 2015).

For other poljes in Bosnia and Herzegovina, published data is much more scarce (Kulijer, 2013), with Hutovo Blato being the only such area with more detailed knowledge (43 known species), but this area is hardly comparable with Nevesinjsko polje. Hutovo Blato is a permanent Mediterranean wetland situated at sea level, making it significantly different to most other karst poljes in Bosnia and Herzegovina (Kulijer, 2013, 2014, 2015b; Bukvić & Kulijer, 2021).

There is still no national Red List of dragonflies for Bosnia and Herzegovina. While dragonflies are included in the two entity-level regional red lists, these have been poorly drafted in regard to dragonflies, and do not reflect actual threat statuses of the species, either in the entities or at the national level (Kulijer, 2017). The Red List of Protected Species of Flora and Fauna of Republika Srpska lists 46 dragonfly species, but does not provide any threat category for any of these. With the exception of *A. isoceles*, *A. parthenope, B. pratense*, *S. flavomaculata* and *L. fulva*, all recorded species are included in this Red List (Službeni glasnik Republike Srpske, 2012). The second document to cover threatened and protected species in Republika Srpska, the Act on Strictly Protected and Protected Wild Species, does not include any of the recorded species (Službeni glasnik Republike Srpske, 2020).

Our records represent a valuable contribution to the knowledge of the dragonfly fauna of karst poljes, biodiversity hotspots of Bosnia and Herzegovina and the wider Dinaric Alps. We believe that future surveys will certainly result in the identification of more species and expand the knowledge on dragonfly fauna in Nevesinjsko polje. Such surveys should focus on the north-western part of Nevesinjsko polje, with a specific focus on Nevesinjsko Lake and the marshy habitats in its vicinity, as well on the canals and other small watercourses in the north, where *C. ornatum* was found, and primarily be undertaken in the spring months.

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SAŽETAK

U ovom radu dat je prvi pregled faune vilinih konjica Nevesinjskog polja, jednog od najvećih kraških polja u Bosni i Hercegovini, kao i dva susjedna mala polja, Lukavačko i Slato, koja su sa Nevesinjskim poljem blisko povezana. Terenska istraživanja koja su provedena od 2012. do 2020. godine rezultirala su sa 40 zabilježenih vrsta (63% faune vilinih konjica Bosne i Hercegovine). Od toga broja ovih 12 vrsta zabilježeno je prvi put na istraživanom području: ***Calopteryx splendens*** (Harris, 1780), ***Calopteryx virgo*** (Linnaeus, 1758), ***Lestes barbarus*** (Fabricius, 1798), ***Coenagrion ornatum*** (Selys, 1850), ***Ischnura pumilio*** (Charpentier, 1825), ***Aeshna isoceles*** (Müller, 1767), ***Aeshna mixta*** (Latreille, 1805), ***Anax parthenope*** (Selys, 1839), ***Brachytron pratense*** (Müller, 1764), ***Cordulia aenea*** (Linnaeus, 1758), ***Libellula fulva*** (Müller, 1764) i ***Orthetrum brunneum*** (Fonscolombe, 1837). Najznačajniji je prvi nalaz ***C. ornatum***, vrste od evropskog konzervacijskog značaja, pronađen u Nevesinjskom polju. Prikupljeni podaci važan su doprinos poznavanju faune vilinih konjica kraških polja, vruće tačke biodiverziteta dinarskog krša.

Ključne riječi: Bosna i Hercegovina, ***Coenagrion ornatum***, distribucija, kraška polja

The type specimens in Herbarium of the National Museum of Bosnia and Herzegovina (SARA)

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Abstract: *Herbarium Types* represents the greatest value of the scientific collection of the Herbarium of the National Museum of Bosnia and Herzegovina (SARA); it is represented by a total of 383 type specimens collected in the period from 1868 to 2012. The types are classified into 37 families, 107 genera, 248 species, 122 subspecies, 190 varieties, 86 forms and 5 hybrids. There are 284 holotypes, 15 isotypes, 41 syntypes, 8 topotypes, 1 neotype, as well as 34 types for which categories have not yet been determined. The types were mostly collected in Bosnia and Herzegovina (342), followed by Croatia (19), Montenegro (12), North Macedonia (5), Kosovo (2), Serbia (2) and Austria (1). Families with the highest number of type specimens include Compositae, Lamiaceae, Salicaceae, Rosaceae, Fabaceae, Caryophyllaceae, Apiaceae, Campanulaceae and Rubiaceae. The genera with the highest representation in descending order are: *Hieracium* L., *Stachys* L., *Populus* L., *Rosa* L., *Ulmus* L., *Satureja* L., *Campanula* L. and *Asperula* L. The Herbarium of the National Museum of Bosnia and Herzegovina (SARA) has type specimens from the historically important collections of O. Blau, G. Beck, E. Brandis, F. Fiala and K. Malý. The collectors with the largest number of type specimens are K. Malý, K. Malý & K.H. Zanh, N. Janjić, Č. Šilić, G. Beck, F. Fiala and O. Reiser.

Key words: vascular plants, collection, nomenclatural types, distribution, collector(s) and determiner(s), year of collection

INTRODUCTION

The second half of the 19th century was a turning point for the emergence and development of natural sciences in Bosnia and Herzegovina. Numerous foreign natural history researchers (geologists, geographers, professional botanists), researchers in the field of social sciences, as well as certain diplomats, began to, among other things, research the fossil and modern flora of Bosnia and Herzegovina. This explains the fact that the material of the newly described species, as with the other material, was mostly shipped to the herbaria of the researchers' native countries. In the same period, there was a gradual affirmation of the National Museum as a scientific institution, and the collection and processing of materials was carried out by the experts of this institution with the occasional help and cooperation of recognized experts from other countries in the form of determination and revision. Within this material, in addition to endemic, rare and unique specimens, nomenclatural types have a special scientific and museological value.

The terminology, typification, significance, and the manner of keeping and managing such valuable material is regulated by numerous international codes. The rules governing botanical nomenclature have a long history dating back to 1867, when the first meeting of the International Botanical Congress (IBC) was held in Paris, in which the "Law of botanical nomenclature" (*Lois de la nomenclature botanique*) was adopted (Nicolson, 1991). Subsequent congresses produced revised versions of these rules, which came to be known as the International Code of Botanical Nomenclature (ICBN), later renamed the International Code of Nomenclature for Algae, Fungi and Plants (ICN) at the IBC in Melbourne (July 2011) as part of the Melbourne Code, replacing the Vienna Code from 2005. The current and valid version of the code is the Shenzhen Code, adopted at the IBC in Shenzhen on 26 June 2018 (ICN, 2018).

According to the Shenzhen Code, a type (*typus*) is one or more specimens on the basis of which a species is described, and forms the backbone of the permanent binding of the name of the species and its type; i.e., the botanical name itself is fixed by the type, which is itself a specific specimen (or in some cases several specimens) of the species to which the scientific name is officially attached.

THE HERBARIUM OF THE NATIONAL MUSEUM OF BOSNIA AND HERZEGOVINA (SARA)

Since the founding of the National Museum of Bosnia and Herzegovina, the Department of Natural Sciences has been a center for the research of the biological and geological diversity of Bosnia and Herzegovina. The scientific collections of the Department of Natural Sciences, such as the Herbarium, constitute the oldest and largest database of plant species in Bosnia and Herzegovina and the Balkans. Historically speaking, this collection represents continuous botanical scientific activity even before the establishment of the National Museum in Sarajevo. The foundations were established by the donation of Franjo Fiala of 1,200 plants, with this then being expanded by the collections of numerous collectors, the most important among which being E. Brandis, K. Malý, O. Reiser, V. Loschnigg and H. Ritter, wih these collections later jointly becoming the basis of the Herbarium Collection and the Botanical Department (Dautbegović, 1988).

Today, the *Herbarium Bosniae et Hercegovinae* (SARA) collection is one of the most important and largest herbaria in the country and region, and has been identified as a reference centre for biodiversity research in Bosnia and Herzegovina. It is estimated to contain around 150,000 specimens, and is organized into six separate units: herbarium of world flora (*Herbarium Generale*), herbarium of the flora of Bosnia and Herzegovina (*Herbarium B&H sensu stricto*), herbarium of Erich Brandis (*Herbarium Brandisianum*), herbarium of Otto Blau (*Herbarium Blavianum*), herbarium of type specimens (*Herbarium Types*) and the cryptogamic herbarium (*Herbarium Cryptogamicum: algae, fungi, lichens and mosses*).

The project of the SIZ (Self-management community of interests) for Science and Education of the Socialist Republic of Bosnia and Herzegovina in 1984 included work on revising and labelling the type specimens in the botanical collection of the Herbarium, and separating them into a discrete collection, resulting in the creation of a report titled "Scientific processing of types in the collections of the Department of Natural Sciences of the National Museum" (Šilić et al., 1984), which aimed to present the world-renowned herbarium collection (SARA) to the domestic and international scientific public. An unpublished study states that within the collection material are represented 300 types (254 holotypes, 4 isotypes, 33 syntypes, 6 topotypes, 1 neotype and 2 types of undetermined category), which in turn represent 107 genera, 61 species, 67 subspecies and 124 varieties. Certain data from this study has been used in the creation of monographs (Šilić, 1979), the Index of BiH Flora (Mišić, 2014; Bjelčić, 2015; Šilić, 2018; Sarajlić, 2020; Kutleša & Muratović, 2022), scientific (Berberović et al., 2022) and review papers (Lagumdžija, 2020).

Given the fact that the mentioned study has never been published, the goal of this paper is to facilitate data transparency through the presentation of a general overview of the type collection, which has been significantly enhanced by the addition of new nomenclatural types in the past four decades.

MATERIAL AND METHODS

The basis for the work was the rich herbarium material stored in the scientific collection of the Botany Department of the Natural History Department of the National Museum of Bosnia and Herzegovina, registered in the *Index Herbariorum* under the code name SARA. Type specimens were separated from all collections (general herbarium: over 60,000 specimens, herbarium of BiH *sensu stricto*: about 55,000, Brandis's herbarium: 13,013, Otto Blau's herbarium: 2,503) into an independent collection called *Herbarium Types*.

Scientific processing of types (Šilić et al., 1984) required a special approach regulated by valid international codes. In this sense, all necessary literature was collected and reviewed, primarily those containing original descriptions. The status of the type was established and its category determined in terms of the valid nomenclatural rules. Most of the type material was processed according to the Montreal Code from 1961 (ICN, 2018).

In the cited study, the type specimens were processed according to a form containing the following data: name of the expert who performed the scientific processing of the type; belonging to a family; scientific name of the taxon; where the description was first published; *iconotypus* (if found); *locus classicus* with the date and name of the collector; diagnosis (original description); flowering time, typical habitat, remarks, other bibliographic data and revisions (depending on the expert who processed certain families); inventory number and attached photos. Following restoration, inclusion of a linear scale and "TYPUS" markings without a specific category, most of the types were photographed in black-and-white.

All isolated type specimens, regardless of whether they underwent scientific treatment or not, had been stored alphabetically in a special metal cabinet, and their inventory was made in a separate inventory book.

Subsequently, in 2015 the need arose to rearrange the collection, which included work on urgent restoration, fixing-in-place of the known category labels for each type, revision of the materials according to the existing inventory book, and assigning new vouchers. During the first inspection, incomplete or incorrectly entered data of the original material was observed to be present in the inventory documentation (double inventory of the same nomenclature type, unmarked type categories and inconsistent data for *locus classicus*). A direct check of the documentation was performed according to the data from the labels of the type specimens, which contain: species name, locality (*locus classicus*), altitude, phytocenological affiliation (individual), type of geological substrate (individual), date of collection, name of collector, audit data, if any (revised name of the species, name of the auditor, date of revision), inventory number and bag with dried seeds (individual), and the literature in which the new species was published for the first time. Considering that this is an extremely sensitive and valuable collection, the process of digitizing the type catalogue is underway, preceded by a taxonomic revision of the names of families whose statuses have changed significantly after almost 40 years (Euro+Med, 2021; WFO, 2021).

RESULTS AND DISCUSSION

The SARA list of type specimens provides an updated reference list of 383 registered nomenclatural types of vascular plants classified in 107 genera from 37 families (Euro+Med, 2021; WFO, 2021), which include 248 species, 122 subspecies, 190 varieties, 86 forms and 5 hybrids (Appendix 1).

Figure 1. Map of 383 identified ***locus classicus*** of type specimens stored in the Herbarium of the National Museum of Bosnia and Herzegovina (SARA)

According to the 1961 Montreal Code (ICN, 2018), the type collection includes 284 holotypes, 15 isotypes, 41 syntypes, 8 topotypes, 1 neotype, and 34 types of undetermined category. The geographic areas represented by the type collection include 7 countries: Bosnia and Herzegovina (254 holotypes, 7 isotypes, 41 syntypes, 8 topotypes, 1 neotype, 31 types), Croatia (14 holotypes, 4 isotypes, 1 type), Montenegro (8 holotypes, 3 isotypes, 1 type), North Macedonia (5 holotypes), Kosovo (1 holotype, 1 isotype), Serbia (1 holotype, 1 type) and Austria (1 holotype) (Fig. 1). The largest number of type specimens or holotypes was collected from upon the territory of Bosnia and Herzegovina (Tab.1).

Families with the highest number of type specimens include Compositae (13 genera, 117 types), Lamiaceae (8 genera, 56 types), Salicaceae (2 genera, 24 types), Rosaceae (6 genera, 23 types), Fabaceae (8 genera, 17 types), Caryophyllaceae (7 genera, 14 types), Apiaceae (7 genera, 14 types),

Campanulaceae (4 genera, 13 types), Rubiaceae (2 genera, 11 types) and others (Tab. 2).

The result of the analysis is expected and logical for Compositae, considering that it is one of the largest and most represented families of the world's vascular flora in terms of the number of genera and species, but it is also directly related to the specific area of expertise of prominent botanists in relation to certain plant groups or subgroups. Karlo Malý's scientific interest mostly related to the genera *Hieracium* L., *Stachys* L., *Rosa* L., *Acer* L., *Lathyrus* L. and others. The included types of Dr. Čedomil Šilić are the result of long-term research of the genera *Satureja* L., *Calamintha* Mill., *Micromeria* Benth., *Acinos* Mill. and *Clinopodium* L., with these also being treated in a monograph (Šilić, 1979). The type specimens deposited by Prof. Dr. Nikola Janjić (*Populus* L., *Ulmus* L.) and Prof. Dr. Dubravka Šoljan (*Edraianthus* DC., *Campanula* L.) were likewise largely influenced by their scientific commitment to the aforementioned groups.

Genera with the largest number of nomenclatural types include *Hieracium* L. (96 taxa), *Stachys* L. (25 taxa), *Populus* L. (22 taxa), *Rosa* L. (13 taxa), *Ulmus* L. (9 taxa),

Satureja L. (9 taxa), *Campanula* L. (9 taxa), *Asperula* L. (9 taxa) and *Acer* L. (7 taxa), while the genera *Euphorbia* L., *Scabiosa* L., *Lathyrus* L., *Micromeria* Benth. and *Thymus* L. are represented by 5 taxa each (Fig. 2).

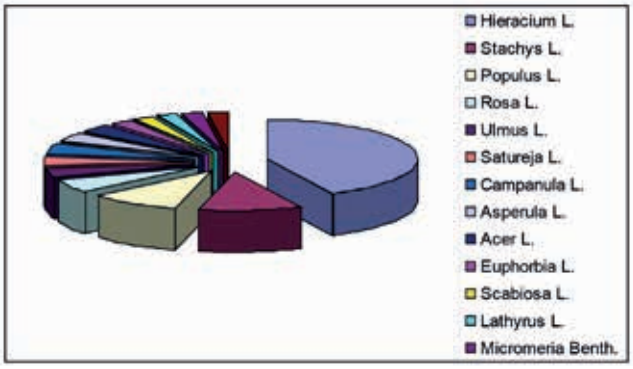

Figure 2. Representation of genera in the SARA type collection

From 1868 to 2012, a total of 44 collectors significantly contributed to the enrichment of the SARA type collection with new specimens. Within this broader period, the period from 1901 to 1950 evidenced particularly high levels of activity, with 250 nomenclature types being contributed to the collection (K. Malý, V. Ćurčić, W. Retzdorf, I. Bucalović, J. Stadlmann, O. Reiser, E. Brandis, L. Adamović, A. Latzel, V. Hawelka, V. Loschnigg, S. Tarasović, G. Beck, K. Fiedler and S. Plavšić) (Tab. 3).

The oldest SARA type is the holotype of the species *Potentilla reptans* L. var. *blavii* Aschers. & Graebn., which was collected by Otto Blau in 1868 in his garden in the Jezero district of Sarajevo, and labelled as a weed species (Herb. *Blavianum* no. 326 – Dublets) (Fig. 3).

The collectors with the largest number of SARA type specimens are K. Malý (167), K. Malý & K. H. Zanh (85), N. Janjić (31), Č. Šilić (21), G. Beck (13), V. Loschnigg (10), F. Fiala (8) and O. Reiser (7) (Appendix 1).

