Who is jumping in a Serbian bog? – Orthopteran fauna of the Vlasina region

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Abstract
Vlasina Plateau is a highland bog situated in the mountains of southeastern Serbia, close to the border with Bulgaria. From a conservation point of view, bogs are one of the most important habitats and they are considered as threatened all across Europe. As the Orthopteran fauna of southern European bogs has not been studied in detail, we decided to make an inventory of grasshoppers and bush-crickets of Vlasina region. During eight years (2012 to 2019) of orthopterological study, 63 species were recorded at Vlasina Plateau. Interesting findings are those of Balkan Field Grasshopper (Chorthippus bornhalmi) and Bures’ Bush-cricket (Isophya bureschi) recently reported as first for Serbia, as well as regionally rare Serbian Pygmy Bush-cricket (Anterastes serbicicus), Domogled Meadow Bush-cricket (Broughtonia domogledi), Short-winged Cone-head (Conecephalus dorsalis), Club-legged Grasshopper (Gomphocerus sibiricus), Fieber’s Walking Bush-cricket (Psorodonotus fieberi) and Pygmy Toothed Grasshopper (Stenobothrus crassipes). In addition, we provided new distributional and bioacoustic data for Poecilimon pseudornatus and I. bureschi.

Keywords
Balkans, bogland, boreal, Broughtonia domogledi, bush-crickets, grasshoppers, IUCN, peatland, species-richness.
Introduction

Peatlands are peculiar wet habitats rich in accumulated dead organic matter. They are characteristic for areas that meet several combined climatic and pedological features, such as high soil humidity with low nutrients as well as low annual and minimal temperature, and they usually appear across the Northern Hemisphere, the most numerous being those in taiga and tundra (Langheinrich et al. 2004). Despite their long-time recognized status of high conservation significance, due to ongoing climate change, increasing habitat degradation caused by human activities, and succession (Brigić et al. 2019), peatlands are still among the most vulnerable and endangered sites (Langheinrich et al. 2004). Well-studied peatlands in the Western Balkans are bogs, i.e. peatlands rich in *Sphagnum* (see e.g. Brigić et al. 2017), which are today small and disjunctive remnants of Pleistocene meadows exhibiting boreal fauna and flora (Horvat 1950; Topić and Stančić 2006). There are several peat bogs in Serbia, mainly in the southwestern and southeastern part of the country, some of them among the largest in the Balkans. Examples are the Pešter Plateau and Vlasina Plateau (Šovran et al. 2013). Vlasinsko blato (Vlasina mud) in southeastern Serbia was considered to be the largest peat bog in Balkan Peninsula prior to its submersion in the 1950s. Although most of its parts were submerged, crucial habitats with endemic and relict species survived, and amongst these species, the best known is the insectivorous *Drosera rotundifolia* L. (Ranđelović and Zlatković 2010). Today, the remaining peatland is conserved under the “Vlasina” Landscape of Outstanding Features. In this area, intensive research has been carried on numerous taxa, mostly vertebrates – birds (Puzović et al. 2009), reptiles and amphibians (Crnobrnja-Isailović et al. 2011; Dinov and Crnobrnja-Isailović 2013); but also some invertebrates – ants (Petrov 2011), butterflies (Tot et al. 2015; Tot et al. 2017), true bugs (Šeat 2017), hoverflies (Tot et al. 2018) and dragonflies (Đukić et al. 2019).

Literature data on Orthoptera of the Vlasina region are scarce (Pančić 1883; Adamović 1950, 1975; Skejo and Ivković 2015; Pavićević et al. 2014), so we aim to gather all historic data as well as new information related to the group in this peculiar peatland. We briefly present composition of the grasshoppers’ assemblages at each locality, provide new data about song and distribution of *Poecilimon pseudornatus* and *Isophya bureschi* in Serbia and we put the highland into context of European Orthoptera fauna.

Material and methods

**Studied area.** Vlasina Plateau, situated in SE Serbia (Fig. 1), close to the border with Bulgaria, represents a mountainous peatbog in the centre of the Balkan Peninsula. Average height of area is from 1000 to 1300 m a.s.l. In the centre of plateau there is Vlasina Lake, laying at 1210 m a.s.l. The lake is surrounded by the numerous peaks – Čemernik Mt. (1638 m a.s.l.) to the west, Gramada Mt. (1721 m a.s.l.) to
Figure 1. Map of investigated area. Markings represents visited localities listed in the Supplementary file. Red line represents area of “Vlasina” Landscape of outstanding features.
the north and Vardenik Mt. (1875 m a.s.l.) to the south. Besides peat bog vegetation (Fig. 2D), which is dominant on Vlasina Plateau, different types of grasslands and pastures with dwarf-shrubs are present (Figs 2A, B, C), whereas forest vegetation is reduced to small fragments as a consequence of anthropogenic activities in the past (Ranđelović and Zlatković 2010).

**Data collection.** Orthoptera were investigated in the field on 151 localities between 2012 and 2019 (Fig. 1) by common entomological methods (visual and acoustic searching, sweep netting). All the species were identified to species level and usually photographed or collected for evidence. Part of collected material was pinned, while the majority was preserved in 96% ethanol. Besides fieldwork investigations, amateur data on Orthoptera of Vlasina were collected from Serbian web pages specialized in biodiversity data accumulation and curation – Alciphron (Ivković 2014–2020) and Biologer (Popović et al. 2020). All detailed data are provided in Supplementary file 1.