World-renowned herbarium collections registered in the *Index herbariorum* today undertake the practice of allowing a review of the list of type specimens that are available on their websites, such as the National Collection of Vascular Plants – AAFC Canada. Ontario. Ottawa. (DAO) with 4,000 types (Catalogue of Type Specimens in the Vascular Plant Herbarium (DAO), 2018), National Collection of Vascular Plants University of Oklahoma USA – Robert Bebb Herbarium (OKL) with 213 types (The Vascular Plant Type Specimens in the Robert Bebb Herbarium, 2017), and others.

The Catalogue of Type Specimens of Canada's National Collection of Vascular Plants (DAO) lists among the contents in its 2018 version the type specimen of the species *Pedicularis hoermannianum* K. Malý (Bosnia: pr. Sarajevo, May 1904, K. Malý) of undetermined type category. The Kew Herbarium Catalogue (Herbarium Catalogue - Kew Gardens, 2021) shows seven specimens of the species *Melampyrum hoermannianum* K. Malý from the territory of Bosnia and Herzegovina without an indicated type category. The holotypes of both species have been deposited in the SARA type collection, indicating the need for greater informational flow on a global level, which should certainly involve the Herbarium (SARA) through digitization and permanent availability of data.

CONCLUSION

The *Herbarium Types* collection represents the most sensitive segment of the Herbarium of the National Museum of Bosnia and Herzegovina (SARA). Revision of the types according to the museum documentation, inclusion of the new type material and changes in the taxonomic status of the families resulted in an indexed and relevant list with valuable information about its contents.

The SARA type collection includes 383 nomenclatural types collected in the period from 1868 to 2012.

The type collection includes 284 holotypes, 15 isotypes, 41 syntypes, 8 topotypes, 1 neotype and 34 types of undetermined category.

The types are represented by 37 families, 107 genera, 248 species, 122 subspecies, 190 varieties, 86 forms and 5 hybrids from Bosnia and Herzegovina (254 holotypes, 7 isotypes, 41 syntypes, 8 topotypes, 1 neotype, 31 types), Croatia (14 holotypes, 4 isotypes, 1 type), Montenegro (8 holotypes, 3 isotypes, 1 type), North Macedonia (5 holotypes),

Table 1. Nomenclature types of SARA according to geographical areas

	holotypus	isotypus	sintypus	topotypus	neotypus	typus	
B&H	254	7	41	8	1	31	**342**
Croatia	14	4				1	**19**
Montenegro	8	3				1	**12**
North Macedonia	5						**5**
Kosovo	1	1					**2**
Serbia	1					1	**2**
Austria	1						**1**
Total: 383	**284**	**15**	**41**	**8**	**1**	**34**	

Table 2. Number of SARA types according to families and number of genera

Number of genera per family	Families (number of types)
1	Amaryllidaceae (1), Apocynaceae (1), Asparagaceae (1), Caprifoliaceae (1), Dipsacaceae (5), Euphorbiaceae (5), Fagaceae (1), Liliaceae (1), Lythraceae (2), Plantaginaceae (4), Polygalaceae (1), Rhamnaceae (3), Santalaceae (1), Sapindaceae (7), Saxifragaceae (2), Tiliaceae (2), Ulmaceae (9), Viburnaceae (1), Violaceae (1)
2	Iridaceae (3), Juncaceae (2), Rubiaceae (11), Salicaceae (24), Scrophulariaceae (4)
3	Boraginaceae (3), Orchidaceae (3), Campanulaceae (13)
4	Orobanchaceae (6), Ranunculaceae (8)
5	Brassicaceae (7)
6	Poaceae (9), Rosaceae (23)
7	Apiaceae (14), Caryophyllaceae (14)
8	Fabaceae (17), Lamiaceae (56)
13	Compositae (117)

Table 3. Collectors and number of collected SARA types through different time periods

Period	Collectors	Period	Collectors
1868-1900	O. Blau J. Pantocsek F. Hoffmann G. Beck E. Brandis F. Fiala L. Adamović K. Vandas K. Malý O. Reiser H. Raap & A. Callier R. Keller V. Ćurčić A. Kneucker A. Baldacci	1956-1988	Ž. Bjelčić H. Ritter Č. Šilić N. Janjić, A. Latzel B. Korica Č. Šilić & S. Abadžić A. Podobnik & T. Wraber R. Lakušić & H. Markišić D. Šoljan & S. Abadžić T. Wraber D. Šoljan M. Lovka & T. Wraber
	Total number: 77 types		**Total number: 54 types**
1901-1950	K. Malý V. Ćurčić W. Retzdorf I. Bucalović J. Stadlmann O. Reiser E. Brandis L. Adamović A. Latzel V. Hawelka V. Loschnigg S. Tarasović G. Beck K. Fiedler S. Plavšić	1995-2012	D. Ballian & N. Janjić A. Hajrudinović & F. Bogunić
	Total number: 250 types		**Total number: 2 types**

Figure 3. The oldest SARA holotype ***Potentilla reptans*** L. var. ***blavii*** Aschers. & Graebn. ***Locus classicus***: Unkraut in meinem Garten, Jezero in Sarajevo (according to the original catalogue)

Kosovo (1 holotype, 1 isotype), Serbia (1 holotype, 1 type) and Austria (1 holotype).

The most numerous type specimens come from the families Compositae (117), Lamiaceae (56), Salicaceae (24), Rosaceae (23), Fabaceae (17), Caryophyllaceae (14), Apiaceae (14), Campanulaceae (13), Rubiaceae (11) and others.

The genera with the highest representation in the type collection are: *Hieracium* L. (96 taxa), *Stachys* L. (25 taxa), *Populus* L. (22 taxa), *Rosa* L. (13 taxa), *Ulmus* L. (9 taxa), *Satureja* L. (9 taxa), *Campanula* L. (9 taxa), *Asperula* L. (9 taxa) and *Acer* L. (7 taxa), while the genera *Euphorbia* L., *Scabiosa* L., *Lathyrus* L., *Micromeria* Benth. and *Thymus* L. are represented by 5 taxa each.

The collectors with the largest number of type specimens are K. Malý, K. Malý & K.H. Zanh, N. Janjić, Č. Šilić, G. Beck, F. Fiala and O. Reiser.

Of the 44 participating collectors, Karlo Malý made the greatest contribution, with 167 holotypes collected in Bosnia and Herzegovina, singlehandedly giving the SARA type collection its unique characteristics.

The most productive period was from 1901 to 1950, when 250 nomenclature types were added to the collection (K. Malý, V. Ćurčić, W. Retzdorf, I. Bucalović, J. Stadlmann, O. Reiser, E. Brandis, L. Adamović, A. Latzel, V. Hawelka, V. Loschnigg, S. Tarasović, G. Beck, K. Fiedler and S. Plavšić).

The availability of a list of nomenclatural types is necessary for future taxonomic research of global significance, which would resolve the numerous dilemmas regarding those still untypified according to the regulations of the current International Code of Nomenclature (ICN, 2018) and confirm the accuracy of previously typified specimens through much-needed revisions by authorities.

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APPENDIX 1

List of SARA type collections with basic data

No	Family	Sp./var./f.	B&H	Other countries	Collector	Determiner	Date	Type category
1	Amaryllidaceae	*Sternbergia colchiciflora* W. K. var. *dalmatica* Rchb. f. *biflora* Šilić	+		Č. Šilić	Č. Šilić	12.09.1965	typus
2	Apiaceae	*Angelica brachyradia* var. *planinensis* K. Malý	+		K. Malý	K. Malý	05.08.1911	syntypus
3	Apiaceae	*Angelica illyrica* K. Malý	+		K. Malý	K. Malý	12.09.1909	holotypus
4	Apiaceae	*Anthriscus fumaroides* (W. K.) Spreng. var. *calvescens* K. Malý	+		K. Malý	K. Malý	09.07.1906	typus
5	Apiaceae	*Anthriscus fumaroides* (W. K.) Spreng. var. *glaber* (Evers) Ginzb. & Malý	+		K. Malý	K. Malý	20.06.1909	syntypus
6	Apiaceae	*Astrantia major* L. subsp. *elatior* (Friv.) K. Malý var. *integra* K. Malý	+		K. Malý	K. Malý	15.07.1901	holotypus
7	Apiaceae	*Heracleum sphondylium* L. var. *atropurpureum* K. Malý	+		K. Malý	K. Malý	13.08.1918	holotypus
8	Apiaceae	*Heracleum sphondylium* L. var. *chloranthum* (Borb.) K. Malý f. *involucratum* K. Malý	+		K. Malý	K. Malý	18.07.1901	typus
9	Apiaceae	*Heracleum orsini* Guss. f. *hypoglaucum* K. Malý	+		K. Malý	K. Malý	13.08.1913	typus
10	Apiaceae	*Heracleum orsini* Guss. f. *typicum* K. Malý	+		K. Malý	K. Malý	04.08.1911	typus
11	Apiaceae	*Peucedanum illyricum* K. Malý	+		K. Malý	K. Malý	21.08.1908	syntypus
12	Apiaceae	*Pimpinella saxifraga* L. subsp. *alpina* Host. var. *erythrocephala* K. Malý	+		F. Fiala	K. Malý	23.08.1893	typus
13	Apiaceae	*Pimpinella saxifraga* L. var. *neglecta* K. Malý	+		V. Ćurčić	K. Malý	09.07.1898	holotypus
14	Apiaceae	*Seseli bosnense* K. Malý	+		A. Kneucker	K. Malý	29.08.1900	holotypus
15	Apiaceae	*Seseli hercegovinum* K. Malý	+		K. Vandas	K. Malý	05.09.1891	holotypus
16	Apocynaceae	*Cynanchum vincetoxicum* (L.) Pers. var. *bosniacum* K. Malý	+		K. Malý	K. Malý	05.07.1903	syntypus
17	Asparagaceae	*Hyacinthus dalmaticus* Baker var. *velezensis* G. Beck	+		O. Reiser	G. Beck	31.05.1892	syntypus
18	Brassicaceae	*Alyssum cinereum* O. Blau (Syn. *A. moellendorffianum* P. F. Ascherson)	+		O. Blau	P. F. Ascherson	01.09.1869	holotypus
19	Brassicaceae	*Arabis auriculata* Lam. var. *varbossania* K. Malý	+		K. Malý	K. Malý	03.06.1906	holotypus
20	Brassicaceae	*Arabis bosniaca* G. Beck (Syn. *A. sudetica* Tausch)	+		G. Beck	G. Beck	00.06.1892	holotypus
21	Brassicaceae	*Barbarea bracteosa* Guss. var. *illyrica* K. Malý	+		K. Malý	K. Malý	14.07.1908	holotypus
22	Brassicaceae	*Cardamine enneaphyllos* (L.) Cr. f. *crenatifolia* K. Malý	+		K. Malý	K. Malý	14.06.1932	syntypus
23	Brassicaceae	*Cardamine enneaphyllos* (L.) Cr. f. *latisecta* K. Malý	+		V. Loschnigg	K. Malý	21.06.1929	holotypus
24	Brassicaceae	*Hesperis dinarica* G. Beck	+		G. Beck	G. Beck	00.00.1892	isotypus
25	Boraginaceae	*Cerinthe lamprocarpa* Murb. var. *luteo-laciniata* K. Malý	+		V. Ćurčić	K. Malý	15.05.1897	typus
26	Boraginaceae	*Myosotis ronnigeri* K. Malý	+		K. Malý	K. Malý	28.06.1908	holotypus
27	Boraginaceae	*Onosma velenovskyi* K. Malý	+		F. Fiala	K. Malý	18.06.1889	holotypus
28	Campanulaceae	*Campanula cervicaria* L. var. *micrantha* K. Malý	+		K. Malý	K. Malý	05.07.1907	holotypus
29	Campanulaceae	*Campanula hercegovina* Fiala & Degen	+		F. Fiala	F. Fiala & A. Degen	24.07.1893	isotypus
30	Campanulaceae	*Campanula hercegovina* Fiala & Degen var. *squarrosa* Degen & Fiala	+		F. Fiala	A. Degen & F. Fiala	00.08.1893	holotypus

31	Campanulaceae	*Campanula moesiaca* Vel. f. *oblongifolia* K. Malý	+		E. Brandis	K. Malý	27.07.1886	holotypus
32	Campanulaceae	*Campanula patula* L. var. *jahorinae* K. Malý	+		K. Malý	K. Malý	29.07.1906	holotypus
33	Campanulaceae	*Campanula patula* L. var. *micrantha* K. Malý	+		K. Malý	K. Malý	17.09.1908	holotypus
34	Campanulaceae	*Campanula portenschlagiana* R. S. var. *hirsuta* Šoljan		Croatia	D. Šoljan	D. Šoljan	04.07.1986	holotypus
35	Campanulaceae	*Campanula portenschlagiana* R. S. var. *portenschlagiana* f. *grandiflora* Šoljan		Croatia	D. Šoljan	D. Šoljan	16.05.1988	holotypus
36	Campanulaceae	*Campanula portenschlagiana* R. S. var. *pumila* Šoljan		Croatia	D. Šoljan	D. Šoljan	18.05.1988	holotypus
37	Campanulaceae	*Edraianthus pumilio* (Portenschl.) DC. var. *gracilis* Šoljan & Abadžić		Croatia	D. Šoljan & S. Abadžić	D. Šoljan & S. Abadžić	05.07.1983	holotypus
38	Campanulaceae	*Edraianthus serpyllifolius* (Vis.) DC. var. *compactus* Šoljan & Abadžić		Croatia	D. Šoljan & S. Abadžić	D. Šoljan & S. Abadžić	11.06.1982	holotypus
39	Campanulaceae	*Edraianthus tenuifolius* (W. K.) DC. f. *hercegovinus* (Malý) Janchen	+		I. Santarius	K. Malý	08.08.1896	holotypus
40	Campanulaceae	*Phyteuma sieberi* Spreng. var. *brandisianum* K. Malý	+		K. Malý	K. Malý	07.08.1900	holotypus
41	Caprifoliaceae	*Dipsacus laciniatus* L. var. *indivisus* K. Malý	+		K. Malý	K. Malý	27.08.1903	holotypus
42	Caryophyllaceae	*Cerastium campanulatum* Viv. var. *parviflorum* K. Malý	+		F. Fiala	K. Malý	00.06.1890	typus
43	Caryophyllaceae	*Cerastium lanigerum* Clem. var. *dollineri* G. Beck	+		G. Beck	G. Beck	16.07.1888	isotypus
44	Caryophyllaceae	*Cerastium lanigerum* Clem. var. *pseudolanatum* K. Malý	+		K. Malý	K. Malý	08.08.1908	holotypus
45	Caryophyllaceae	*Cerastium lanigerum* Clem. var. *silvaticum* K. Malý	+		K. Malý	K. Malý	03.06.1920	holotypus
46	Caryophyllaceae	*Dianthus croaticus* Borb. f. *longearistatus* K. Malý	+		K. Malý	K. Malý	03.06.1920	holotypus
47	Caryophyllaceae	*Dianthus freynii* Vandas	+		K. Vandas	K. Vandas	04.08.1889	topotypus
48	Caryophyllaceae	*Dianthus nitidus* W. K. subsp. *lakusicii* T. Wraber		Montenegro	M. Lovka & T.Wraber	M. Lovka & T. Wraber	21.07.1987	isotypus
49	Caryophyllaceae	*Heliosperma quadridentata* (Murr.) Pers. subsp. *retzdorffiana* (Malý) Neumayer	+		W. Retzdorf	H. Neumayer	26.05.1903	holotypus
50	Caryophyllaceae	*Moehringia malyi* Hayek var. *siparuntia* K. Malý	+		V. Loschnigg	K. Malý	22.06.1934	holotypus
51	Caryophyllaceae	*Moenchia mantica* (L.) Bartl. var. *hercegovina* K. Malý	+		F. Fiala	K. Malý	00.06.1890	syntypus
52	Caryophyllaceae	*Scleranthus serpentini* G. Beck	+		K. Malý	K. Malý	29.06.1902	topotypus
53	Caryophyllaceae	*Silene armeria* L. var. *serpentini* G. Beck	+		G. Beck	G. Beck	25.08.1936	syntypus
54	Caryophyllaceae	*Silene reiseri* K. Malý		Croatia	O. Reiser	K. Malý	19.06.1907	holotypus
55	Caryophyllaceae	*Silene retzdorffiana* (K. Malý) Walters subsp. *nikolicii* Seliger & Wraber (Syn. *Heliosperma nikolicii* /Selinger & Wraber/ Niketić & Stevan.)		Kosovo	T. Wraber	A. Seliger & T. Wraber	05.06.1982	isotypus
56	Compositae	*Achillea* x *albinea* Malý & Bjelčić (*A. abrotanoides* Vis. x *A. clavenae* L.)	+		Ž. Bjelčić	K. Malý & Ž. Bjelčić	26.07.1950	holotypus
57	Compositae	*Achillea clavenae* L. var. *argentea* Vis. f. *volujakensis* Bjelčić & Mayer	+		Ž. Bjelčić	Ž. Bjelčić & E. Mayer	12.08.1965	holotypus
58	Compositae	*Achillea clavenae* L. var. *intercedens* Heim. f. *velebitica* Bjelčić & Mayer		Croatia	Đ. Đuran & Ž. Bjelčić	Ž. Bjelčić & E. Mayer	11.07.1979	typus
59	Compositae	*Anthemis cotula* L. var. *eradiata* K. Malý	+		K. Malý	K. Malý	25.07.1943	holotypus
60	Compositae	*Aster illyricus* (Murb.) K. Malý	+		K. Malý	K. Malý	09.08.1908	typus
61	Compositae	*Carduus alpestris* W. K. var. *discolor* K. Malý	+		E. Brandis	K. Malý	00.08.1912	holotypus
62	Compositae	*Carduus illyricus* K. Malý	+		K. Malý	K. Malý	08.07.1931	holotypus
63	Compositae	*Carduus nutans* L. var. *naronitanus* K. Malý	+		K. Malý	K. Malý	17.07.1923	holotypus
64	Compositae	*Centaurea deusta* Ten. var. *nobilis* (Grov.) f. *hypsophila* K. Malý	+		I. Bucalović	K. Malý	06.08.1909	holotypus
65	Compositae	*Centaurea glaberrima* Tsch. var. *majoriceps* K. Malý		Croatia	V. Loschnigg	K. Malý	19.07.1926	holotypus
66	Compositae	*Centaurea variegata* Lam. var. *pseudomontana* K. Malý	+		K. Malý	K. Malý	00.07.1903	holotypus