**Bioacoustic terminology.** Audio recordings were taken with a Roland R-05 digital audio recorder (sampling rate 96 kHz, 24-bit amplitude resolution, microphone response frequency up to 40 kHz). Sound analysis and figures of the oscillo-

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**Figure 2.** Different habitat types in Landscape of outstanding features “Vlasina”: A, B – Vrtop (subalpine meadow with low vegetation; photo by Ivan Tot); C – Veliki Strešer (mountain grasslands; photo by Ivan Tot); D – Blato (hygrophilous meadow by the lake; photo by Slobodan Ivković).
grams were prepared using Adobe Audio CC 2015 software. The song terminology follows Heller et al. (2004): calling song – song produced by an isolated male; functional unit of the song – the smallest part of the song, which contains all necessary song elements in appropriate order to elicit a female response; syllable - the sound produced by one complete up (opening) and down (closing) stroke of the forewings; impulse - a simple, undivided, transient train of sound waves; after-click – click produced with considerable delay after the main impulse group.

**Identification and taxonomy.** Specimens were determined using Harz (1969, 1975), Iorgu & Iorgu (2008), Willemse (1985), Willemse et al. (2009), Chobanov et al. (2013), Chobanov and Heller (2010) and Bellman et al. (2019). Taxonomy and nomenclature follow Orthoptera Species File v5.0/5.0 (Cigliano et al. 2019); the chorotypes follow Popov (2007).

**Results**

Based on published data and results presented in this article, a total of 64 orthopteran species occur in the area of Vlasina lake. Of these, 30 belong to Ensifera and 34 to Caelifera. Four species – *Oedipoda caerulescens* (Linnaeus, 1758), reported by Adamović (1950), *Oedaleus decorus* (Germar, 1825), *Chorthippus mollis* (Charpentier, 1825) reported by Adamović (1975) and *Poecilimon schmidtii* (Fieber, 1853) (leg. M. Karaman, 17.7.1971), deposited in the Zoological Collection of the Department of Biology and Ecology at Novi Sad (ZZDBE), were not recorded during our surveys and they are thus not included in the list of species. We can expect that these species are still present in the area of Vlasina Lake, but during our field trips, we probably overlooked them.

In terms of chorology the species from Vlasina Lake belong to 17 categories – most numerous are species with Eurosiberian distribution (19), followed by the species with Central and South European (12), followed by Palearctic (8) Northern and Central Balkan (4), Eastern Mediterranean (3), Southeastern European (3), Western Palearctic (2), European (2), Central Balkan (2), Afro tropical–Palearctic (1), Balkan–Anatolian (1), European–Western Asian (1), Rila–Pirin–Slavyanka (1), Holomediterranean (1), South European (1), Turanian–Mediterranean (1), Holarctic (1) distribution.

**Notes on interesting species**

*Isophya bureschi* (Fig. 3A) - Until recently, this species was known in Serbia only from the Vlasina Plateau. Here, we report one new locality situated in Senokos, eastern Serbia (N 43.15901°, E 22.93186°). Stridulatory file in male from Senokos bears 72 teeth (Fig. 3B) and in two males from Vlasina Lake 66 and 71 teeth, while in both populations males have a long and pointed cercal tooth (Figs 3C–E). According to our observations, the song of *I. bureschi* can be heard from a distance
Figure 3. A – Bures’ Plump Bush-cricket (*Isophya bureschi*), Senokos, 5 VII 2016; SEM photos of a male from Senokos; B – Stridulatory file; C – Cercus; D, E – Detailed view of a tooth on the tip of the cercus; F – Oscillographic sound analysis in a specimen from Čemernik Mt.; G – Oscillographic sound analysis in a specimen from Senokos.
of about 20 m, where males usually sing in the morning between 09:00–12:00 h and in the evening between 19:00–21:00 h. Their song consists of syllables that include a main part followed by an additional part of several after-clicks (Figs 3F, G). The main part of the syllable consists of 19–25 impulses and lasts 47–75 ms (mean 59.8±8) in specimens from Čemernik Mt. (n=10, 26 °C), whereas in specimens from Senokos (n=9, 24 °C), the main part consisted of 16–25 impulses and lasted 82–110 ms (mean 97.1±8.2). The additional part consisted of 3–7 separate impulses (after-clicks) in specimen from Čemernik Mt. and 4–7 in specimen from Senokos. Along with the after-clicks, the main syllable lasted between 563 ms and 679 ms (mean 639.4±35.4) in specimen from Čemernik Mt. and between 1.482 and 1.889 ms (mean 1758.2±128.2) in Senokos specimens.

*Poecilimon pseudornatus* (Figs 4B, C) - In Serbia, *P. pseudornatus* was reported from mountainous meadows and bushes in the western part of the country. After analysing the song of several populations (Table 2, Fig. 4A) in central and eastern Serbia, we discovered that *P. pseudornatus* has a wider distribution range, whereas the locality around Vlasina Lake represented the easternmost finding of

![Figure 4](image-url). A – Oscilograms in *Poecilimon ornatus*, Slovenia (Gomboc and Šegula 2014), *P. pseudornatus*, Vlasina, Blato, *P. pseudornatus* – Radan Mt.; B – *P. pseudornatus*, female (Vlasina, Blato); C – *P. pseudornatus*, male (Vlasina, Blato).
| Species | Chorology | No. of locality |
|---------|-----------|----------------|
| Gryllus campestris Linnaeus, 1758 | WPa | 5, 21, 41, 55, 94, 100, 103, 130 |
| Oecanthus pellucens (Scopoli, 1763) | WPa | 80, 85 |
| Anterastes serbicus Brunner von Wattenwyl, 1882 | Ba-An | 95, 110, 146, 149, 151 |
| Bicolornora bicolor (Philippi, 1830) | EuSi | 27, 28, 56, 103, 130 |
| Broughtonia domogledi (Brunner von Wattenwyl, 1882) | NCBa | 28, 47, 69, 70, 86, 87, 100, 105, 111, 112, 133, 145, 146, 150 |
| Conocephalus dorsalis (Latreille, 1804) | E–WAs | 13 |
| Conocephalus fuscus (Fabricius, 1793) | Pal | 13, 15, 21, 27, 28, 35, 100 |
| Decticus verrucivorus (Linnaeus, 1758) | Pal | 13, 35, 56, 49, 101, 122, 130 |
| Ephippiger ephippiger (Fiebig, 1784) | CSEu | 1, 2, 3, 9, 28, 29, 32, 35, 38, 40, 45, 55, 59, 62, 65, 67, 74, 81, 87, 91, 99, 100, 101, 105, 109, 111, 119, 124, 140 |
| Isophya speciosa (Frivaldszky, 1868) | EMe | 123, 142, 151 |
| Isophya bureschi Peshev, 1959 | Ri–P–S | 28, 39, 43, 96, 100, 130 |
| Isophya modestior Brunner von Wattenwyl, 1882 | CSEu | 28 |
| Meconema thalassinum (De Geer, 1773) | Eu | 50, 147 |
| Pachytrachis gracilis (Brunner von Wattenwyl, 1861) | CSEu | 108, 119, 132 |
| Phaneroptera falcata (Poda, 1761) | EuSi | 50 |
| Pholidoptera aptera karnyi Ebner, 1908 | NCBa | 120, 123, 130, 142, 146, 148 |
| Pholidoptera griseoaptera (De Geer, 1773) | Eu | 29, 59, 90, 108 |
| Pholidoptera fallax (Fischer, 1853) | CSEu | 10, 28, 29, 55, 59, 90, 100, 111, 112, 119 |
| Pholidoptera frivaldszkyi (Herman, 1871) | SEEu | 11, 12, 28, 29, 32, 35, 40, 55, 59, 64, 99, 100, 107, 111, 121, 122, 123, 130, 135, 139, 140, 142 |
| Platycleis grisea (Fabricius, 1781) | CSEu | 41 |

**Chorotypes:** WPa – Western Palearctic; Ba-An – Balkan–Anatolian; EuSi – Eurosiberian; NCBa – Northern and Central Balkan; E–WAs – European–Western Asian; Pal – Palearctic; CSEu – Central and South European; EMe – Eastern Mediterranean; Ri–P–S – Rila–Pirin–Slavyanka; Eu – European; SEEu – Southeastern European; CBa – Central Balkan; HoMe – Holomediterranean; SEu – South European; Tu–Me – Turanian–Mediterranean; Hol – Holarctic.
| Species                               | Chorology | No. of locality |
|---------------------------------------|-----------|----------------|
| Poecilimon affinis affinis (Frivaldszky, 1868) | CSEu      | 28, 55, 71, 100, 103, 107, 122, 123, 136 |
| Poecilimon fussii Fieber, 1878          | CSEu      | 63, 91, 100    |
| Poecilimon pseudornatus Ingrisch & Pavičević, 2010 | CBA      | 13, 130        |
| Poecilimon thoracicus (Fieber, 1853)    | NCBa      | 6, 7, 15, 22, 28, 29, 40, 44, 58, 59, 69, 72, 73, 88, 99, 100, 102, 104, 107, 114, 119, 122, 123, 124, 130, 133, 135, 142, 147, 151 |
| Polysarcus denticauda (Charpentier, 1825) | CSEu      | 34, 129, 130, 135, 146 |
| Psorodonotus fiebleri (Frivaldszky, 1853) | NCBa      | 64, 66, 91, 100, 103, 112, 115, 116, 118, 122, 127, 130, 131, 135, 142, 143 |
| Roeseliana roeselii (Hagenbach, 1822)   | EuSi      | 14, 21, 23, 27, 28, 36, 52, 54, 56, 100, 107 |
| Ruspolia nitidula (Scopoli, 1786)       | Pal       | 27, 35         |
| Tettigonia viridissima (Linnaeus, 1758) | Pal       | 1, 2, 21, 28, 56, 67, 100, 129, 130, 138, 148 |
| Arcyptera fusca (Pallas, 1773)          | EuSi      | 64, 97, 100, 113, 130 |
| Chorthippus biguttulus (Linnaeus, 1758) | Pal       | 102, 126       |
| Chorthippus bornhalmi Harz, 1971        | EMe       | 21, 28, 48, 49, 56, 100, 103, 111, 130, 144 |
| Chorthippus brunneus (Thunberg, 1815)   | EuSi      | 28, 103, 130, 144 |
| Chorthippus dorsatus (Zetterstedt, 1821) | EuSi      | 21, 35, 56, 103, 107, 119, 130 |
| Chorthippus oschei pusztensis Vedenina & Helversen, 2009 | SEEu      | 35, 68, 69, 87, 102 |
| Chrysochraon dispar (Germar, 1834)      | EuSi      | 10, 13, 15, 16, 17, 21, 28, 32, 35, 46, 56, 57, 68, 83, 89, 90, 98, 100, 107, 125, 130 |
| Euchorthippus declivus (Brisout de Barneville, 1848) | CSEu      | 60 |
| Euthystira brachyptera (Ocskay, 1826)   | EuSi      | 4, 8, 15, 21, 24, 28, 29, 32, 35, 42, 47, 51, 56, 59, 69, 70, 73, 93, 99, 100, 102, 103, 104, 107, 111, 113, 119, 122, 123, 124, 126, 129, 130, 135, 139, 142, 146, 151 |
| Gomphocerus sibiricus (Linnaeus, 1767)  | EuSi      | 142, 144       |
| Miramella albanica Mistshenko, 1952     | CBA       | 104, 128       |