67	Compositae	*Crepis aurea* (L.) Cass. var. *bosniaca* K. Malý	+		K. Malý	K. Malý	15.07.1913	syntypus
68	Compositae	*Crepis aurea* (L.) Cass. var. *bosniaca* K. Malý	+		F. Fiala	K. Malý	00.07.1891	syntypus
69	Compositae	*Crepis blavii* (Asch.) Stadlmann (Syn. *Mulgedium blavii* Ascherson)	+		O. Blau	J. Stadlmann	28.08.1869	holotypus
70	Compositae	*Crepis* x *malyi* Stadlmann (*C. blavii* x *chondrilloides*)	+		J. Stadlmann, F. Faltis & E. Wibiral	J. Stadlmann	17.07.1907	holotypus
71	Compositae	*Hieracium amphitales* Malý & Zahn		Serbia	K. Malý	K. Malý & K. H. Zahn	21.08.1921	holotypus
72	Compositae	*Hieracium andrasovszkyi* Zahn subsp. *euglabratisimile* Behr. & Zahn f. *loschniggianum* Zahn	+		V. Loschnigg	K. H. Zahn	29.07.1934	typus
73	Compositae	*Hieracium austroslavicum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	08.08.1925	holotypus
74	Compositae	*Hieracium austroslavicum* Malý & Zahn var. *jahorinae* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	14.07.1931	holotypus
75	Compositae	*Hieracium bauhini* Bess. subsp. *chamae-bauhini* Malý & Zahn		Austria	K. Malý	K. Malý & K. H. Zahn	27.06.1917	holotypus
76	Compositae	*Hieracium bauhini* Bess. subsp. *colorifilum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	29.06.1918	holotypus
77	Compositae	*Hieracium bauhini* Bess. subsp. *pseudotransgressum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	29.05.1910	holotypus
78	Compositae	*Hieracium bifidum* Kit. subsp. *caesiiflorum* Almg. var. *basicrinuloides* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	14.06.1925	holotypus
79	Compositae	*Hieracium bifidum* Kit. subsp. *caesiotropum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	03.06.1914	holotypus
80	Compositae	*Hieracium bifidum* Kit. subsp. *stenolepis* Lbg. var. *leucochloreilema* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	29.05.1927	holotypus
81	Compositae	*Hieracium bifidum* Kit. subsp. *subcaesiifloriforme* Zahn var. *ovale* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	29.05.1914	holotypus
82	Compositae	*Hieracium biflorum* A. T. subsp. *vučjanum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	20.08.1913	holotypus
83	Compositae	*Hieracium bjelušae* Malý & Zahn subsp. *melacense* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	26.06.1910	syntypus
84	Compositae	*Hieracium blyttianum* Fr. subsp. *supratensiforme* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	20.08.1913	holotypus
85	Compositae	*Hieracium bodewigianum* Zahn subsp. *konjskae livadae* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	20.08.1913	holotypus
86	Compositae	*Hieracium brachiatum* Bertol. subsp. *minuticapitulum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	15.07.1922	holotypus
87	Compositae	*Hieracium brachiatum* Bertol. subsp. *tapeinophyles* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	05.08.1911	holotypus
88	Compositae	*Hieracium brachiatum* Bertol. subsp. *trichobrachiatum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	05.07.1919	holotypus
89	Compositae	*Hieracium brevifolium* Tausch subsp. *brevifolium* (Tsch.) Zahn var. *glabratum* Posp. f. *serratum* Malý & Zahn	+		K. Malý	K. Malý	01.09.1920	typus
90	Compositae	*Hieracium brevifolium* Tausch subsp. *brachyphyllum* (Vukot.) Zahn var. *pseudosabaudum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	13.09.1930	typus
91	Compositae	*Hieracium brevifolium* Tausch. subsp. *hellwegeri* Murr & Zahn var. *borovnicae* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	01.10.1920	typus
92	Compositae	*Hieracium caesiogenum* Wol. & Zahn subsp. *borjae planinae* Loschnigg & Zahn	+		V. Loschnigg	V.Loschnigg & K. H. Zahn	23.06.1931	holotypus
93	Compositae	*Hieracium cernuiforme* (N. P.) Zahn subsp. *kozarevicae* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	06.07.1913	holotypus
94	Compositae	*Hieracium cottetii* (Godet.) Gremli & Zahn subsp. *glogošnicae* Loschnigg & Zahn	+		V. Loschnigg	V. Loschnigg & K. H. Zahn	10.07.1931	holotypus
95	Compositae	*Hieracium cottetii* (Godet.) Gremli & Zahn subsp. *hawelkae* Malý & Zahn		Montenegro	V. Hawelka	K. Malý & K. H. Zahn	28.07.1927	holotypus
96	Compositae	*Hieracium cydonifolium* (Rchb.) Zahn subsp. *malyanum* Zahn	+		K. Malý	K. Malý & K. H. Zahn	04.08.1911	holotypus
97	Compositae	*Hieracium dentatum* Hoppe subsp. *subruncinatum* N. P. var. *zlatištense* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	23.06.1914	typus

98	Compositae	*Hieracium dolopicum* Freyn. & Sint. subsp. *banjanum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	20.07.1920	syntypus
99	Compositae	*Hieracium flagellare* Willd. subsp. *ravnae planinae* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	28.06.1934	holotypus
100	Compositae	*Hieracium guentheri beckii* Zahn subsp. *ortisanum* Zahn	+		O. Fiedler	K. H. Zahn	12.08.1934	topotypus
101	Compositae	*Hieracium gymnocephalum* Griseb. subsp. *laxipellitum* Zahn f. *omeniformе* Zahn (Syn. *H. orieni* Kern.)		Montenegro	L. Adamović	L. Adamović	00.07.1908	typus
102	Compositae	*Hieracium hypeurium* N. P. subsp. *macranthogenes* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	15.07.1922	holotypus
103	Compositae	*Hieracium leptophyton* N. P. subsp. *bracchiatisimile* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	30.07.1933	holotypus
104	Compositae	*Hieracium leptophyton* N. P. subsp. *hojtae* Loschnigg & Zahn	+		V. Loschnigg	V. Loschnigg & K. H. Zahn	25.07.1930	holotypus
105	Compositae	*Hieracium leptophyton* N. P. subsp. *klisense* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	06.07.1923	holotypus
106	Compositae	*Hieracium leptophyton* N. P. subsp. *tenuifiliferum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	29.06.1918	syntypus
107	Compositae	*Hieracium macutense* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	30.05.1911	holotypus
108	Compositae	*Hieracium murorum* L. subsp. *cophosinuatum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	14.10.1924	holotypus
109	Compositae	*Hieracium murorum* L. subsp. *pleiophyllogenes* Zahn f. *magnum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	17.07.1928	typus
110	Compositae	*Hieracium murorum* L. subsp. *ravnanum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	06.07.1913	holotypus
111	Compositae	*Hieracium murorum* L. subsp. *semipraecurrens* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	23.05.1909	holotypus
112	Compositae	*Hieracium murorum* L. subsp. *subbifidiforme* Zahn var. *euviolascens* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	08.05.1927	holotypus
113	Compositae	*Hieracium murorum* L. subsp. *toplicense* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	05.07.1928	holotypus
114	Compositae	*Hieracium murorum* L. subsp. *trebevićicolum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	03.06.1914	syntypus
115	Compositae	*Hieracium murorum* L. subsp. *varešense* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	12.06.1923	holotypus
116	Compositae	*Hieracium naegelanium* Panč. subsp. *ferdinandi regis* Stoj. & Zahn f. *kukoranum* Malý & Zahn (Syn. *H. heterogynum* /Froel./ Gutermann)	+		K. Malý	K. Malý & K. H. Zahn	14.09.1911	typus
117	Compositae	*Hieracium neo-malyii* Zahn	+		K. Malý	K. H. Zahn	11.07.1934	holotypus
118	Compositae	*Hieracium neosyllectum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	15.06.1930	holotypus
119	Compositae	*Hieracium pallescentifrons* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	06.08.1911	holotypus
120	Compositae	*Hieracium pavichii* Heuff. subsp. *jazinae* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	21.05.1914	holotypus
121	Compositae	*Hieracium pavichii* Heuff. subsp. *sub-pavichii* Zahn var. *glabrisquamum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	19.06.1930	holotypus
122	Compositae	*Hieracium pavichii* Heuff. subsp. *tenuiflagellatum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	07.06.1921	syntypus
123	Compositae	*Hieracium pilosella* L. subsp. *nigrovirescens* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	17.05.1913	holotypus
124	Compositae	*Hieracium pilosella* L. subsp. *sericomastix* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	02.06.1920	holotypus
125	Compositae	*Hieracium pilosella* L. subsp. *stenophyllophorum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	06.07.1913	holotypus
126	Compositae	*Hieracium praecurrens* Vukot. subsp. *megalodenophyes* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	02.06.1929	holotypus
127	Compositae	*Hieracium praecurrens* Vukot. subsp. *praecurrens* (Vukot.) Zahn var. *pseudograndidens* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	04.08.1911	holotypus
128	Compositae	*Hieracium praecurrens* Vukot. subsp. *pseudopleiophylloides* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	03.07.1923	holotypus

129	Compositae	*Hieracium praecurrens* Vukot. subsp. *pseudopleiophylloides* Malý & Zahn var. *sub-loschniggianum* Zahn	+		V. Loschnigg	K. H. Zahn	07.06.1930	holotypus
130	Compositae	*Hieracium praecurrens* Vukot. subsp. *subserratifolium* Zahn var. *multisinuatifrons* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	03.07.1910	holotypus
131	Compositae	*Hieracium praecurrens* Vukot. subsp. *subumbelliramum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	05.08.1911	holotypus
132	Compositae	*Hieracium praecurrens* Vukot. subsp. *subumbelliramum* Malý & Zahn f. oligocephalum Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	09.06.1924	typus
133	Compositae	*Hieracium praecurrens* Vukot. subsp. *trachysetum* (Borb.) Zahn var. *trachysetiforme* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	20.08.1913	holotypus
134	Compositae	*Hieracium praecurrens* Vukot. subsp. *zvijezdae* Loschnigg & Zahn	+		V. Loschnigg	V. Loschnigg & K. H. Zahn	20.06.1929	holotypus
135	Compositae	*Hieracium pseudo-tommasinii* Rohl. & Zahn subsp. *doljaninum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	09.08.1922	holotypus
136	Compositae	*Hieracium pseudo-tommasinii* Rohl. & Zahn subsp. *kerstacense* Malý & Zahn		Montenegro	K. Malý	K. Malý & K. H. Zahn	04.10.1909	holotypus
137	Compositae	*Hieracium racemosum* W. K. subsp. *stiriacum* (Kern.) Zahn var. *subcrinitiforme* Malý & Zahn f. *govcae* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	13.09.1930	typus
138	Compositae	*Hieracium raiblense* (Hut.) Zahn subsp. *hadromastix* N. P. var. *furcatum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	08.08.1929	syntypus
139	Compositae	*Hieracium raiblense* (Hut.) Zahn subsp. *igmanicum*Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	08.08.1929	holotypus
140	Compositae	*Hieracium raiblense* (Hut.) Zahn subsp. *raiblense* Huter f. *minoriceps* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	22.07.1918	typus
141	Compositae	*Hieracium raiblense* (Hut.) Zahn subsp. *subtricolor* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	15.07.1922	holotypus
142	Compositae	*Hieracium scorzoneraefolium* Vill. subsp. *hodžae* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	14.07.1911	holotypus
143	Compositae	*Hieracium tajanum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	30.09.1920	holotypus
144	Compositae	*Hieracium tauschii* Zahn subsp. *adeno-tauschii* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	17.07.1932	holotypus
145	Compositae	*Hieracium tauschii* Zahn subsp. *bokševicianum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	11.07.1926	holotypus
146	Compositae	*Hieracium tauschii* Zahn subsp. *dobrunense* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	29.05.1914	holotypus
147	Compositae	*Hieracium tauschii* Zahn subsp. *viridentiforme* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	11.07.1926	holotypus
148	Compositae	*Hieracium tephrocephalum* N. P. subsp. *minutiglandulum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	08.06.1920	holotypus
149	Compositae	*Hieracium tommasinii* Reichb. subsp. *castelli novi* Malý & Zahn		Croatia	K. Malý	K. Malý & K. H. Zahn	05.10.1909	holotypus
150	Compositae	*Hieracium trebevićianum* K. Malý	+		K. Malý	K. Malý	10.06.1898	holotypus
151	Compositae	*Hieracium trebevićianum* Malý subsp. *caespitiferum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	23.05.1909	holotypus
152	Compositae	*Hieracium trebevićianum* Malý subsp. *epiprasinum* Zahn var. *grandidentiforme* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	14.09.1930	holotypus
153	Compositae	*Hieracium trebevićianum* Malý subsp. *epiprasinum* Zahn var. *ledenicae* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	29.07.1929	holotypus
154	Compositae	*Hieracium trebevićianum* Malý subsp. *epiprasinum* Zahn var. *permagnidens* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	14.09.1930	holotypus
155	Compositae	*Hieracium trebevićianum* Malý subsp. *horridentiferum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	17.07.1928	holotypus
156	Compositae	*Hieracium trebevićianum* Malý subsp. *jablanense* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	14.07.1929	holotypus
157	Compositae	*Hieracium trebevićianum* Malý subsp. *loschniggianum* Malý & Zahn	+		V. Loschnigg	K. Malý & K. H. Zahn	28.06.1928	holotypus
158	Compositae	*Hieracium trebevićianum* Malý subsp. *loschniggianum* Malý & Zahn var. *subcalvipedunculatum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	27.08.1930	typus