**Chorotypes:**
- **WPa** – Western Palearctic
- **Ba-An** – Balkan–Anatolian
- **EuSi** – Eurosiberian
- **NCBa** – Northern and Central Balkan
- **E–WAs** – European–Western Asian
- **Pal** – Palearctic
- **CSEu** – Central and South European
- **EMe** – Eastern Mediterranean
- **Ri–P–S** – Rila–Pirin–Slavyanka
- **Eu** – European
- **SEEu** – Southeastern European
- **CBA** – Central Balkan
- **HoMe** – Holomediterranean
- **SEu** – South European
- **Tu–Me** – Turanian–Mediterranean
- **Hol** – Holarctic
| Species | Chorology | No. of locality |
|---------|-----------|----------------|
| *Myrmeleotettix maculatus* (Thunberg, 1815) | EuSi | 21, 94, 100, 110, 119, 123, 125, 130, 135, 142, 143, 144, 146, 150 |
| *Odontopodisma decipiens* Ramme, 1951 | SEEu | 104 |
| *Omocestus haemorrhoidalis* (Charpentier, 1825) | EuSi | 35, 56, 92, 115 |
| *Omocestus rufipes* (Zetterstedt, 1821) | Pal | 35, 56, 99, 100, 107 |
| *Omocestus viridulus* (Linnaeus, 1758) | EuSi | 103, 130 |
| *Para caloptenus caloptenoides* (Brunner von Wattenwyl, 1861) | EMe | 45, 53 |
| *Pezotettix giornae* (Rossi, 1794) | HoMe | 50 |
| *Pseudochorthippus parallelus* (Zetterstedt, 1821) | EuSi | 4, 13, 21, 25, 26, 27, 29, 31, 35, 37, 40, 59, 64, 69, 75, 76, 77, 78, 79, 82, 84, 87, 90, 98, 99, 102, 103, 107, 111, 112, 113, 119, 121, 135, 142, 147 |
| *Pseudopodisma fieberi* (Scudder, 1897) | SEu | 100, 106, 112, 134, 136 |
| *Psophus stridulus* (Linnaeus, 1758) | EuSi | 61, 130 |
| *Stauroderus scalaris* (Fischer von Waldheim, 1846) | EuSi | 21, 56, 94, 103, 104, 107, 117, 129, 130, 134, 135, 137, 141, 142 |
| *Stenobothrus crassipes* (Charpentier, 1825) | CSEu | 112, 124, 132, 146 |
| *Stenobothrus lineatus* (Panzer, 1796) | EuSi | 21, 47, 56, 64, 69, 99, 100, 102, 103, 111, 112, 120, 130, 135 |
| *Stenobothrus nigromaculatus* (Herrich-Schäffer, 1840) | EuSi | 64, 92 |
| *Stenobothrus stigmaticus faberi* Harz, 1975 | CSEu | 119, 130 |
| *Stethophyma grossum* (Linnaeus, 1758) | EuSi | 13, 15, 18, 19, 20, 27, 30 |
| *Tetrix bipunctata* (Linnaeus, 1758) | Pal | 21, 28, 33 |
| *Tetrix bolivari* Saulcy, 1901 | Tu–Me | 28 |
| *Tetrix subulata* (Linnaeus, 1758) | Hol | 21, 28 |
| *Tetrix temicorinum* (Sahlberg, 1891) | Pal | 28 |

**Chorotypes:** WPa – Western Palearctic; Ba-An – Balkan–Anatolian; EuSi – Eurosiberian; NCBa – Northern and Central Balkan; E–WAs – European–Western Asian; Pal – Palearctic; CSEu – Central and South European; EMe – Eastern Mediterranean; Ri–P–S – Rila–Pirin–Slavyanka; Eu – European; SEEu – Southeastern European; CBa – Central Balkan; HoMe – Holomediterranean; SEu – South European; Tu–Me – Turanian–Mediterranean; Hol – Holarctic.
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this species. New distribution data raised the question about the distribution of *P. pseudornatus* and *P. affinis* in Serbia (Fig. 5), a topic already discussed by Chobanov and Heller (2010). The main problems in this matter are the lack of research in Serbia and the fact that the previous authors used only the morphological details, whereas they did not use the song, which is the most significant character for distinguishing between the species from the *P. ornatus* group. Based on the analysed specimens, we can confirm that *P. ornatus* is not present in Serbia; thus, it has been confused with either *P. pseudornatus* or *P. affinis*.

**Discussion**

Orthopteran fauna of the alpine habitats of Serbia remains poorly studied; Grebenščikov (1950) provided data on orthoptera found on high mountains, but as his research data was obtained from several mountains in Serbia, it is not comparable with research presented in this article. To date, only Adamović and Mladenović (1993-94) provided information on the orthopteran fauna on peat bogs in Serbia to date, and they reported 23 species, most of which were found at Vlasina Plateau. Only two species reported by Adamović and Mladenović—*Polysarcus scutatus* (Brunner von Wattenwyl, 1882) and *Broughtonia arnoldi* (Ramme, 1933), were not reported from Vlasina Plateau.