159	Compositae	*Hieracium trebevićianum* Malý subsp. *multisinuatum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	07.06.1909	holotypus
160	Compositae	*Hieracium trebevićianum* Malý subsp. *obliquifidum* Rohlena & Zahn var. *amauradenophorum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	08.08.1925	holotypus
161	Compositae	*Hieracium trebevićianum* Malý subsp. *obliquifidum* Rohlena & Zahn var. *dentellatum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	08.05.1927	holotypus
162	Compositae	*Hieracium trebevićianum* Malý subsp. *obliquifidum* Rohlena & Zahn var. *pleiophyllotropum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	08.08.1925	holotypus
163	Compositae	*Hieracium trebevićianum* Malý subsp. *platyodontozum* Malý & Zahn	+		K. Malý	K. Malý & K. H. Zahn	29.05.1927	holotypus
164	Compositae	*Hieracium trebevićianum* Malý subsp. *treskavicae* Malý & Zahn			K. Malý	K. Malý & K. H. Zahn	05.08.1911	syntypus
165	Compositae	*Hieracium valdepilosum* Vill. subsp. *loschniggii* Zahn	+		K. Malý	K. H. Zahn	30.07.1934	holotypus
166	Compositae	*Hieracium wettsteinianum* Zahn subsp. *malyanum* Zahn	+		K. Malý	K. H. Zahn	14.07.1929	holotypus
167	Compositae	*Hypochoeris illyrica* K. Malý	+		O. Reiser	K. Malý	00.07.1897	holotypus
168	Compositae	*Leontodon illyricus* K. Malý	+		K. Malý	K. Malý	05.08.1900	holotypus
169	Compositae	*Petasites kablikianus* Tausch var. *bosniacus* K. Malý	+		K. Malý	K. Malý	29.04.1900	holotypus
170	Compositae	*Reichardia adriatica* K. Malý		Croatia	I. Bucalović	K. Malý	19.06.1909	holotypus
171	Compositae	*Tragopogon tommasinii* Schult. & Bip. var. *glaber* K. Malý	+		V. Ćurčić	K. Malý	25.06.1896	holotypus
172	Compositae	*Xeranthemum cylindraceum* Sibth. & Sm. var. *daorsinum* K. Malý	+		K. Malý	K. Malý	21.07.1912	holotypus
173	Dipsacaceae	*Scabiosa delminiana* Abadžić	+		Č. Šilić & S. Abadžić	S. Abadžić	20.09.1977	holotypus
174	Dipsacaceae	*Scabiosa leucophylla* Borb. var. *integrifolia* K. Malý	+		K. Malý	K. Malý	31.05.1903	holotypus
175	Dipsacaceae	*Scabiosa leucophylla* Borb. var. *luteola* K. Malý	+		K. Malý	K. Malý	26.09.1899	holotypus
176	Dipsacaceae	*Scabiosa leucophylla* Borb. f. *bipinnatisecta* K. Malý	+		K. Malý	K. Malý	16.07.1905	syntypus
177	Dipsacaceae	*Scabiosa leucophylla* Borb. f. *coronopifolia* K. Malý	+		K. Malý	K. Malý	05.08.1906	holotypus
178	Euphorbiaceae	*Euphorbia carniolica* Jacqu. var. *varbossania* K. Malý	+		K. Malý	K. Malý	02.07.1905	holotypus
179	Euphorbiaceae	*Euphorbia gregersenii* K. Malý	+		K. Malý	K. Malý	03.06.1920	holotypus
180	Euphorbiaceae	*Euphorbia polychroma* A. Kerner f. *latifolia* K. Malý	+		K. Malý	K. Malý	21.06.1942	holotypus
181	Euphorbiaceae	*Euphorbia taurinensis* All. var. *isophylla* K. Malý	+		K. Malý	K. Malý	07.06.1908	syntypus
182	Euphorbiaceae	*Euphorbia villosa* W. K. var. *drinensis* K. Malý (Syn. *E. villosa* W. K. var. *verrucosa* K. Malý)	+		K. Malý	K. Malý	08.06.1908	syntypus
183	Fabaceae	*Anthyllis alpestris* (Kit.) Rchb. var. *subalpina* K. Malý	+		K. Malý	K. Malý	17.07.1932	holotypus
184	Fabaceae	*Anthyllis dillenii* Schuex var. *chlebianae* K. Malý	+		F. Fiala	K. Malý	24.06.1893	holotypus
185	Fabaceae	*Anthyllis jancheniana* K. Malý	+		I. Bucalović	K. Malý	00.06.1907	holotypus
186	Fabaceae	*Anthyllis polyphylla* Kit. var. *carstigena* K. Malý	+		K. Malý	K. Malý	07.07.1931	holotypus
187	Fabaceae	*Astragalus passtelianus* Poll. var. *bosniacus* Fiala (Syn. *A. fialae* Degen)	+		F. Fiala	K. Malý	27.07.1893	holotypus
188	Fabaceae	*Cytisus austriacus* L. var. *maezeius* K. Malý (Syn. *C. maezeius* K. Malý)	+		K. Malý	K. Malý	04.06.1921	holotypus
189	Fabaceae	*Cytisus bosniacus* G. Beck	+		G. Beck	G. Beck	10.06.1885	isotypus
190	Fabaceae	*Cytisus tommasinii* Vis. var. *keranius* K. Malý (Syn. *C. austriacus* L. var. *keranius* K. Malý)	+		K. Malý	K. Malý	29.07.1909	holotypus
191	Fabaceae	*Hedysarum silicii* Lakušić		Kosovo	R. Lakušić	R. Lakušić	30.07.1980	holotypus

192	Fabaceae	*Lathyrus latifolius* L. var. *purpureus* Gilib. f. *varešensis* K. Malý	+		S. Plavšić	K. Malý	19.07.1939	typus
193	Fabaceae	*Lathyrus venetus* (Mill.) W. K. f. *fiedleri* K. Malý		Montenegro	K. Fiedler	K. Malý	03.06.1937	holotypus
194	Fabaceae	*Lathyrus vernus* (L.) Bernh. var. *flaccidus* (Ser.) Arcang. f. *graminifolius* K. Malý	+		S. Plavšić	K. Malý	11.05.1940	holotypus
195	Fabaceae	*Lathyrus vernus* (L.) Bernh. var. *flaccidus* (Ser.) Arcang. f. *misočensis* K. Malý	+		S. Plavšić	K. Malý	28.05.1940	holotypus
196	Fabaceae	*Lathyrus vernus* (L.) Bernh. var. *regis alexandri* Širjaev	+		V. Loschnigg	G. Širjaev	23.07.1933	typus
197	Fabaceae	*Oxytropis prenja* G. Beck	+		G. Beck	G. Beck	00.07.1888	topotypus
198	Fabaceae	*Trifolium repens* L. var. *ochranthum* K. Malý	+		K. Malý	K. Malý	30.07.1905	holotypus
199	Fabaceae	*Vicia oroboides* (Wulf.) Jacqu. var. *sarajevensis* K. Malý	+		K. Malý	K. Malý	29.06.1899	holotypus
200	Fagaceae	*Fagus silvatica* L. var. *pseudograndidentata* Janjić & Ballian	+		D. Ballian	D. Ballian & N. Janjić	00.07.1995	holotypus
201	Iridaceae	*Crocus maudi* K. Malý		North Macedonia	V. Loschnigg	K. Malý	10.06.1935	holotypus
202	Iridaceae	*Crocus vilmae* Fiala	+		F. Fiala	F. Fiala	00.03.1890	holotypus
203	Iridaceae	*Iris varbossania* K. Malý	+		K. Malý	K. Malý	31.05.1913	holotypus
204	Juncaceae	*Juncus thomasii* Ten. subsp. *palensis* K. Malý	+		K. Malý	K. Malý	04.08.1907	holotypus
205	Juncaceae	*Luzula campestris* (L.) DC. var. *atrofusca* K. Malý	+		K. Malý	K. Malý	02.07.1905	holotypus
206	Lamiaceae	*Acinos alpinus* (L.) Moench subsp. *dinaricus* Šilić	+		K. Malý	Č. Šilić	11.06.1939	holotypus
207	Lamiaceae	*Acinos alpinus* (L.) Moench subsp. *dinaricus* var. *dinaricus* f. *hirsutus* (Pant.) Šilić		Montenegro	J. Pantocsek	Č. Šilić	21.07.1872	holotypus
208	Lamiaceae	*Acinos hungaricus* (Simk.) Šilić f. *albiflorus* (K. Malý) Šilić	+		K. Malý	Č. Šilić	04.06.1902	holotypus
209	Lamiaceae	*Acinos orontius* (K. Malý) Šilić f. *albiflora*Šilić	+		Č. Šilić	Č. Šilić	14.05.1970	holotypus
210	Lamiaceae	*Calamintha glandulosa* (Req.) Bentham f. *albiflora* (K. Malý) Šilić	+		K. Malý	Č. Šilić	17.10.1918	holotypus
211	Lamiaceae	*Calamintha sylvatica* Bromf. subsp. *sylvatica* f. *boveana* (K. Malý) Šilić	+		K. Malý	Č. Šilić	01.09.1903	holotypus
212	Lamiaceae	*Calamintha vardarensis* Šilić		North Macedonia	Č. Šilić	Č. Šilić	15.08.1970	holotypus
213	Lamiaceae	*Clinopodium vulgare* L. f. *minus* Šilić	+		Č. Šilić	Č. Šilić	27.07.1970	holotypus
214	Lamiaceae	*Clinopodium vulgare* L. f. *rubrotinctum* Šilić		North Macedonia	Č. Šilić	Č. Šilić	05.10.1975	holotypus
215	Lamiaceae	*Clinopodium vulgare* L. f. *unicephalum* Šilić	+		Č. Šilić	Č. Šilić	08.11.1970	holotypus
216	Lamiaceae	*Micromeria dalmatica* Bentham f. *multiflora* Šilić		Croatia	K. Malý	Č. Šilić	04.10.1909	holotypus
217	Lamiaceae	*Micromeria kosaninii* Šilić		North Macedonia	Č. Šilić	Č. Šilić	11.10.1970	holotypus
218	Lamiaceae	*Micromeria parviflora* (Vis.) Rchb. f. *monantha* Latzel ex Šilić	+		A. Latzel	A. Latzel	25.06.1911	holotypus
219	Lamiaceae	*Micromeria parviflora* (Vis.) Rchb. f. *rubrotincta* Šilić		Montenegro	Č. Šilić	Č. Šilić	25.08.1968	holotypus
220	Lamiaceae	*Micromeria pseudocroatica* Šilić		Croatia	Č. Šilić	Č. Šilić	10.10.1975	holotypus
221	Lamiaceae	*Salvia glutinosa* L. var. *sagittifolia* Šilić	+		Č. Šilić	Č. Šilić	14.10.1986	holotypus
222	Lamiaceae	*Salvia pratensis* L. var. *varbossania* K. Malý	+		K. Malý	K. Malý	00.07.1891	holotypus
223	Lamiaceae	*Satureia adamovicii* Šilić		North Macedonia	Č. Šilić	Č. Šilić	15.10.1970	holotypus
224	Lamiaceae	*Satureia bosniaca* K. Malý *(Calamicromeria* x *hostii* /Caruel/ Šilić)	+		K. Malý	K. Malý	00.08.1903	holotypus
225	Lamiaceae	*Satureia horvatii* Šilić		Montenegro	Č. Šilić	Č. Šilić	09.10.1975	isotypus
226	Lamiaceae	*Satureia montana* L. subsp. *montana* var. *domaviana* (K. Malý) Šilić (Syn. *Satureia montana* L. var *domaviana* K. Malý)	+		K. Malý	Č. Šilić	22.08.1929	holotypus
227	Lamiaceae	*Satureia narentana* K. Malý (*S. thymifolia* x *nepeta*)	+		K. Malý	K. Malý	21.08.1908	holotypus

228	Lamiaceae	*Satureia orjenii* Šilić (*S. horvatii* Šilić x *S. montana* L. subsp. *montana*)		Montenegro	Č. Šilić	Č. Šilić	19.10.1972	holotypus
229	Lamiaceae	*Satureia orontia* K. Malý (Syn. *Acinos orontius* /K. Malý/ Šilić)	+		K. Malý	K. Malý	11.05.1902	holotypus
230	Lamiaceae	*Satureia subspicata* Bartl. subsp. *subspicata* f. *obovata* Šilić	+		Č. Šilić	Č. Šilić	10.09.1970	holotypus
231	Lamiaceae	*Satureia visianii* Šilić		Croatia	Č. Šilić	Č. Šilić	10.10.1975	holotypus
232	Lamiaceae	*Stachys alpina* L. var. *sulphurea* K. Malý	+		K. Malý	K. Malý	14.06.1907	holotypus
233	Lamiaceae	*Stachys anisochila* Vis. & Panč. var. *diversicalix* K. Malý	+		K. Malý	K. Malý	22.06.1902	syntypus
234	Lamiaceae	*Stachys anisochila* Vis. & Panč. var. *diversicalix* K. Malý f. *micrantha* K. Malý	+		K. Malý	K. Malý	22.06.1902	syntypus
235	Lamiaceae	*Stachys anisochila* Vis. & Panč. f. *elliptica* K. Malý	+		K. Malý	K. Malý	22.06.1902	typus
236	Lamiaceae	*Stachys karstiana* Borb. var. *eriocaulis* K. Malý	+		K. Malý	K. Malý	15.07.1900	holotypus
237	Lamiaceae	*Stachys montenegrinus* K. Malý		Montenegro	A. Baldacci	K. Malý	20.07.1900	holotypus
238	Lamiaceae	*Stachys nitens* Janka var. *serpentina* K. Malý	+		K. Malý	K. Malý	00.06.1910	holotypus
239	Lamiaceae	*Stachys recta* L. subsp. *hayekii* K. Malý	+		G. Beck	K. Malý	00.07.1888	holotypus
240	Lamiaceae	*Stachys recta* L. subsp. *hayekii* K. Malý f. *lanceolata* K. Malý	+		K. Malý	K. Malý	29.07.1901	holotypus
241	Lamiaceae	*Stachys recta* L. subsp. *hayekii* K. Malý f. *luteola* K. Malý	+		K. Malý	K. Malý	10.07.1901	holotypus
242	Lamiaceae	*Stachys recta* L. subsp. *hayekii* K. Malý f. *oxyphylla* K. Malý	+		K. Malý	K. Malý	03.08.1902	holotypus
243	Lamiaceae	*Stachys recta* L. var. *decumbens* K. Malý	+		K. Malý	K. Malý	12.06.1900	typus
244	Lamiaceae	*Stachys recta* L. var. *jugoslavica* K. Malý	+		V. Hawelka	K. Malý	25.06.1925	holotypus
245	Lamiaceae	*Stachys recta* L. var. *murbeckii* K. Malý	+		K. Malý	K. Malý	09.06.1900	typus
246	Lamiaceae	*Stachys recta* L. var. *sarajevensis* K. Malý (Syn. *S. karstiana* Borb. var. *sarajevensis* K. Malý)	+		K. Malý	K. Malý	27.06.1900	holotypus
247	Lamiaceae	*Stachys recta* L. var. *sarajevensis* K. Malý f. *jagodinae* K. Malý	+		K. Malý	K. Malý	18.09.1902	holotypus
248	Lamiaceae	*Stachys sendtneri* G. Beck	+		O. Reiser	K. Malý	24.06.1892	typus
249	Lamiaceae	*Stachys serpentinus* K. Malý	+		K. Malý	K. Malý	08.06.1908	syntypus
250	Lamiaceae	*Stachys subcrenatus* Vis. var. *angustifolia* Vis. f. *hercegovinus* K. Malý	+		G. Beck	K. Malý	00.08.1888	holotypus
251	Lamiaceae	*Stachys subcrenatus* Vis. var. *epidauria* K. Malý		Croatia	K. Malý	K. Malý	30.05.1908	holotypus
252	Lamiaceae	*Stachys subcrenatus* Vis. var. *illyrica* K. Malý	+		F. Fiala	K. Malý	00.08.1896	syntypus
253	Lamiaceae	*Stachys subcrenatus* Vis. var. *petragena* (Jan.) Hayek f. *illyrica* K. Malý	+		K. Malý	K. Malý	05.08.1900	typus
254	Lamiaceae	*Stachys žepčensis* Forman. var. *gymnocalyx* K. Malý	+		K. Malý	K. Malý	01.06.1920	holotypus
255	Lamiaceae	*Stachys žepčensis* Forman. f. *glanduligerus* K. Malý	+		K. Malý	K. Malý	03.06.1920	syntypus
256	Lamiaceae	*Stachys žepčensis* Forman. f. *grosse-crenata* K. Malý	+		K. Malý	K. Malý	29.06.1902	typus
257	Lamiaceae	*Thymus bosnensis* K. Malý (Syn. *Th. jankae* var. *bosnensis* K. Malý)	+		K. Malý	K. Malý	18.06.1908	holotypus
258	Lamiaceae	*Thymus jankae* Čel. var. *hirsutus* K. Malý	+		K. Malý	K. Malý	14.06.1908	holotypus
259	Lamiaceae	*Thymus jankae* Čel. var. *jugoslavicus* K. Malý	+		K. Malý	K. Malý	05.06.1921	holotypus
260	Lamiaceae	*Thymus jankae* Čel. var. *oreophilus* K. Malý	+		K. Malý	K. Malý	23.06.1918	holotypus
261	Lamiaceae	*Thymus jankae* Čel. var. *sedoides* K. Malý	+		K. Malý	K. Malý	08.05.1903	holotypus
262	Liliaceae	*Lilium carniolicum* Bernh. var. *bosniacum* G. Beck	+		F. Fiala	G. Beck	00.07.1887	syntypus
263	Lythraceae	*Punica granatum* L. var. *sativum* K. Malý	+		K. Malý	K. Malý	09.06.1914	holotypus

264	Lythraceae	*Punica granatum* L. var. *spontaneum* K. Malý	+		K. Malý	K. Malý	26.05.1912	holotypus
265	Orchidaceae	*Gymnadenia conopsea* (L.) R. Br. var. *anomala* K. Malý	+		Ž. Bjelčić	K. Malý	06.06.1949	holotypus
266	Orchidaceae	*Orchis bosniaca* G. Beck	+		G. Beck	G. Beck	00.07.1888	syntypus
267	Orchidaceae	*Serapias lingua* L. var. *leucoglossa* K. Malý	+		K. Malý	K. Malý	18.05.1912	syntypus
268	Orobanchaceae	*Alectorolophus abbreviatus* (Murb.) Maly var. *brevifolius* K. Malý	+		K. Malý	K. Malý	24.08.1898	holotypus
269	Orobanchaceae	*Alectorolophus rumelicus* (Vel.) Borb. var. *mostarensis* K. Malý	+		K. Malý	K. Malý	06.06.1912	holotypus
270	Orobanchaceae	*Euphrasia brandisii* Freyn.	+		E.Brandis	F. J. Freyn	03.08.1885	syntypus
271	Orobanchaceae	*Euphrasia liburnica* Wettst. var. *bosnensis* K. Malý	+		F. Fiala	F. Fiala	18.06.1895	holotypus
272	Orobanchaceae	*Melampyrum hoermannianum* K. Malý	+		K. Malý	K. Malý	09.06.1898	holotypus
273	Orobanchaceae	*Pedicularis hoermanniana* K. Malý (Syn. *P. hacquetii* Graf.)	+		F. Fiala	K. Malý	14.06.1886	holotypus
274	Plantaginaceae	*Veronica crinita* Kit. f. *bosniaca* Fiala (Syn. *V. teucrium* L. subsp. *crinita* /Kit./ Vel. f. *bosniaca* /Fiala/ Watzl)	+		F. Fiala	F. Fiala	16.06.1892	holotypus
275	Plantaginaceae	*Veronica orbiculata* Kern. var. *emarginata* K. Malý (Syn. *V. austriaca* subsp. *orbiculata* /Kern./ K. Malý var. *emarginata* K. Malý)	+		K. Malý	K. Malý	30.08.1906	syntypus
276	Plantaginaceae	*Veronica orbiculata* Kern. var. *hercegovina* K. Malý (Syn. *V. austriaca* subsp. *orbiculata* /Kern./ K. Malý var. *hercegovina* K. Malý)	+		H. Raap & A. Callier	K. Malý	10.05.1895	syntypus
277	Plantaginaceae	*Veronica teucrium* L. var. *tajana* K. Malý	+		K. Malý	K. Malý	06.06.1921	syntypus
278	Poaceae	*Alopecurus myosuroides* Huds. var. *muticus* K. Malý	+		K. Malý	K. Malý	26.05.1912	holotypus
279	Poaceae	*Avena blavii* Asch. & Jank. (Syn. *Avenastrum blavii* G. Beck)	+		G. Beck	P. F. Ascherson & V. Janka	00.07.1888	holotypus
280	Poaceae	*Bromus arvensis* L. var. *varbossanius* K. Malý	+		K. Malý	K. Malý	12.07.1900	holotypus
281	Poaceae	*Bromus bosnensis* K. Malý (Syn. *B. japonicus* Thrumb. var. *bosniacus* K. Malý)	+		K. Malý	K. Malý	28.10.1920	typus
282	Poaceae	*Bromus erectus* Huds. (Syn. *B. moellendorffianus* A. G.)	+		O. Blau	A. Gaertner	28.05.1869	typus
283	Poaceae	*Koeleria splendens* Presl. var. *ciliata* K. Malý	+		K. Malý	K. Malý	22.06.1902	holotypus
284	Poaceae	*Koeleria splendens* Presl. var. *silvatica* K. Malý	+		K. Malý	K. Malý	26.06.1910	syntypus
285	Poaceae	*Sesleria argentea* Savi var. *intermedia* Beck (Syn. *S. latifolia* /Adam./ Degen var. *serpentinica* Deyl)	+		K. Malý	G. Beck	12.06.1923	typus
286	Poaceae	*Trisetum flavescens* (L.) P. B. f. *luxurians* K. Malý	+		S. Tarasović	K. Malý	19.06.1935	holotypus
287	Polygalaceae	*Polygala supina* Schreb. var. *celakovskyana* K. Malý	+		K. Malý	K. Malý	29.05.1910	holotypus
288	Ranunculaceae	*Aquilegia blecicii*Podobnik		Montenegro	A. Podobnik & T.Wraber	A. Podobnik	17.07.1980	isotypus
289	Ranunculaceae	*Aquilegia pancicii*Degen		Serbia	O. Reiser	A. Degen	05.06.1899	typus
290	Ranunculaceae	*Caltha cornuta* Sch. N. K. var. *natans* K. Malý	+		K. Malý	K. Malý	09.06.1914	holotypus
291	Ranunculaceae	*Helleborus hercegovinus* Martinis f. *hercegovinus* Martinis (Syn. *H. multifidus* Vis.)	+		K. Malý	Z. Martinis	06.04.1913	holotypus
292	Ranunculaceae	*Helleborus hercegovinus* Martinis f. *pauciflorus* Martinis	+		H. Ritter	Z. Martinis	20.05.1956	holotypus
293	Ranunculaceae	*Helleborus odorus* W. K. f. *corollinus* K. Malý	+		K. Malý	K. Malý	04.03.1899	holotypus
294	Ranunculaceae	*Helleborus odorus* W. K. f. *laceratus* K. Malý	+		K. Malý	K. Malý	28.05.1898	holotypus
295	Ranunculaceae	*Ranunculus velatus* Hal. var. *bosniacus* K. Malý	+		I. Bucalović	K. Malý	18.06.1904	holotypus
296	Rhamnaceae	*Rhamnus illyrica* Gris. var. *ernesti-mayeri* Šilić		Croatia	Č. Šilić	Č. Šilić	30.05.1975	holotypus

297	Rhamnaceae	*Rhamnus malyana* Kasp. (*Rh. cartatica* x *orbiculata* Bornm.)	+		K. Malý	Kasp.	11.08.1925	holotypus
298	Rhamnaceae	*Rhamnus pumilla* Turra subsp. *illyrica* Šilić (Syn. *Oreoherzogia pumila* /Turra/ Vent subsp. *illyrica* Šilić)	+		Č. Šilić & Đ. Đuran	Č. Šilić	04.10.1965	holotypus
299	Rosaceae	*Crataegus monogyna* Jacqu. var. *ronnigeri* K. Malý	+		K. Malý	K. Malý	29.07.1911	holotypus
300	Rosaceae	*Potentilla australis* Kraš. var. *serpentina* G. Beck	+		V. Ćurčić	G. Beck	28.04.1898	topotypus
301	Rosaceae	*Potentilla heptaphylla* L. var. *veležensis* G. Beck	+		O. Reiser	G. Beck	09.06.1911	topotypus
302	Rosaceae	*Potentilla reptans* L. var. *blavii* Ascherson & Graebner	+		O. Blau	P. F. Ascherson & K. O. Graebner	08.06.1868	holotypus
303	Rosaceae	*Prunus spinosa* L. var. *varbossania* K. Malý	+		K. Malý	K. Malý	30.09.1928	holotypus
304	Rosaceae	*Rosa brandisii* Keller	+		E. Brandis	J. Keller	12.08.1908	holotypus
305	Rosaceae	*Rosa canina* L. var. *blavii* K. Malý	+		K. Malý	K. Malý	04.06.1899	syntypus
306	Rosaceae	*Rosa canina* L. var. *bossiana* K. Malý	+		K. Malý	K. Malý	23.06.1901	syntypus
307	Rosaceae	*Rosa canina* L. var. *husreviana* K. Malý	+		K. Malý	K. Malý	12.06.1900	syntypus
308	Rosaceae	*Rosa dumetorum* Thuill. var. *varbossania* K. Malý	+		K. Malý	K. Malý	05.07.1899	syntypus
309	Rosaceae	*Rosa miljackae* K. Malý (*R. arvensis* x *R. gallica*)	+		K. Malý	K. Malý	08.06.1899	holotypus
310	Rosaceae	*Rosa pendulina* L. var. *adenosepala* Borb. f. *turbinata* K. Malý	+		K. Malý	K. Malý	05.08.1899	holotypus
311	Rosaceae	*Rosa pendulina* L. var. *cadocarpa* G. Beck	+		K. Malý	G. Beck	01.09.1899	holotypus
312	Rosaceae	*Rosa pendulina* L. var. *sarajevensis* K. Malý	+		K. Malý	K. Malý	28.09.1902	holotypus
313	Rosaceae	*Rosa pendulina* L. var. *trebeviciana* K. Malý	+		K. Malý	K. Malý	05.08.1899	holotypus
314	Rosaceae	*Rosa tomentosa* Sm. var *drinensis* K. Malý	+		K. Malý	K. Malý	19.06.1930	holotypus
315	Rosaceae	*Rosa tomentosa* Sm. var. *jajcensis* G. Beck	+		R. Keller	G. Beck	00.00.1896	holotypus
316	Rosaceae	*Rosa tormentella* Lam. var. *murbeckiana* K. Malý	+		K. Malý	K. Malý	29.06.1903	holotypus
317	Rosaceae	*Rubus alterniflorus* M. & Lef.	+		F. Hoffmann	J. Hruby	00.07.1879	holotypus
318	Rosaceae	*Rubus hercegovinicus* Malý & Zahn	+		K. Malý	J. Hruby	04.07.1926	holotypus
319	Rosaceae	*Rubus ulmifolius* Schott. var. *zahnii* Hruby	+		K. Malý	J. Hruby	27.07.1908	holotypus
320	Rosaceae	*Sorbus aria* (L.) Crantz subsp. *umbellata* (Desf.) Hayek var. *illyrica* Plavšić	+		S. Plavšić	S. Plavšić	04.08.1939	holotypus
321	Rosaceae	*Sorbus bosniaca* Hajrudinović, Frajman, Schönsw. & Bogunić	+		A. Hajrudinović & F. Bogunić	A. Hajrudinović & F. Bogunić	09.10.2012	isotypus
322	Rubiaceae	*Asperula aristata* L. fil. subsp. *bosnensis* K. Malý var. *umbrosa* K. Malý		Montenegro	I. Bucalović	K. Malý	07.08.1909	holotypus
323	Rubiaceae	*Asperula aristata* L. fil. var. *bosnensis* K. Malý f. *ibrahimana* K. Malý	+		I. Bucalović	K. Malý	06.08.1909	holotypus
324	Rubiaceae	*Asperula aristata* L. fil. var. *gracilis* K. Malý	+		K. Malý	K. Malý	07.08.1908	holotypus
325	Rubiaceae	*Asperula aristata* L. fil. var. *micrantha* K. Malý	+		I. Bucalović	K. Malý	07.08.1909	holotypus
326	Rubiaceae	*Asperula borbasiana* (Korica) Korica		Croatia	B. Korica	B. Korica	10.09.1973	isotypus
327	Rubiaceae	*Asperula staliana* Vis. subsp. *issaea* Korica		Croatia	B. Korica	B. Korica	11.09.1973	isotypus
328	Rubiaceae	*Asperula visianii* Korica		Croatia	B. Korica	B. Korica	08.10.1976	isotypus
329	Rubiaceae	*Asperula wettsteinii* Adamović	+		L. Adamović	L. Adamović	00.07.1888	holotypus
330	Rubiaceae	*Asperula woloszczakii* Korica		Croatia	B. Korica	B. Korica	24.07.1981	isotypus
331	Rubiaceae	*Galium divaricatum* Lam. var. *asperum* K. Malý	+		K. Malý	K. Malý	24.05.1906	holotypus
332	Rubiaceae	*Galium mollugo* L. subsp. *erectum* (Huds.) var. *illyricum* K. Malý	+		K. Malý	K. Malý	22.07.1935	holotypus
333	Salicaceae	*Populus alba* var. *alba* f. *bosniaca* Janjić	+		N. Janjić	N. Janjić	09.08.1969	holotypus
334	Salicaceae	*Populus alba* var. *alba* f. *ovatifolia* Janjić	+		N. Janjić	N. Janjić	09.08.1969	holotypus

335	Salicaceae	*Populus alba* var. *alba* f. *quiercifolia* Janjić	+		N. Janjić	N. Janjić	22.07.1970	holotypus
336	Salicaceae	*Populus alba* var. *alba* f. *stenophylla* Janjić	+		N. Janjić	N. Janjić	28.06.1970	holotypus
337	Salicaceae	*Populus alba* var. *alba* f. *trevifolia* Janjić	+		N. Janjić	N. Janjić	29.09.1969	holotypus
338	Salicaceae	*Populus* x *canescens* Sm. f. *albostigmata* Janjić	+		N. Janjić	N. Janjić	02.05.1970	holotypus
339	Salicaceae	*Populus canescens* (Ait.) Sm. f. *corticaeformis* Janjić	+		N. Janjić	N. Janjić	05.09.1970	holotypus
340	Salicaceae	*Populus* x *canescens* Sm. f. *cuneifolia* Janjić	+		N. Janjić	N. Janjić	12.09.1970	holotypus
341	Salicaceae	*Populus canescens* (Ait.) Sm. f. *glabra* Janjić	+		N. Janjić	N. Janjić	29.03.1970	holotypus
342	Salicaceae	*Populus* x *neapolitana* Ten. f. *kakanjensis* Janjić	+		N. Janjić	N. Janjić	24.04.1969	holotypus
343	Salicaceae	*Populus nigra* subsp. *caudina* (Ten.) Bugala var. *grandifolia* (Džekov) Janjić f. *pseudocaudina* Janjić	+		N. Janjić	N. Janjić	30.07.1970	isotypus
344	Salicaceae	*Populus nigra* subsp. *caudina* (Ten.) Bugala var. *grandifolia* (Džekov) Janjić f. *pseudocaudina* Janjić	+		N. Janjić	N. Janjić	25.10.1969	isotypus
345	Salicaceae	*Populus* x *pannonica* Kit. f. *ilidshensis* Janjić	+		N. Janjić	N. Janjić	16.09.1970	holotypus
346	Salicaceae	*Populus tremula* L. subsp. *tremula* var. *tremula* f. *grossedentata* Janjić	+		N. Janjić	N. Janjić	22.07.1971	holotypus
347	Salicaceae	*Populus tremula* L. subsp. *tremula* var. *villosa* f. *obovata* Janjić	+		N. Janjić	N. Janjić	09.07.1971	holotypus
348	Salicaceae	*Populus tremula* L. subsp. *tremula* var. *villosa* f. *pseudopentangularis* Janjić	+		N. Janjić	N. Janjić	21.07.1971	holotypus
349	Salicaceae	*Populus tremula* L. var. *tremula* f. *macrophylla* Janjić	+		N. Janjić	N. Janjić	11.05.1970	holotypus
350	Salicaceae	*Populus tremula* L. var. *tremula* f. *petiolaris* Janjić	+		N. Janjić	N. Janjić	21.06.1969	holotypus
351	Salicaceae	*Populus tremula* L. var. *tremula* f. *trebevicensis* Janjić	+		N. Janjić	N. Janjić	28.05.1970	holotypus
352	Salicaceae	*Populus tremula* L. var. *villosa* f. *sentellifolia* Janjić	+		N. Janjić	N. Janjić	24.06.1970	holotypus
353	Salicaceae	*Populus tremula* L. var. *villosa* f. *subintegra* Janjić	+		N. Janjić	N. Janjić	28.05.1970	holotypus
354	Salicaceae	*Populus tremula* L. var. *villosa* f. *subpyramidalis* Janjić	+		N. Janjić	N. Janjić	19.06.1969	holotypus
355	Salicaceae	*Salix cinerea* L. f. *obtusifolia* K. Malý	+		K. Malý	K. Malý	06.06.1897	holotypus
356	Salicaceae	*Salix silesiaca* W. K. var. *bosniaca* G. Beck	+		G. Beck	G. Beck	14.06.1892	topotypus
357	Santalaceae	*Thesium auriculatum* Vand. var. *bosnense* K. Malý	+		K. Malý	K. Malý	08.06.1908	holotypus
358	Sapindaceae	*Acer bornmülleri* Borb. (*A. campestre* x *A. monspessulanum*)	+		J. Bornmüller	V. Borbas	00.06.1886	syntypus
359	Sapindaceae	*Acer bosniacum* K. Malý	+		K. Malý	K. Malý	22.06.1905	holotypus
360	Sapindaceae	*Acer campestre* L. var. *varbossanium* K. Malý	+		K. Malý	K. Malý	15.05.1906	holotypus
361	Sapindaceae	*Acer heldreichii* Orph. subsp. *visianii* (Nym.) K. Malý var. *palense* K. Malý	+		K. Malý	K. Malý	08.06.1913	holotypus
362	Sapindaceae	*Acer hyrcanum* Fisch. & Mayer var. *divaricatum* K. Malý	+		K. Malý	K. Malý	00.09.1908	syntypus
363	Sapindaceae	*Acer hyrcanum* Fisch. & Mayer var. *divaricatum* K. Malý f. *neglectum* K. Malý	+		K. Malý	K. Malý	00.08.1908	holotypus
364	Sapindaceae	*Acer obtusatum* W. K. var. *anomalum* Pax f. *opuloideum* K. Malý	+		K. Malý	K. Malý	03.09.1905	holotypus
365	Saxifragaceae	*Saxifraga blavii* G. Beck	+		O. Blau	G. Beck	31.07.1868	syntypus
366	Saxifragaceae	*Saxifraga prenja* G. Beck	+		G. Beck	G. Beck	00.07.1888	topotypus
367	Scrophulariaceae	*Scrophularia canina* L. var. *tristis* K. Malý	+		K. Malý	K. Malý	08.06.1908	holotypus
368	Scrophulariaceae	*Scrophularia scopolii* Hoppe var. *kindtii* K. Malý	+		K. Malý	K. Malý	13.05.1906	syntypus
369	Scrophulariaceae	*Verbascum abietinum* x *thapsus*	+		K. Malý	K. Malý	08.09.1935	holotypus
370	Scrophulariaceae	*Verbascum bosnense* K. Malý	+		K. Malý	K. Malý	13.05.1908	holotypus