The majority of the investigated species are endangered by habitat loss caused by the rapid tourism development in the area around Vlasina Lake. One of the endangered species is *Broughtonia domogledi*, whose populations are threatened with habitat destruction throughout their distribution range (Chobanov et al. 2016). We observed this species around Vlasina Lake in a tourist resort. Even though the species is very common on Vlasina Plateau in late summer, the conservation of its habitats is still necessary. Besides habitat loss, the greatest threat not only to Orthoptera, but to the entire flora and fauna of Vlasina Plateau, are small hydropower plants constructed on several rivers in Crna Trava municipality. Regardless of the fact that Vlasina Lake is man-made, extensive changes, such as water regime changes, can

| Source                                      | Number of stridulatory teeth | Syllable duration [ms] |
|---------------------------------------------|------------------------------|------------------------|
| Pavičević and Ingrisch 2010                | 187–241                      | 225–252                |
| Ivković 2017                                | 181–381                      | 284–331                |
| New data, Vlasina (n of syllables=5; 28 °C) | 235                          | 320–342                |
| New data Kopaonik, Brzeće (n of syllables=10; 30 °C) | -                            | 210–236                |
| New data, Radan Mt., Gornji Gajtan (n of syllables=10; 25 °C) | -                            | 349–400                |
Figure 5. Distribution map of *Poecilimon pseudornatus* (green circles) together with literature data on *P. affinis/P. ornatus* (red circles).
endanger hygrophilous species through the disappearance of bogs and habitat homogenisation.

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### Appendix 1. Detailed data on the investigated sites.

| Locality No | Northing  | Easting  | Collector/Publication            | Date       | UTM 10x10 | Altitude m a.s.l. |
|-------------|-----------|----------|----------------------------------|------------|-----------|------------------|
| 1           | 42.6932   | 22.2293  | Slobodan Ivković                 | 04 IX 2019 | FN02      | 650              |
| 2           | 42.6849   | 22.2627  | Slobodan Ivković                 | 04 IX 2019 | FN02      | 767              |
| 3           | 42.6744   | 22.2818  | Slobodan Ivković                 | 04 IX 2019 | FN02      | 907              |
| 4           | 42.7596   | 22.4225  | Bojana Nadaždin                  | 21 VII 2019| FN13      | 982              |
| 5           | 42.7308   | 22.3846  | Mihailo Vujić                    | 20 V 2017  | FN13      | 1091             |
| 6           | 42.7859   | 22.3248  | Milan Đurić                      | 13 VIII 2019| FN03     | 1157             |
| 7           | 42.7584   | 22.3224  | Slobodan Stevčić                 | 13 VIII 2019| FN03     | 1176             |
| 8           | 42.7575   | 22.3222  | Emanuel Veverica                 | 23 VI 2019  | FN03      | 1176             |
| 9           | 42.7612   | 22.3179  | Slobodan Stevčić                 | 13 VIII 2019| FN03     | 1181             |
| 10          | 42.7628   | 22.3197  | Mihailo Vujić                    | 13 VIII 2019| FN03     | 1183             |
| 11          | 42.7589   | 22.3226  | Slobodan Stevčić                 | 23 VI 2019  | FN03      | 1192             |
| 12          | 42.7592   | 22.3222  | Slobodan Stevčić                 | 23 VII 2019 | FN03     | 1193             |
| 13          | 42.6757   | 22.3400  | Slobodan Ivković                 | 15 VII 2012  | FN02    | 1208             |
| 14          | 42.6795   | 22.3541  | Nikola Veljković                 | 23 VII 2019 | FN12     | 1209             |
| 15          | 42.6780   | 22.3556  | Slobodan Ivković                 | 15 VII 2012  | FN12    | 1210             |
| 16          | 42.6753   | 22.3238  | Nikola Veljković                 | 26 VII 2018  | FN02    | 1210             |
| 17          | 42.6864   | 22.3250  | Nikola Veljković                 | 24 VII 2019 | FN02    | 1211             |
| 18          | 42.6878   | 22.3249  | Nikola Veljković                 | 24 VII 2019 | FN02    | 1211             |
| 19          | 42.6797   | 22.3219  | Nikola Veljković                 | 24 VII 2019 | FN02    | 1211             |
| 20          | 42.6864   | 22.3250  | Nikola Veljković                 | 24 VII 2019 | FN02    | 1211             |
| 21          | 42.7099   | 22.3296  | Skejo and Ivković (2015)         | 17 VII 2014 | FN02    | 1212             |
| 22          | 42.7200   | 22.334   | Mihailo Vujić                    | 12 VII 2017 | FN03    | 1212             |
| 23          | 42.6792   | 22.3223  | Nikola Veljković                 | 24 VII 2019 | FN02    | 1212             |
| 24          | 42.6792   | 22.3529  | Nikola Veljković                 | 23 VII 2019 | FN12    | 1212             |
| 25          | 42.6791   | 22.3528  | Nikola Veljković                 | 23 VII 2019 | FN12    | 1212             |
| 26          | 42.6910   | 22.3235  | Nikola Veljković                 | 24 VII 2019 | FN02    | 1212             |
| 27          | 42.7452   | 22.3257  | Slobodan Ivković                 | 13 VII 2012 | FN03    | 1213             |
| 28          | 42.7456   | 22.3254  | Skejo and Ivković (2015)         | 14 VII 2014 | FN03    | 1213             |
| 29          | 42.7095   | 22.3273  | Slobodan Ivković                 | 04 IX 2019  | FN02    | 1213             |
| 30          | 42.6870   | 22.3264  | Nikola Veljković                 | 24 VII 2019 | FN02    | 1213             |
| 31          | 42.6943   | 22.3243  | Nikola Veljković                 | 24 VII 2019 | FN02    | 1214             |
| 32          | 42.6545   | 22.3824  | Mihailo Vujić                    | 16 VIII 2019| FN12    | 1215             |
| 33          | 42.6802   | 22.3529  | Slobodan Stevčić                 | 22 VI 2019  | FN12    | 1215             |
| 34          | 42.7195   | 22.3320  | Vladimir Žikić                   | 28 VI 2012  | FN03    | 1218             |
## Appendix 1. (continued)