371	Tiliaceae	*Tilia platyphyllos* Scop. var. *illyrica* K. Malý	+		K. Malý	K. Malý	27.07.1918	holotypus
372	Tiliaceae	*Tilia travnicensis* K. Malý	+		K. Malý	K. Malý	10.09.1905	holotypus
373	Ulmaceae	*Ulmus glabra* Huds. var. *montana* (Stokes) Lindq. f. *denndata* Janjić	+		N. Janjić	N. Janjić	25.07.1970	holotypus
374	Ulmaceae	*Ulmus minor* subsp. *minor* var. *elongata* Janjić	+		N. Janjić	N. Janjić	25.08.1968	holotypus
375	Ulmaceae	*Ulmus minor* subsp. *minor* var. *juglandifolia* Janjić	+		N. Janjić	N. Janjić	24.08.1968	holotypus
376	Ulmaceae	*Ulmus minor* subsp. *minor* var. *salicifolia* Janjić	+		N. Janjić	N. Janjić	14.07.1967	holotypus
377	Ulmaceae	*Ulmus minor* subsp. *tortuosa* var. *narentana* Janjić f. *narentana*	+		N. Janjić	N. Janjić	09.09.1973	holotypus
378	Ulmaceae	*Ulmus minor* subsp. *tortuosa* var. *narentana* Janjić f. *urophylla* Janjić	+		N. Janjić	N. Janjić	03.08.1971	holotypus
379	Ulmaceae	*Ulmus minor* subsp. *tortuosa* var. *pilifera* (Borb.) Janjić	+		N. Janjić	N. Janjić	31.08.1969	neotypus
380	Ulmaceae	*Ulmus minor* subsp. *tortuosa* var. *pilifera* f. *rotundifolia* Janjić	+		N. Janjić	N. Janjić	23.10.1969	holotypus
381	Ulmaceae	*Ulmus minor* subsp. *tortuosa* var. *tortuosa* f. *excelsa* Janjić	+		N. Janjić	N. Janjić	15.09.1968	holotypus
382	Viburnaceae	*Viburnum lantana* L. var. *naronitanum* K. Malý	+		K. Malý	K. Malý	09.08.1922	holotypus
383	Violaceae	*Viola beckiana* Fiala	+		W. Friedrich Fritz	F. Fiala	17.05.1895	holotypus

Index florae Bosnae et Hercegovinae (Part 6)

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INTRODUCTION

The five parts of the *Index Florae Bosnae et Hercegovinae* published in the Herald of the National Museum of Bosnia and Herzegovina to date have included several families of flowering plants (Angiospermae). In the first part, the Fabaceae family was covered by Prof. Dr. Ljubomir Mišić, who listed 51 genera, 260 species and 74 subspecies (Mišić & Šoljan, 2014). The second part of the Index, compiled by Dr. Željka Bjelčić, covered the Brassicaceae family, with 53 genera, 171 species and 44 subspecies (Bjelčić & Šoljan, 2015). The third part of the Index presented the Lamiaceae family, elaborated by Dr. Čedomil Šilić, who listed 30 genera, 124 species, 58 subspecies and 8 hybrids (Šilić & Šoljan, 2018). In the fourth part, the Poaceae family was documented by Nermina Sarajlić, MSc, who listed 97 genera, 312 species and 48 subspecies (Sarajlić & Šoljan, 2020). The fifth part of the Index, by Lijerka Kutleša, MSc & Prof. Dr. Edina Muratović, presented two families, Violaceae and Liliaceae, with 28 species and 10 subspecies listed as belonging only to one genera, *Viola*, in the family Violaceae, and 6 genera, 20 species and 3 subspecies belonging to the family Liliaceae (Kutleša et al., 2022).

The sixth part of *Index Florae Bosnae et Hercegovinae* presents the family Rhamnaceae. In this family, Dr. Če-

domil Šilić & Prof. Dr. Nedžad Bašić list 5 genera, 11 species, 2 nothospecies and 4 subspecies.

Part 6 of the Index, as with the previous parts, provides the following details for each taxon:

- botanical name of the genus, authority, and common name(s) in local languages and English
- botanical name of the taxa, authority, and first publication
- synonyms, where applicable
- the nomenclature according to the Euro+MedPlantBase (Euro+Med, 2006-)
- conservation status at the EU biogeographical level as indicated by the IUCN Red List (IUCN, 2019) and within Bosnia and Herzegovina using the Red List of Vascular Flora for the Federation of B&H (Đug et al., 2013) and Republika Srpska (Crvena lista zaštićenih vrsta flore i faune Republike Srpske – Lista vaskularne flore, 2018)
- within the family, the genera and the species within each genus are listed alphabetically

Citation:
Šilić, Č. & Bašić, N. (2023) Rhamnaceae. Index Florae Bosnae et Hercegovinae, Part 6. In Šoljan, D. (ed.).

INDEX PART 6:

RHAMNACEAE JUSS., GEN. PL.: 376. 1789.

***CEANOTHUS* L.**, SP. PL. 195. 1753.
(CALIFORNIAN LILIAC)

cult. × ***delilianus* Spach.** – unresolved status, Hist. Nat. Vég. 2: 459. 1834.

cult. × ***pallidus* Lindl.** – unresolved status, Edwards's Bot. Reg. 26.: t. 20. 1840.

***FRANGULA* MILL.**, GARD. DICT. ABR., ED. 4. 1754. – **T R U Š LJ I K A, P A S J E L I J E S K E (ALDER BUCKTHORNS)**

(LC1) ***alnus* Mill.**, Gard. Dict. ed., 8: Frangula no. 1. 1768. (= *Rhamnus frangula* L., *Frangula nigra* Samp., nom. illeg., *F. vulgaris* Hill, nom. inval.)

(LC1) ***rupestris* (Scop.) Schur**, Enum. Pl. Transsilv.: 142. 1866. (= *Rhamnus rupestris* Scop., *Rh. albanica* Pènzes, *Rh. nicolae* Simonk., *Rh. wulfenii* Reichenb.)

***PALIURUS* MILL.**, GARD. DICT. ABR., ED. 4. 1754. (= *AUBLETIA* LOUR.) – **D R A Č, D R A Č A, D I R A K A, Č A L I J**

***spina-christi* Mill.**, Gard. Dict. ed. 8: Paliurus no. 1. 1768. (= *Rhamnus paliurus* L., *Paliurus trinervatus* Moench, nom. illeg., *P. australis* Geartn., nom. ileg., *P. aculeatus* Lam., nom. illeg., *P. microcarpus* Wilmontt)

***RHAMNUS* L.**, SP. PL.: 193. 1753. (= *OREOHERZOGIA* W. VENT.) – **P A S D R I J E N, P A S J A K O V I N A, K R K A V I N A, LJ I G O V I N A (BUCKTHORNS)**

(LC1) ***alaternus* L.**, Sp. Pl.: 193. 1753. (= *Alaternus glabrus* Mill., *Rhamnus clusii* Willd., *Rh. alaternus* subsp. *munyozgarmendiae* Rivas Mart. & J. M. Pizarro)

(LC1) ***alpina* L.**, Sp. Pl.: 193. 1753. (= *Alaternus alpinus* (L.) Moench, *Frangula latifolia* Mill., *Oreoherzogia alpina* (L.) W. Vent., *Rhamnus kabylica* (Maire) Grubov)

subsp. ***fallax* (Boiss.) Maire&Petitm.**, Bull. Soc. Sci. Nancy, ser. 3, 9: 208. 1908. (= *Oreoherzogia fallax* (Boiss.) W. Vent., *O. fallax* subsp. *liburnia* W. Vent., *Rhamnus fallax* Boiss., *Rh. carniolicus* Kerner, *Rh. glaberrima* Post)

(LC1) ***catharctica* L.,** Sp. Pl.: 193. 1753. (= *Rhamnus hydriensis* Hacq., *Rh. spinosa* Gilibert)

(EN2) ***illyrica* Griseb. apud Pantocsek,** Adnot. u. Verh., Ver. für Naturk. Pressburg, Noe Folge 2: 110-111 1874.(= *Rhamnus orbiculata* Bornm.)

(LC1, EN2) ***intermedia* Steud. & Hochst.**, Flora 10: 74. 1827. (= *Rhamnus adriatica* Jord., *Rh. infectorius* Vis., *Rh. prunifolius* G. Beck, non Sibht. & Sm.)

***pumila* Turra**, Giorn. Italia Sci. Nat. 1: 120. 1765. (= *Oreoherzogia pumila* (Turra) W. Vent., *O. legionensis* (Rothm.) W. Vent, *O. pumila* subsp. *hispanica* W. Vent, *O. pumila* subp. *velutina* (Bornm.) W. Vent, *Rhamnus pumila* subsp. *legionensis* (Turra) Rothm.)

(EN2) subsp. ***illyrica* Č. Šilić, stat. nov.** (= *Oreoherzogia pumila* subsp. *illyrica* Č. Šilić) TYPUS: Herzegovina: Rakitnica canyon, approx. 600 m AMSL, Bosnia and Herzegovina: leg. Č. Šilić & Đ. Đuran, no. HOLOTYPUS: SARA, ISOTYPUS: SARA, LJU

***saxatilis* Jacq.**, Enum. Stirp. Vindob.: 39. 1762. (= *Rhamnus saxatilis* subsp. *villarsi* (Jord.) P. Forun., *Rh. villarsii* Jord.)

subsp. ***saxatilis* Jacq.**

subsp. ***tinctoria* Niman.**, Consp. Fl. Eur.: 146. 1878. (*Rhamnus tinctoria* Waldst. &Kit., *Rh. baphicocca* Rothm.)

ZIZIPHUS MILL., GARD, DICT. ABR. ED. 4. 1754. – **Č I Č I M A K, Č I Č I N D R A (JUJUBE)**

cult. ***jujuba* Mill.**, Gard, Dict., ed. 8: Zizyphus no. 1. 1768, nom. cons. (= *Rhamnus zizyphus* L., *Ziziphus officinarum* Medik., nom. ileg., *Z. sativa* Gaertn., nom. ileg., *Z. vulgaris* Lam., nom. ileg., *Z. zizyphus* (L.) H. Karst., nom. rej.)

ABBREVIATIONS AND SYMBOLS

(cult.) – cultivated
(EN) – endangered
(LC) – least concern

[1]Conservation status at the EU biogeographical level (IUCN, 2023)

[2]Conservation status within Bosnia and Herzegovina according to the Red List of Vascular Flora for the Federation of B&H (Đug et al., 2013) and Republika Srpska (Crvena lista zaštićenih vrsta flore i faune Republike Srpske – Lista vaskularne flore, 2018).

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Synecology of the European common spadefoot toad, *Pelobates fuscus* (Laurenti, 1768) (Amphibia: Anura: Pelobatidae), in agroecosystems of Bosnia and Herzegovina

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Abstract: The European common spadefoot toad (***Pelobates fuscus***) is a lowland, semi-fossorial and secretive anuran species with a narrow ecological niche. The southernmost border of its habitat reaches the northern parts of Bosnia and Herzegovina (Posavina region), where the species has lost the vast majority of its natural habitat, resulting in it being restricted to agroecosystems close to aquatic habitats. This paper describes the ecology of ***P. fuscus*** in such habitats – and generally in Bosnia and Herzegovina – for the first time. Two types of independent research were performed: (1) assessment of population density and microhabitat preferences along with habitat quality analysis (performed in three localities) and (2) a food preferences study and morphometry in one locality (Čardak, Modriča), where the largest known population of ***Pelobates fuscus*** in Bosnia and Herzegovina resides.

Key Words: fossorial, Posavina, agriculture, ecology, population, density, microhabitat, morphometry, sex ratio, diet

INTRODUCTION

The European common spadefoot toad – *Pelobates fuscus* (Laurenti, 1768), is a semi-fossorial and nocturnal anuran species, which inhabits lowlands areas and hilly regions of the central, eastern and south-eastern parts of Europe. The vertical distribution of the species goes from 0 to 800 m AMSL (Speybroeck et al., 2016). Typical natural habitats of *P. fuscus* are dunes, open forests, heathlands, river valleys and steppes (Rot-Nikčević et al., 2001; Speybroeck et al., 2016). However, they can be found in anthropogenic habitats (such as agricultural areas) in low population densities (Bosman, 2005; Bosman & van den Munckhof, 2006). Due to their secretive behaviour and low abundance, the knowledge on the species's ecology is scarce. It is a highly specialized toad, and occupies a narrow ecological niche (Džukić et al., 2008; Cogălniceanu et al., 2013), mostly confined to flat and open areas with loose soil (Speybroeck et al., 2016). *Pelobates fuscus* selects breeding habitats based on characteristics of the terrestrial and aquatic environment (Rannap et al., 2011). Aquatic habitats are used only during the mating period; however, individuals always live very close to water, and they appear to be poor migrants (Eggert, 2002). *Pelobates fuscus* is an opportunistic predator, feeding on the most abundant trophic resources available in their environment (Juszczyk, 1974; Medvedev, 1974; Sczerbak & Sczerban, 1980; Kuzmin, 1995; Cogălniceanu et al., 1998, Tarkhnishvili & Gokhelashvili, 1999; Covaciu-Marcov et al., 2010; Alekseev & Korzikov, 2013).

The southernmost border of the spadefoot toad's distribution is the area of the northern Balkan Peninsula. More precisely, the floodplains of the Sava River [natural border between Bosnia and Herzegovina (hereinafter: B&H) and Croatia], known as the Posavina region, represent the south-western border of the species's distribution (Agasyan et al., 2009; Ćurić et al., 2018; Dufresnes et al., 2019a,b). In the Balkans, *P. fuscus* is quite rare, and its populations are fragmented due to the presence of mountain ranges (Dinarides, Carpathians, Balkan), which represent natural barriers (Džukić et al., 2005; Ćurić et al., 2018; Dufresnes et al., 2019a,b). Within the species range, populations are further fragmented due to intensive agricultural activities (Ćurić et al., 2018). According to IUCN (International Union for Conservation of Nature) criteria, *P. fuscus* is considered Data Deficient in Serbia (Ljubisavljević & Džukić, 2015) and Croatia (Jelić et al., 2012) and Not Evaluated in B&H, due to its recent discovery (Ćurić et al., 2018).

The aim of this study is to provide basic information on the biology and ecology of these populations in B&H: population density, habitat and microhabitat preferences, sex ratio, sexual size dimorphism and food preferences.

MATERIAL AND METHODS

Study area. The study was carried out from 7 to 14 May 2016 in Posavina region (Pannonian part) of Bosnia and Herzegovina. We selected three different agricultural sites (monocultures of corn, wheat and sunflower) close to three different types of aquatic habitats: (1) eutrophicated pond in Čardak, Modriča (44.956271° 18.404087°; 96 m AMSL), (2) hypereutrophicated pond in Okanovići, Gradačac (44.930588° 18.405854°; 98 m AMSL) and (3) flood forest (vegetation communities: *Salicetum cinereae, Alnetum glutiosae, Alno-Quercion roboris*) in Gromiželj, Bijeljina (44.866651° 19.309240°; 80 m AMSL) (Fig. 1). All aquatic habitats belong to the vegetation of *Caricetum ripariae*, while Gromiželj has additional *Alnetum glutiosae* and *Alno-Quercion roboris*. Farmers change the type of monoculture on these agricultural sites every year (mainly corn and wheat).

Each field research was conducted during the evening and night from 21:00 to 01:00. Only adult individuals (body length >33mm) were taken into consideration for the purposes of this study. Two types of independent research were done: (1) assessment of population density and microhabitat preferences along with habitat quality analysis (performed in all three localities); and (2) study of food preferences and morphometry (performed in only one locality: Čardak) (Fig. 1).

Population density assessment. We used linear transects, counting the number of individuals found along transects. For each individual/cluster of animals, we estimated its perpendicular distance from the transect line (in cm). The cluster size was annotated along the transects. A total of 50 randomly selected transects (each 25 m length, with an overview of 10 metres both to the right and left) were carried out independently for each of the three sites: Čardak (number of transects (n) = 15; 375 m), Okanovići (n = 20; 500 m) and Gromiželj (n = 15; 375 m). We pooled the data within each locality as if it were one continuous transect, according to the instructions provided by Sutherland (2006) and the DISTANCE 6.0 manual. In this way, the analysis increased the possibility of recording an individual in any part of transect without any impact on the accuracy of the overall assessment. Population density analyses were performed using the Distance software (version 6). We used the suggested *Model 1*, the classic "*single observer*" option and "*cluster data*" without multiplication coefficient.

Additionally, we chose a 1km^2 area that had a body of water within it for each locality, and divided it into small squares, size 25x25m using the software QGIS 2.12.3. We searched a total of 97 randomly chosen squares (26 in Čardak, 29 in Okanovići and 42 in Gromiželj), in which we counted *P. fuscus* and other anuran species, logging the localities using a Garmin GPSMAP 64s. We calculated mean values of

Figure 1. Positions of investigated localities: (1) Čardak, (2) Okanovići and (3) Gromiželj; approximate distribution border of ***Pelobates fuscus*** is given according to: Ćurić et al. (2018)

individuals for each anuran species, to determine the most abundant species in the arable ecosystems (Fig. 2).

quality of the aquatic habitat. The state of the aquatic habitat suitable for the reproduction of *P. fuscus* was assessed using eight parameters (modified from Rannap et al., 2011). Lower values of the parameters indicate minor threat, while higher values indicate a higher threat or risk. The parameters that were used were: (1) number of fish species (sp.): (0 – no sp., 1 – one sp., 2 – two sp. and 3 – three or more sp.), (2) water body origin (0 – natural or 1 – artificial), (3) oxygen level (0 – high, 1 – medium, 2 – low, 3 – very low), (4) size (volume) of aquatic habitat (0 – big, 1 – small, 2 – very small), (5) depth of littoral zone (0 – shallow or 1 – deep), (6) forest presence around water bodies (0 – no forest, 1 – forest leftovers, 2 – large forest areas and 3 – huge forest areas), (7) the presence of open landscapes around water bodies (0 – yes, 1 – no) and (8) amphibian diversity in water bodies (number of other breeding species: 0 – five or more sp., 1 – four or three sp., 2 – two or fewer sp.) Scores for each parameter were estimated on the basis of personal experience. The overall index of habitat quality for each locality was determined as the sum of the scores of all variables divided by the total number of variables (mean). The lower the index, the higher the quality of the habitat.

Microhabitat preferences. At the start of each field research, we recorded air temperature and relative humidity 5 cm above the ground using a hand-held data logger (Kestrel 4000 Weather Meter). Soil temperature was recorded using a PCE-IR 100 thermometer (Figs. 3-5). For every individual found we recorded the microhabitat at its exact location: arable land (bare, overgrown (10-30 cm) or densely overgrown (>30 cm), meadow (<5 cm or densely overgrown), road, macadam, gravel, forest edge and other (Fig. 6).

Morphometry. This study was conducted at the Čardak locality. We collected the following data from each captured toad: (1) sex (detecting presence or absence of oval glands on upper front limbs), (2) snout-to-vent length (hereinafter: SVL) and (3) head width at the ends of the mouth (hereinafter: HW) with a digital calliper and (4) body weight (hereinafter: W) with electronic pocket scale (model: Camry EHA901 with 0.01g precision). Sexual dimorphism was tested by means of a t-test or the Wilcoxon test if the distribution of the data was not normal. Morphometric measurements were carried out on a sample of 121 individuals (63 females and 58 males) (Tab. 3). To eliminate the possibility of measurements being taken from the same individual in subsequent field visits, each toad was photographed from the dorsal side, with these photographs being examined later. A study of the photographs indicated that no individual was measured on two occasions.

ANALYSIS OF FOOD PREFERENCES. We flushed the stomachs of 124 individuals from the Čardak locality, following the instructions provided by Solé et al. (2005). The animals were released afterwards. Stomach flushes were stored in 1.5ml tubes with 10% formaldehyde and studied in the laboratory using a binocular magnifier according to Clessin (1877), Chinery (1986) and Stresemann (2011).

RESULTS

Population densities. We recorded 102 individuals along a total length of 1225m of linear transects. The total area analysed across all three localities was 6000 m^2 (0.6ha). For each locality, we obtained the following population densities: (1) 703 individuals per hectare of habitat in Čardak (95% confidence interval: min. 491 – max. 1006), (2) 191 individuals per hectare of habitat in Okanovići (min. 111 – max. 326) and (3) 309 individuals per hectare of habitat in Gromiželj (min. 194 – max. 491) (Tab. 1).

Registered anuran species for each locality were: *Bombina bombina, Hyla arborea, Rana dalmatina* and *Pelophylax* complex species (most likely *ridibundus-esculentus* system). Čardak additionally includes the anuran species *Bufo bufo*, and Gromiželj *Bufotes viridis*. On all three localities *P. fuscus* was the most numerous amphibian species along the transect (Fig. 2).

Habitat quality. Parameters for estimation of habitat quality showed that the Čardak locality possesses a habitat that is in excellent condition, and significantly better than the other two (with an index of 0.5 compared to values of 0.7 and 0.9) (Tab. 2).

Microhabitat preferences. In a sample of 137 individuals, we recorded the highest number of the individuals at an air temperature between 15°C and 18°C (Fig. 3) and at a humidity ranging from 60% to 80% (Fig. 4). From a sample of 111 individuals, most were caught at soil temperatures between 11°C and 13°C (Fig. 5). The majority of *P. fuscus* individuals were found in open areas, such as bare arable land and meadows (Fig. 6).

Sex ratio and morphometry. The sex ratio at the Čardak locality was 1:1. The first sample (from 1 to 5 May 2017), consisting of 121 individuals, had 58 males (48%) and 63 females (52%). The second sample (from 10 to 14 May 2017) consisted of 72 individuals, of which35 were males (49%) and 37 were females (51%).

Table 1. Population densities in the three localities: **P** – total area, **nt** – number of transects, **Td** – total length of transects, **N** – estimated number of individuals per total area (min – max: 95% confidence interval), **G** – density of individual per m^2, **p** – the probability of finding one individual along 25m of transect

Locality	P (m^2)	n_t	Td (m)	N (individual/P)	N (min - max)	G (individual/m^2)	p (%)
1. Čardak	1500	20	500	5	4 - 8	0.0703	0.55525
2. Okanovići	2250	15	375	3	2 - 5	0.0191	0.27692
3. Gromiželj	2250	15	375	5	3 - 7	0.0309	0.49966

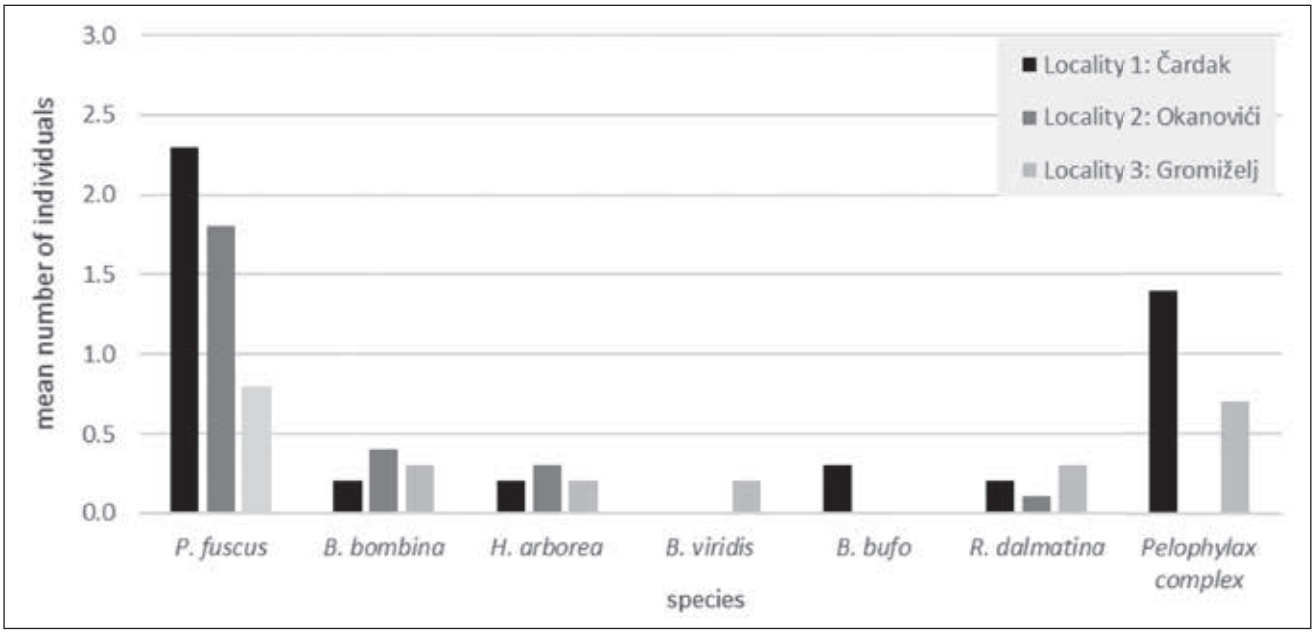
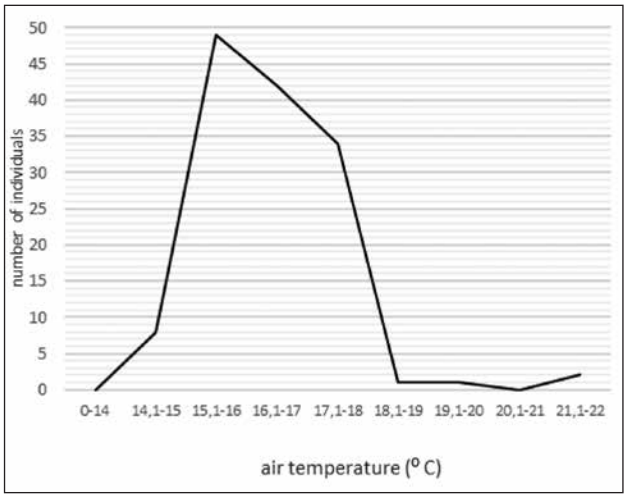
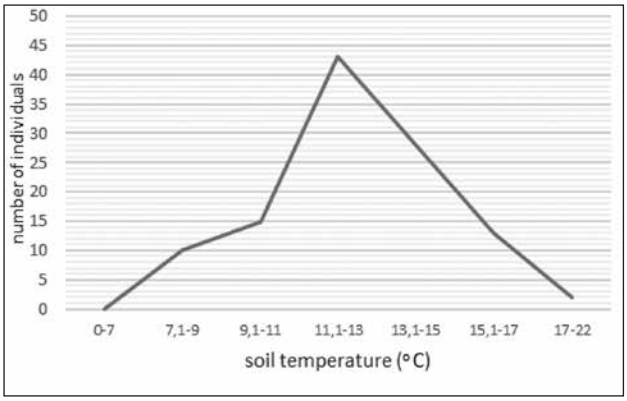


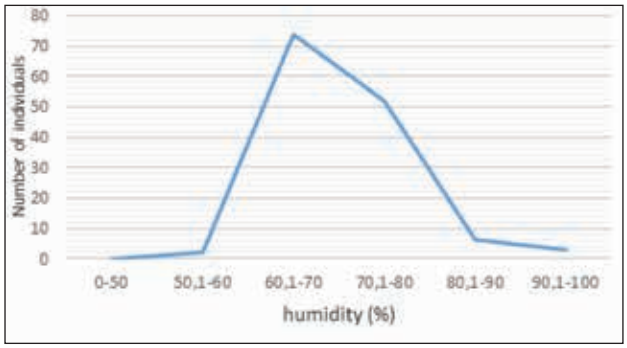
Figure 2. Mean values of individuals in 25x25m quadrat samples at three sites for each anuran species

Table 2. Characteristics of aquatic habitats of *P. fuscus* at the observed localities

Characteristics of aquatic habitats		1. Čardak	2. Okanovići	3. Gromiželj
1.	Presence of fish	0	0	3
2.	Water quality/presence of wastewater	2	3	0
3.	Water body permanence	0	0	0
4.	Size of the water body/eutrophication level	0	3	0
5.	Depth of littoral zone	0	0	1
6.	Presence of woodland	0	1	2
7.	Presence of roads/traffic	3	0	0
8.	Presence of open land	0	0	0
9.	Number of other breeding species	0	1	0
Habitat quality index:		0.5	0.9	0.7







Figures 3-5. Activity of *P. fuscus* individuals based on the abiotic parameters of: air temperature (3), soil temperature (4), and relative humidity (5)

The body weight and length differed significantly between males and females, in contrast to head width of measured individuals (Tab. 3).

Food composition. From the sample of 124 individuals, 64 (51%) had empty stomachs or non-animal content inside. Non-biological material found inside the stomach compromised: stones and soil in 16 individuals (17%), and vegetation remains in 22 individuals (20%). Regarding the plant material, in two samples we found the remains of *Fraxinus* sp. seed, while one sample had algae, from the following taxa: *Oedogonium* sp., *Epithemia adnate*, *Rhopalodia* sp., *Euastrum* sp. and *Scenedesmus* sp. present. A total of 60 individuals (49%) had faunal remains within their stomach contents.

All of the prey items were invertebrates. Representatives of three phyla were identified: (1) Arthropoda with 164 individuals, representing 80% of the sample, (2) Mollusca with 29 individuals, or 14%, and (3) Annelida with 9 individuals, or 5% of the sample. Only 1% of the materials remained unidentified. The most numerous taxa within the phylum Arthropoda were members of the class Insecta (47% of total) and Diplopoda (46% of total).

DISCUSSION

According to the transect method, the number of individuals of *P. fuscus* is highest in the Čardak locality (703 individuals), followed by Gromiželj (309 individuals) and lowest at Okanovići (191 individuals). These results are predominantly related to the condition of the aquatic habitat, with Čardak having the best habitat quality, followed by Gromiželj and then Okanovići. The habitat at Okanovići is hyper-eutrophic with desiccation most likely occuring during the early summer. Gromiželj differs significantly, because it has a naturally clean water source, while the water quality at the other two localities (Čardak and Okanovići) is very low, mainly due to

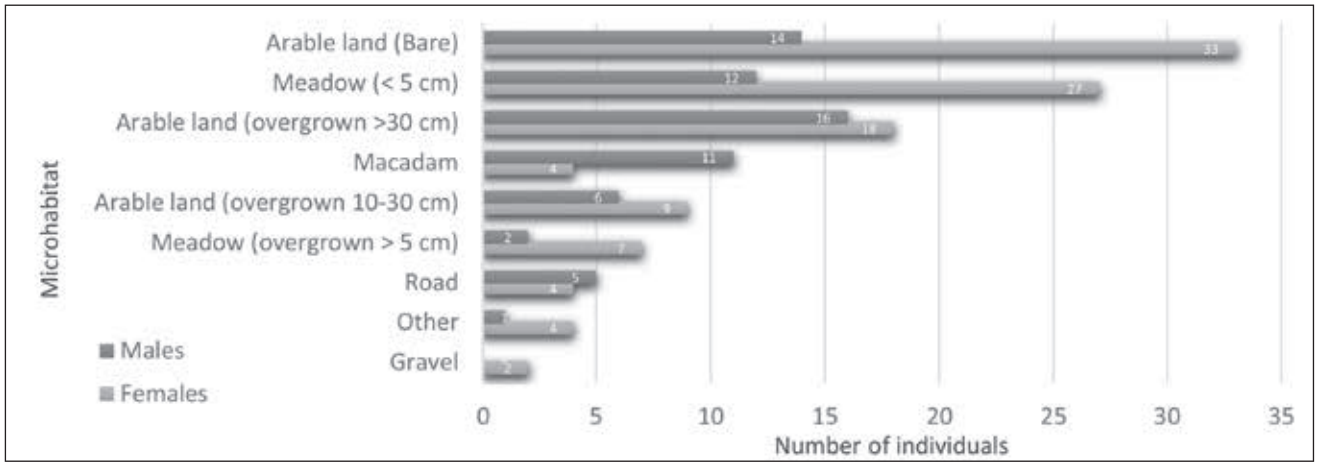


Figure 6. Microhabitat preferences of *P. fuscus* summarized for three sites in Bosnia and Herzegovina

Table 3. Comparative analysis of morphological traits of *P. fuscus* (**t** – t value, **w** – Wilcoxon value, **p** – p value); Number of individuals: 58 ♂ and 63 ♀; **t** – t test, (**w**) – Wilcoxon test; *bootstrap value 9999x

Morphometric Characteristic					t (w)	p
SVL (mm)						
MIN-MAX		MEDIAN	MEAN	CONFIDENCE INTERVAL (95%)		
♂	34.85-56.45	45.48	45.59	44.38-46.8	3.20	0.001
♀	38.43-56.45	45.48	45.59	47.18-49.7		
*HW (mm)					(1289)	0.042
♂	10.39-27.05	17.16	17.34	16.87-17.86		
♀	10.60-21.51	18.02	18.04	17.61-18.65		
W (g)					3.39	0.001
♂	6.68-20.32	11.08	12.04	10.70-12.46		
♀	6.24-34.28	13.72	15.39	12.74-15.74		

the direct impact of wastewater. Gromiželj is also a habitat for at least two fish species: the northern pike (*Esox lucius* Linnaeus, 1758) and the European mudminnow (*Umbra krameri* Walbaum, 1792). True forest habitats were present around the water ecosystem in Gromiželj, while the other two sites have open landscapes surrounding the aquatic habitats. However, the Čardak locality has a road running along one side of the habitat, where a lot of dead on road (DOR) individuals were found (Tab. 4).