| Locality No | Northing  | Easting  | Collector/Publication          | Date         | UTM 10x10 | Altitude m a.s.l. |
|-------------|-----------|----------|--------------------------------|--------------|-----------|------------------|
| 35          | 42.6942   | 22.3202  | Slobodan Ivković               | 04 IX 2019   | FN02      | 1219             |
| 36          | 42.6941   | 22.3199  | Slobodan Ivković               | 04 IX 2019   | FN02      | 1221             |
| 37          | 42.6955   | 22.3253  | Nikola Veljković               | 24 VII 2019  | FN02      | 1227             |
| 38          | 42.6930   | 22.3196  | Milan Đurić                    | 12 VII 2019  | FN02      | 1231             |
| 39          | 42.7372   | 22.3287  | Pavićević et al. (2014)       | 10 VII 2008  | FN03      | 1231             |
| 40          | 42.7158   | 22.3295  | Slobodan Ivković               | 04 IX 2019   | FN03      | 1234             |
| 41          | 42.7306   | 22.3692  | Slobodan Ivković               | 16 VII 2012  | FN13      | 1238             |
| 42          | 42.6673   | 22.3820  | Milan Đurić                    | 15 VII 2019  | FN12      | 1239             |
| 43          | 42.7006   | 22.3212  | Pavićević et al. (2014)       | 15 VII 2014  | FN02      | 1241             |
| 44          | 42.7486   | 22.3239  | Slobodan Ivković               | 13 VII 2012  | FN03      | 1241             |
| 45          | 42.6702   | 22.3832  | Slobodan Ivković               | 02 IX 2019   | FN12      | 1243             |
| 46          | 42.6682   | 22.3820  | Mihailo Vujić                  | 16 VIII 2019 | FN12      | 1243             |
| 47          | 42.6702   | 22.3834  | Slobodan Ivković               | 02 IX 2019   | FN12      | 1244             |
| 48          | 42.7426   | 22.3267  | Slobodan Stevčić              | 22 VI 2019   | FN03      | 1245             |
| 49          | 42.7424   | 22.3268  | Slobodan Stevčić              | 23 VII 2019  | FN03      | 1245             |
| 50          | 42.7422   | 22.3273  | Ivan Tot                       | 04 IX 2016   | FN03      | 1247             |
| 51          | 42.6814   | 22.3578  | Slobodan Stevčić              | 27 V 2018    | FN12      | 1247             |
| 52          | 42.6714   | 22.3842  | Slobodan Ivković               | 02 IX 2019   | FN12      | 1256             |
| 53          | 42.6716   | 22.3842  | Slobodan Ivković               | 02 IX 2019   | FN12      | 1259             |
| 54          | 42.7213   | 22.3270  | Slobodan Ivković               | 04 IX 2019   | FN03      | 1261             |
| 55          | 42.7017   | 22.3152  | Skejo and Ivković (2015)      | 17 VII 2014  | FN02      | 1264             |
| 56          | 42.7017   | 22.3152  | Skejo and Ivković (2015)      | 17 VII 2014  | FN02      | 1264             |
| 57          | 42.6763   | 22.3865  | Slobodan Ivković               | 02 IX 2019   | FN12      | 1264             |
| 58          | 42.7591   | 22.3261  | Slobodan Stevčić              | 13 VIII 2019 | FN03      | 1272             |
| 59          | 42.7213   | 22.3270  | Slobodan Ivković               | 04 IX 2019   | FN03      | 1273             |
| 60          | 42.6775   | 22.3859  | Slobodan Ivković               | 02 IX 2019   | FN12      | 1275             |
| 61          | 42.6803   | 22.3884  | Slobodan Ivković               | 02 IX 2019   | FN12      | 1280             |
| 62          | 42.7240   | 22.3239  | Slobodan Ivković               | 02 IX 2019   | FN03      | 1286             |
| 63          | 42.6831   | 22.3895  | Slobodan Ivković               | 02 IX 2019   | FN12      | 1286             |
| 64          | 42.6819   | 22.3899  | Bojana Nadaždin               | 24 VII 2019  | FN12      | 1287             |
| 65          | 42.7242   | 22.3245  | Slobodan Ivković               | 02 IX 2019   | FN03      | 1288             |
| 66          | 42.6848   | 22.3901  | Slobodan Ivković               | 02 IX 2019   | FN12      | 1291             |
| 67          | 42.7235   | 22.3234  | Slobodan Ivković               | 02 IX 2019   | FN03      | 1295             |
| 68          | 42.6858   | 22.3904  | Slobodan Ivković               | 02 IX 2019   | FN12      | 1295             |
### Appendix 1. (continued)