The registered population of Čardak is somewhat larger than expected, considering that this is a population inhabiting an agroecosystem; population densities in such habitats are expected to be lower, as evidenced by the studies of Bosman (2005) and Bosman & van den Munckhof (2006). In these studies, a very low number of common spadefoot toads (88 specimens in their reproductive phase at two sites) was found during intensive field research in an agricultural area called "Groot Soerel", Netherlands. The same authors suggest that stable populations of *P. fuscus* would arguably be twice as large. Rannap et al. (2012) suggest that an effective population size must have at least 500 adult individuals. Population densities of *P. fuscus* can be very high in suitable habitats, where the population density can reach 4-5 specimens per square metre (AmphibiaWeb, 2008). Spadefoot toad populations are known to suffer strong fluctuations in population size, mainly due to interannual variation of the number of metamorphs (Eggert & Guyetant, 2002 and references therein).

Table 4. Stomach contents and taxonomic composition of the diet of ***P. fuscus***, showing total numbers and percentages of different taxa that were found in the stomach; **A** – Percentage abundance; **f** - Frequency of occurrence is given by both the sum of empty and full stomach contents (124 individuals), and only full stomach contents (60 individuals)

Prey taxa	Stomach content			A (%)	f (%) from 60 stomach	f (%) from 124 stomach
	♂	♀	Total			
Annelida/Lumbricidae	5	4	9	4.3	15	7.2
Gastropoda (slugs)	13	14	27	12.8	45	21.8
Gastropoda (snails)	1	1	2	0.9	3.3	1.6
Araneae/Trachelidae	-	1	1	0.5	1.6	0.8
Araneae undet.	4	3	7	3.3	11.6	5.6
Lithobiomopha/Lithobiidae	-	1	1	0.5	1.6	0.8
Diplopoda total	**53**	**22**	**75**	**35.5**	**124.9**	**60.5**
Diplopoda/Julida	48	17	65	30.9	108.3	52.4
Diplopoda/Glomerida	4	4	8	3.8	13.3	6.5
Diplopoda/Polydesmida	1	1	2	0.9	3.3	1.6
Lepidoptera, [i]	-	2	2	0.9	3.3	1.6
Lepidoptera, [l]	1	3	4	1.9	6.6	3.2
Coleoptera total	**21**	**28**	**55**	**26.1**	**91.6**	**44.3**
Coleoptera/Elateridae [i]	8	13	21	9.9	35	16.9
Coleoptera/Carabidae [i]	6	5	15	7.1	25	12.1
Coleoptera/Curculionidae [i]	-	1	1	0.5	1.6	0.8
Coleoptera/Dytiscidae [l,a]	-	1	1	0.5	1.6	0.8
Coleoptera undet. [i]	6	7	15	7.1	25	12.1
Coleoptera undet. [l]	1	1	2	0.9	3.3	1.6
Blattoidea	-	3	3	1.4	5	2.4
Hymenoptera/Formicidae [i]	2	8	10	4.7	16.6	8.1
Heteroptera/Cydnidae [i]	1	-	1	0.5	1.6	0.8
Heteroptera undet. [i]	-	1	1	0.5	1.6	0.8
Diptera/Tipulidae [i,f]	-	1	1	0.5	1.6	0.8
Diptera undet. [l]	-	1	1	0.5	1.6	0.8
Orhtoptera/Gryllidae	1	7	8	3.8	13.3	6.4
Hemiptera/Aphididae	-	1	1	0.5	1.6	0.8
Animalia undet.	1	1	2	0.9	3.3	1.6
Total of prey individuals	**103**	**102**	**211**			

l – larvae, i – imago, a – aquatic taxon, f – flying taxon

The results of this study clearly show that *P. fuscus* prefers arable lands, with a majority of individuals being found on bare cultivable surfaces during spring. Although the presence of individuals on densely covered cultivated surfaces is probably high, the finding of individuals in such a habitat type is hindered by visual limitations. Arable land allows easy digging, providing hiding places; additionally, monoculture plant species that are grown upon such land (wheat, corn and sunflower) represent good shelter from predators.

The optimal sex ratio at the Čardak locality corresponds to the maximum effective population size (close to total population size) and suggests a minimal impact of genetic drift and inbreeding effects (Cavalli-Sforza & Bodmer, 1971). The sex ratio can vary significantly between *P. fuscus* populations, ranging from 1:1 to 3:1 in favour of males (Jehle et al.,

1995; Eggert & Guyétant 2003). Females occasionally refrain from mating in some years, while males routinely come to reproductive habitats to attempt to mate (Jehle et al., 1995).

The results indicate that the weight and SVL measures are significant characteristics for explaining sexual dimorphism, while the head width does not differ significantly between males and females (Tab. 3). These results were to be expected, due to the fact that other studies also emphasize that females of *P. fuscus* are significantly larger than males (e.g. Rot-Nikčević et al., 2001). A larger female body size is applicable to 90% of anuran species, and is believed that this is due to the effects of the fecundity advantage hypothesis (Shine, 1979), whereby larger females produce more offspring and have greater energy storage for reproduction (Ha & Fu, 2013 and references therein).

The presence of stones, soil and vegetation in the diet suggests that *P. fuscus* often fails to catch prey, and/or these materials are accidentally ingested together with the prey that they eat. Non-biological components and vegetation residuals are common in the diet of amphibians (e.g. Garcia-R et al., 2013). The dietary analysis confirms that *P. fuscus* is a generalist, and shows very little specialization in prey choice. Published data on the diet of *P. fuscus* supports the given hypothesis: the diet varies significantly between observed populations (Juszczyk, 1974; Medvedev, 1974; Sczerbak & Sczerban, 1980; Kuzmin, 1995; Cogălniceanu et al., 1998; Tarkhnishvili & Gokhelashvili, 1999; Covaciu-Marcov et al., 2010; Alekseev & Korzikov, 2013). However, the dietary analysis of the populations studied here is of interest for two reasons: Abundance and frequency of prey species belonging to the class Diplopoda are highest (Tab. 4), which is unusual as it is known that they secrete toxic compounds such as alkaloids, phenols, hydrogen cyanide, terpenoids and benzoquinone (Blum & Woodring, 1962; Kuwahara et al., 2002). The second most frequent are representatives of the families Cydnidae (Heteroptera) and Elateridae (Coleoptera), known to be serious agricultural pests (King & Saunders, 1984; Parker & Howard, 2001; Vernon et al., 2008), which are difficult to combat/control, even with insecticides (Doane et al., 1975; van Herk & Vernon, 2007; van Herk et al., 2008). Since Elateridae (Coleoptera) seems to have no natural predators (Berry, 1997), *P. fuscus* may prove to be a very effective predator that can be used in integrated pest management (IPM) programs through the introduction and development of small aquatic ecosystems for *P. fuscus* in places where it is needed.

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SAŽETAK

Žaba češnjarka (***Pelobates fuscus***) predstavlja tajnovitu vrstu sa uskom ekološkom nišom koja naseljava nizijska područja te većinu svog vremena provodi ukopana u tlo. Najjužnija granica ukupnog areala vrste doseže sjeverne dijelove Bosne i Hercegovine (regija Posavine), gdje je vrsta uglavnom izgubila svoja prirodna staništa uslijed intenzivnih poljoprivrednih aktivnosti, te je njen areal ograničen na poljoprivredna područja u blizini odgovarajućih vodenih staništa. Provedene su dvije vrste neovisnih istraživanja: (1) procjena veličine populacije i preferencija mikrostaništa zajedno s analizom kvalitete akvatičnih staništa (izvedena na tri lokaliteta: Čardak, Okanovići i Gromiželj), te (2) preferencije u ishrani i morfometrija na jednom lokalitetu (Čardak). Na osnovu (1) broja pronađenih jedinki, (2) uticaja ribljih vrsta, (3) prisustva muljevitog dna, (4) prisustva široke zone plitke vode, (4) nepostojanja šume i (5) prisustva otvorenih pejzaža (obradivih površina) oko vodenog tijela, stanište na lokalitetu Čardak spada u najbolje stanište za vrstu ***Pelobates fuscus*** u Bosni i Hercegovini, u odnosu na ostala dva istraživana lokaliteta. Najveću aktivnost (optimum ekoloških faktora) žabe češnjarke su pokazale na: temperaturi između 15 °C i 18 °C, s vlažnošću od 60% do 80%, i temperaturi tla između 11 °C i 13 °C. Analize mikrostanišnih preferencija ukazale su na to da češnjarke najviše preferiraju obradive površine (zbog fosorijalnog načina života), nakon čega slijede fragmenti livadskih ekosistema koji su vrlo rijetki na području Bosanske Posavine. Češnjarka je prema literaturnim podacima i poznatom rasprostranjenju najrjeđa vrsta bezrepatih vodozemaca u Bosni i Hercegovini, ali gotovo najčešća vrsta na mjestima u kojima obitava. Iako dijeli stanište sa polovinom ukupnog broja vodozemaca u Bosni i Hercegovini, zastupljena je sa relativnom zastupljenošću od 23% do 68% u zavisnosti od posmatranih lokaliteta. Odnos spolova u populacijama je 1:1, što slijedi biološke zakonitosti matematičke raspodjele za ostvarenje totalne populacione veličine i minimalno ispoljavanje genetičkog drifta i efekata inbridinga. Mužjaci i ženke vrste u populacijama imaju jasno prepoznatljiv spolni dimorfizam. Ženke imaju generalno duže tijelo i veću težinu u odnosu na mužjake, dok se širina glave ne razlikuje unutar populacija.

Kada je u pitanju ishrana, može se jasno zaključiti da češnjarke ne pokazuju specijalizaciju, odnosno da se radi o životinjama sa širokom trofičkom nišom i vrlo aktivnim predatorima. U posmatranim populacijama češnjarke se najviše hrane pripadnicima klase Insecta (unutar kojih se najviše izdvaja red Coleoptera) i Diplopoda (unutar kojih se najviše izdvaja red Julida), s tim da mužjaci preferiraju više toksičnu ishranu u odnosu na ženke.

Ključne riječi: fosorijalno, Posavina, agrokultura, ekologija, populacija, gustina, mikrostanište, morfometrija, odnos polova, ishrana

Records of blue-coloured European tree frog, *Hyla arborea* (Linnaeus, 1758)

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Abstract: Many colour variations have been observed in *Hyla arborea*, but blue is considered to be extremely rare, atypical, and even abnormal by certain authors. Two blue-coloured specimens were observed during recent fieldwork in Bosnia and Herzegovina and Slovakia. The possibility that the blue colouration is a result of temperature fluctuations is discussed.

Key words: colouration, Anura, amphibian, skin, pigment, chromatophores, Bosnia and Herzegovina, Slovakia

INTRODUCTION

Intraspecific colouration (colour polymorphism) can vary widely in amphibians, with this being genetically determined (Hoffman & Blouin, 2000; Rudh & Qvarnstorm, 2013). The ability to reversibly change colour is also controlled by physiological changes (Figon & Casas, 2018). Chromatophores work together as a unit to generate the colour variations found in amphibian skin (Bagnara & Hadley, 1973; Bagnara et al., 1988; Bagnara & Matsumoto, 2006), with the dermal chromatophore unit being a combination of the three chromatophores residing in the dermis just beneath the basal lamina: (1) melanophores with black/brown pigment, (2) xanthophores with yellow and red pigment, and (3) iridophores with light-reflecting properties (Umbers, 2013; Vitt & Caldwell, 2014).

The process of physiological colour change (also known as colour adaptation) is controlled by the interaction of external stimuli, such as environmental (background) colour, light composition, humidity level, habitat temperature and stress/adrenaline level (Figon & Casas, 2018), and is used for crypsis, hydro- and thermo-regulation, UV protection, and intra- and interspecific communication (Stegen at al., 2004; Stuart-Fox & Moussalli, 2009; Caro at al., 2016; Duarte at al., 2017; Figon & Casas, 2018). As well as this, genetic abnormalities – commonly caused by gene mutations that can affect either limited areas of the body or the entire surface – can result in a lack of chromatophores; such colouration effects can range between white (leucism/albinism), yellow (flavism), red (erythrism), blue, black and brown (Jablonski at al., 2014; Kolenda at al., 2017 and references therein). Blue and dark variants can result from a lack of iridophores (ax-

Figure 1. Light blue individual of ***Hyla arborea*** from Bosnia and Herzegovina (a) and Slovakia (b).

anthism), although this can easily be mistaken for melanism (Jablonski at al., 2014).

Hyla arborea, or the European tree frog, is a small tree frog (Speybroeck at al., 2016) that has a uniformly bright green-coloured dorsal, white belly and slightly green-transparent fingers. Because this species is able to change its skin colour, a wide range of dorsal colour varieties and numerous transitional colourations have been recorded – ranging from yellow-green, through pale, olive and dark green, brown, grey, black, turquoise and blue – as well as mottled/marbled (bicolour, tricolour) variations thereof (Koren & Jelić, 2011; Đorđević et al., 2016; Zimić, 2018). Werner (1890) reported a blue-coloured *H. arborea*, which was, together with the yellow-green colour variant, later described as an abnormality by Nielsen (1980).

MATERIALS AND METHODS

During our visit to the "Vrelo Bosne" Natural Monument, Sarajevo, Bosnia and Herzegovina (GPS coordinates X=43.8180, Y=18.27443) on 13 December 2019 at 14:30, a single light-blue-coloured male of *Hyla arborea* was observed in foggy weather on a shrubby meadow (GPS coordinates X=43.8180, Y=18.27443) (Fig. 1a). No other individuals of any amphibian species were observed during this visit; it was expected that amphibians would be hibernating during that time of the year. Another blue-coloured *Hyla arborea* individual was observed on 19 April 2021 at 12:20 in Pánska Morava, Slovakia (GPS coordinates X=48.511812, Y=16.9257342), on meadow close to a pond (GPS coordinates X =48.511812, Y=16.9257342) (Fig. 1b). Nomenclature according to Frost (1998-2021).

RESULTS AND DISCUSSION

The individual at Vrelo Bosne showed low activity with slow movement; at the time of observation, the air temperature was around 8°C, and it may be assumed that the animal was awakened from hibernation due to a warmer temperature in over the preceding days. The second blue individual of *Hyla arborea* observed in Pánska Morava had small patches of green colouration around the hind limbs. As in the previous case, no other amphibians were observed during the visit, and air temperature was around 10°C. To our knowledge, these are only the second and third case of blue-coloured *H. arborea* to ever be recorded, and the first to be documented by photograph (Figs. 1a, b).

Blue colouration (i.e. the blue part of the visible spectrum: 450-490 nm) can be perceived by most animal taxa (Umbers, 2013), including amphibians (Sillman, 1987). However, the trade-offs of blue colour production in animals are still unclear (Umbers, 2013). While blue pigment-containing cells are not found in amphibians, the blue colour is a result of iridophore reflecting the light in the absence of xanthophores, or the yellow pigments that they contain (Bagnara et al., 2007; Vitt & Caldwell, 2014). Blue or partially blue colour variants have been reported within several species of frogs, especially those of the family Ranidae (Jablonski et al., 2014). *Rana temporaria* males have blue throats, while *Rana arvalis* males completely change colour from brown to blue and violet during the mating season (Ries et al., 2008; Hettyey et al., 2009; Speybroeck et al., 2016), where blue colouration acts as a direct visual signal between males to facilitate gender recognition during scramble competition (Ries et al., 2008) and also signals genetic quality (Sheldon et al., 2003), which increases mating success (Hettyey et al., 2009).

The possible cause of blue colour in these individuals of *H. arborea* could be physiological change due to temperature fluctuation at the beginning and end of the activity season resulting in increased stress levels. In the first case, 15 days before the observation, temperatures fluctuated between 0°C and 12°C for three consecutive days. The day immediately preceding the observation, the temperature dropped to around 0°C and then increased to 8°C during the day on which the observation was made. In the second case, temperature fluctuations were also considerable. Before the observation, three days in row, temperatures dropped to 3°C before increasing to 13°C. Such temperature oscillations may be confusing for ectotherms, as they hinder complete hibernation, potentially leading to stressful conditions that likely forced the individual to actively search for a cooler microhabitat. Such pre-hibernation movements to more stable sites are known amongst amphibians (e.g. Green & Yagi, 2018). In this case, we believe that this change in temperature and accumulation of stress may have been the cause of the physiological deviation that provoked colour change from green to blue. In the absence of yellow pigment, the iridophore reflects shorter wavelengths of light, making the organism appear blue-coloured (Rohrlich, 1974; Clothier & Lythgoe, 1987; Bagnara et al., 2007). It has been shown that increased adrenaline levels cause a lightening of colour in *H. arborea* (Nielsen, 1978), with an interruption in hibernation – as is likely to have been the case for both of these specimens – being the likely cause of significant stress. While the occurrence and frequency of blue colouration within the species *Hyla arborea* remains a mystery, *ex-situ* behavioural experiments may help us gain an understanding of the possible link between specific body colouration and stress in the species.

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SAŽETAK

Uočene su mnoge varijacije boja kod vrste ***Hyla arborea***, ali plava boja se smatra ekstremno rijetkom, atipičnom i abnormalnom. Dvije plave jedinke posmatrane su u toku terenskog istraživanja u Bosni i Hercegovini i Slovačkoj. U radu je diskutovana mogućnost uzroka plave boje kao rezultata temperaturne fluktuacije.

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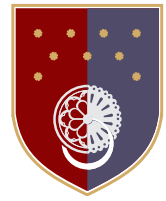

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