| Locality No | Northing  | Easting  | Collector/Publication       | Date      | UTM 10x10 | Altitude m a.s.l. |
|-------------|-----------|----------|-----------------------------|-----------|-----------|------------------|
| 69          | 42.7275   | 22.3290  | Slobodan Ivković            | 01 IX 2019| FN03      | 1297             |
| 70          | 42.6845   | 22.3900  | Slobodan Ivković            | 02 IX 2019| FN12      | 1298             |
| 71          | 42.7257   | 22.3265  | Slobodan Ivković            | 02 IX 2019| FN03      | 1299             |
| 72          | 42.7264   | 22.3271  | Mihailo Vujić               | 11 VII 2017| FN03      | 1299             |
| 73          | 42.7255   | 22.3263  | Nikola Veljković            | 26 VII 2019| FN03      | 1299             |
| 74          | 42.7251   | 22.3286  | Slobodan Ivković            | 02 IX 2019| FN03      | 1301             |
| 75          | 42.7253   | 22.3287  | Nikola Veljković            | 23 VII 2019| FN03      | 1301             |
| 76          | 42.7254   | 22.3286  | Nikola Veljković            | 23 VII 2019| FN03      | 1301             |
| 77          | 42.7254   | 22.3286  | Nikola Veljković            | 23 VII 2019| FN03      | 1301             |
| 78          | 42.7254   | 22.3286  | Nikola Veljković            | 23 VII 2019| FN03      | 1301             |
| 79          | 42.7254   | 22.3286  | Nikola Veljković            | 23 VII 2019| FN03      | 1301             |
| 80          | 42.7252   | 22.3284  | Slobodan Ivković            | 02 IX 2019| FN03      | 1302             |
| 81          | 42.7252   | 22.3249  | Slobodan Ivković            | 02 IX 2019| FN03      | 1302             |
| 82          | 42.7254   | 22.3286  | Nikola Veljković            | 23 VII 2019| FN03      | 1303             |
| 83          | 42.7252   | 22.3289  | Nikola Veljković            | 23 VII 2019| FN03      | 1304             |
| 84          | 42.7252   | 22.3288  | Nikola Veljković            | 23 VII 2019| FN03      | 1304             |
| 85          | 42.7255   | 22.3280  | Slobodan Ivković            | 02 IX 2019| FN03      | 1305             |
| 86          | 42.7262   | 22.3270  | Slobodan Ivković            | 02 IX 2019| FN03      | 1305             |
| 87          | 42.7253   | 22.3246  | Slobodan Ivković            | 01 IX 2019| FN03      | 1310             |
| 88          | 42.7287   | 22.3235  | Slobodan Ivković            | 01 IX 2019| FN03      | 1320             |
| 89          | 42.7167   | 22.3256  | Nikola Veljković            | 25 VII 2019| FN03      | 1322             |
| 90          | 42.7294   | 22.3212  | Slobodan Ivković            | 01 IX 2019| FN03      | 1324             |
| 91          | 42.6859   | 22.3927  | Slobodan Ivković            | 02 IX 2019| FN12      | 1337             |
| 92          | 42.6867   | 22.3943  | Slobodan Ivković            | 02 IX 2019| FN12      | 1364             |
| 93          | 42.7319   | 22.3185  | Milan Đurić                 | 18 IX 2018| FN03      | 1368             |
| 94          | 42.6876   | 22.3949  | Slobodan Ivković            | 02 IX 2019| FN12      | 1371             |
| 95          | 42.6875   | 22.3948  | Slobodan Ivković            | 02 IX 2019| FN12      | 1373             |
| 96          | 42.6882   | 22.3951  | Slobodan Ivković            | 02 IX 2019| FN12      | 1377             |
| 97          | 42.6886   | 22.395   | Slobodan Ivković            | 02 IX 2019| FN12      | 1383             |
| 98          | 42.7275   | 22.3189  | Slobodan Stević             | 07 IX 2018| FN03      | 1388             |
| 99          | 42.6894   | 22.3961  | Slobodan Ivković            | 02 IX 2019| FN12      | 1400             |
| 100         | 42.6558   | 22.3304  | Skejo and Ivković (2015)    | 19 VII 2014| FN02      | 1424             |
| 101         | 42.7326   | 22.3121  | Bojana Nadaždin             | 19 IX 2018| FN03      | 1444             |
| 102         | 42.7428   | 22.3007  | Mihailo Vujić               | 03 IX 2019| FN03      | 1450             |
### Orthopteran fauna of the Vlasina region

#### Appendix 1. (continued)

| Locality No | Northing | Easting | Collector/Publication | Date       | UTM 10x10 | Altitude m a.s.l. |
|-------------|----------|---------|-----------------------|------------|-----------|------------------|
| 103         | 42.7747  | 22.3297 | Skejo and Ivković (2015) | 17 VII 2014 | FN03      | 1453             |
| 104         | 42.6327  | 22.2866 | Ivan Tot              | 24 VII 2019 | FN02      | 1461             |
| 105         | 42.6478  | 22.3208 | Nikola Veljković     | 28 VII 2018 | FN02      | 1464             |
| 106         | 42.6478  | 22.3209 | Nikola Veljković     | 28 VII 2018 | FN02      | 1464             |
| 107         | 42.7308  | 22.2913 | Mihailo Vujić        | 03 IX 2019  | FN03      | 1466             |
| 108         | 42.7765  | 22.3349 | Slobodan Ivković      | 13 VII 2012 | FN03      | 1471             |
| 109         | 42.7286  | 22.3105 | Ivan Tot              | 19 IX 2018  | FN03      | 1482             |
| 110         | 42.6184  | 22.3195 | Bojana Nadaždin      | 22 VII 2019 | FN01      | 1512             |
| 111         | 42.6238  | 22.3207 | Slobodan Ivković      | 02 IX 2019  | FN01      | 1513             |
| 112         | 42.6181  | 22.3153 | Slobodan Ivković      | 02 IX 2019  | FN01      | 1518             |
| 113         | 42.7247  | 22.3109 | Slobodan Stević       | 07 IX 2018  | FN03      | 1519             |
| 114         | 42.7234  | 22.3103 | Milan Đurić           | 14 VII 2018 | FN03      | 1521             |
| 115         | 42.7253  | 22.3106 | Milan Đurić           | 25 VIII 2018| FN03      | 1525             |
| 116         | 42.6121  | 22.2978 | Milan Đurić           | 19 IX 2018  | FN01      | 1535             |
| 117         | 42.7858  | 22.3573 | Slobodan Ivković      | 12 VII 2016 | FN13      | 1539             |
| 118         | 42.7291  | 22.2828 | Bojana Nadaždin       | 30 V 2018   | FN03      | 1547             |
| 119         | 42.7291  | 22.2758 | Mihailo Vujić         | 03 IX 2019  | FN03      | 1557             |
| 120         | 42.6282  | 22.3237 | Bojana Nadaždin       | 22 VII 2019 | FN02      | 1558             |
| 121         | 42.7244  | 22.2917 | Bojana Nadaždin       | 02 IX 2019  | FN03      | 1564             |
| 122         | 42.724   | 22.2973 | Mihailo Vujić         | 14 VII 2017 | FN03      | 1570             |
| 123         | 42.6323  | 22.3272 | Mihailo Vujić         | 11 VII 2016 | FN02      | 1581             |
| 124         | 42.6034  | 22.2909 | Slobodan Ivković      | 03 IX 2019  | FN01      | 1587             |
| 125         | 42.6033  | 22.2908 | Slobodan Ivković      | 03 IX 2019  | FN01      | 1587             |
| 126         | 42.6130  | 22.2854 | Milan Đurić           | 19 IX 2018  | FN01      | 1596             |
| 127         | 42.6027  | 22.2892 | Slobodan Ivković      | 03 IX 2019  | FN01      | 1598             |
| 128         | 42.6336  | 22.2774 | Ivan Tot              | 24 VII 2019 | FN02      | 1599             |
| 129         | 42.6153  | 22.2817 | Miloš Popović         | 11 VII 2016 | FN01      | 1615             |
| 130         | 42.7346  | 22.2795 | Skejo and Ivković (2015) | 18 VII 2014 | FN03      | 1624             |
| 131         | 42.7337  | 22.2772 | Milan Đurić           | 07 VII 2016 | FN03      | 1634             |
| 132         | 42.7349  | 22.2776 | Ivan Tot              | 06 IX 2016  | FN03      | 1636             |
| 133         | 42.6334  | 22.2757 | Slobodan Ivković      | 03 IX 2019  | FN02      | 1637             |
| 134         | 42.6333  | 22.2751 | Slobodan Ivković      | 03 IX 2019  | FN02      | 1658             |
| 135         | 42.7937  | 22.3773 | Slobodan Ivković      | 13 VII 2012 | FN13      | 1670             |
| 136         | 42.6129  | 22.2820 | Slobodan Ivković      | 03 IX 2019  | FN01      | 1670             |
Appendix 1. (continued)

| Locality No | Northing | Easting | Collector/Publication | Date       | UTM 10x10 | Altitude m a.s.l. |
|-------------|----------|---------|-----------------------|------------|-----------|------------------|
| 137         | 42.6120  | 22.2827 | Bojana Nadaždin       | 22 VII 2019| FN01      | 1673             |
| 138         | 42.6340  | 22.2694 | Slobodan Ivković      | 03 IX 2019 | FN02      | 1675             |
| 139         | 42.7917  | 22.3759 | Bojana Nadaždin       | 20 VII 2019| FN13      | 1681             |
| 140         | 42.7891  | 22.3705 | Bojana Nadaždin       | 05 IX 2019 | FN13      | 1683             |
| 141         | 42.6265  | 22.2713 | Milan Đurić           | 11 VII 2016| FN02      | 1690             |
| 142         | 42.7929  | 22.3733 | Slobodan Ivković      | 13 VII 2012| FN13      | 1708             |
| 143         | 42.7929  | 22.3732 | Skejo and Ivković (2015) | 16 VII 2014| FN13      | 1708             |
| 144         | 42.7928  | 22.3733 | Skejo and Ivković (2015) | 16 VII 2014| FN13      | 1708             |
| 145         | 42.6182  | 22.2780 | Slobodan Ivković      | 03 IX 2019 | FN01      | 1709             |
| 146         | 42.6316  | 22.2706 | Slobodan Ivković      | 03 IX 2019 | FN02      | 1721             |
| 147         | 42.6235  | 22.2774 | Slobodan Ivković      | 03 IX 2019 | FN01      | 1743             |
| 148         | 42.6238  | 22.2711 | Slobodan Ivković      | 03 IX 2019 | FN01      | 1787             |
| 149         | 42.6256  | 22.2685 | Slobodan Ivković      | 03 IX 2019 | FN02      | 1826             |
| 150         | 42.6265  | 22.2676 | Slobodan Ivković      | 03 IX 2019 | FN02      | 1862             |
| 151         | 42.6266  | 22.2674 | Slobodan Ivković      | 03 IX 2019 | FN02      | 1863             |