

Shar Mountain National Park (R. North Macedonia) - shelter for caddisfly biodiversity in the country

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Abstract

In this paper we discuss the presence of three rare caddisfly species on the Macedonian part of Shar Mountain. *Crunoecia bosniaca* (Lepidostomatidae) and *Drusus sharrensis*, (Limnephilidae), are recorded for the first time in the country, while *Tinodes kimminsi* (Psychomyiidae) is reported for the first time on Shar Mountain. Detailed information about the ecology and distribution of these species is also provided. This study is an important contribution to the knowledge of the caddisfly fauna, not only for R. North Macedonia, but for the whole Balkan Peninsula.

Key words caddisflies, new records, rare species, habitat, distribution, ecology, Balkan Peninsula.

Introduction

The caddisfly fauna of the Republic of North Macedonia has not been consistently researched, resulting in limited knowledge regarding the diversity and distribution of this aquatic insect order. Although investigations of Macedonian caddisflies started almost ninety years ago (Radovanović 1935, 1943),

only few studies focused on the order Trichoptera over the upcoming years (Botosaneanu 1960; Pavlovski 1984, 1991; Arsov 1991; Kumanski 1997; Kumanski & Malicky 1999). Significant progress has been achieved in recent years, particularly as certain areas have undergone more comprehensive investigation (Oláh 2010, 2011; Oláh *et al.* 2013a, 2013b, 2014, 2015, 2018, 2019; Oláh & Kovács 2013, 2014; Kučinić *et al.* 2016; Vitecek *et al.* 2015a, 2015b, 2015c; Waringer *et al.* 2015; Rimcheska *et al.* 2015; Slavevska-Stamenković *et al.* 2016; Bilalli *et al.* 2018, 2019; Hinić *et al.* 2020; Slavevska-Stamenković *et al.* 2020, 2021). However, as the majority of these studies (Oláh 2010, 2011; Oláh *et al.* 2013a, 2013b, 2014, 2015, 2018, 2019; Oláh & Kovács 2013, 2014; Kučinić *et al.* 2016; Vitecek *et al.* 2015a, 2015b, 2015c; Waringer *et al.* 2015) were focused on investigating the diversity of caddisflies in the Balkan Peninsula rather than specifically within the territory of North Macedonia, some authors (Slavevska-Stamenković *et al.* 2021) speculate there are still parts of the country where only scarce data is available.

One of them undoubtedly is the biodiversity hotspot from Western Balkans, Shar Mountain (Miho *et al.* 2023). Bearing in mind that Shar Mountain in Kosovo is known to be inhabited by great number of rare caddisfly species (Ibrahimi *et al.* 2016a, 2016b; Ibrahimi & Vehapi 2017; Ibrahimi *et al.* 2019a, 2023), it is evident that this mountainous region holds significant importance in terms of caddisfly fauna. However, within the Macedonian part of this mountain, the Trichoptera fauna remains insufficiently known. The first data about the caddisflies on the Macedonian territory of Shar Mountain was published by Radovanović (1953) when *Limnephilus bipunctatus* Curtis, 1834 was reported from Livadichko Lake. More than four decades later, only few studies (Kumanski 1997; Kovachev *et al.* 1999; Mementi and Janeva, 1999) included some localities within the mountain and provided information on the caddisfly diversity, estimating total number of 35 species. Lately some investigations at Popova Shapka, village Brodec, village Bozovce (Oláh and Kovács 2013; 2014) and Tetovska River (Oláh *et al.* 2017) contributed to the knowledge about these insects on Shar Mountain elevating the number to 47 species up to date. Although this number may seem significant, it is apparent that there have been no comprehensive investigations that included different aquatic ecosystems on Shar Mountain, thus leaving many caddisfly species yet undiscovered.

It is worth mentioning that this study was conducted as part of a broader entomological investigation carried out on Shar Mountain (data yet to be published). This contribution aims to enhance our understanding of caddisfly diversity in the Republic of North Macedonia, especially in areas recognized as biodiversity hotspots such as Shar Mountain (Miho *et al.* 2023). Additionally, the study provides insights into the ecology and distribution of these species and discusses the threats their populations are facing.

Material and methods

Study area

Four sampling localities were selected located within the Shar Mountain region in the north-western part of the country (Figure 1). The Shar Mountain spans from southern Kosovo to northwestern North Macedonia and northeastern Albania. The areas within Kosovo and R. North Macedonia are designated national parks. Characterized by rugged terrain and sparse vegetation, these mountains rank among the highest in the Balkans, with 30 peaks exceeding 2,500 meters (Jovanovska *et al.* 2020).

The entomological investigations on the caddisfly fauna on Shar Mountain were conducted over the last six years on a total number of 35 sampling sites that included mountainous streams, springs, rivers, wetlands and glacial lakes on different altitudes situated within and above the forest zone of the mountain. Such selection of sampling sites contributed in revealing the caddisfly diversity of this mountain in R. North Macedonia, having in mind that different habitat types were researched. Although the complete investigations included 35 sampling localities, the species discussed in this study were collected only from four out of 35 sampling sites presented in Figures 1 and 2.

All localities belong to the 6th ecoregion (Hellenic Western Balkan) according to Illies (1978). Detailed information about the sampling localities of the collected adult specimens are presented in Table 1.

Sampling site S1: Stream in Leshnica (42°0'57.47" N, 20°46'37.35" E) is a mountain stream in the region of Dolna Leshnica and a tributary to the spring region of river Pena at 1548 meters altitude.

The sampling site is characterized by well-developed riparian vegetation and substrate dominated by pebbles and large cobbles.

Table 1. Characteristics of the sampling sites from Shar Mountain (R. North Macedonia) where the new species were recorded.

Code	Name of the locality	Habitat type	Longitude	Latitude	Altitude	Sampling period
S1	Stream in Leshnica	Mountain stream	42°0'57.47" N	20°46'37.35" E	1548 m	May 2021 – June 2023
S2	Waterfall before v. Gajre	Mountain stream	42°0'14.02" N	20°56'10.62" E	864 m	
S3	Uliverica	Spring	41°59'38.78" N	20°51'49.36" E	1745 m	
S4	Stream above v. Novo Selo	Mountain stream	41°56'54.83" N	20°51'43.04" E	1344 m	

Sampling site S2: Waterfall before v. Gajre (42°0'14.02" N, 20°56'10.62" E) is located in a secluded woody area near the main road to Popova Shapka, before entering village Gajre at 864 meters altitude. It is a narrow mountain stream that falls over a high rock wall, in such way that the waterfall is hidden by constant shadow. The bottom of the stream bed is mainly composed of pebbles and cobbles.

Sampling site S3: Uliverica (41°59'38.78" N, 20°51'49.36" E) is located around 10 kilometers away from Popova Shapka, near the road leading to Titov Vrv peak. It is a wide sunny area with springs that turn into small open brooks.

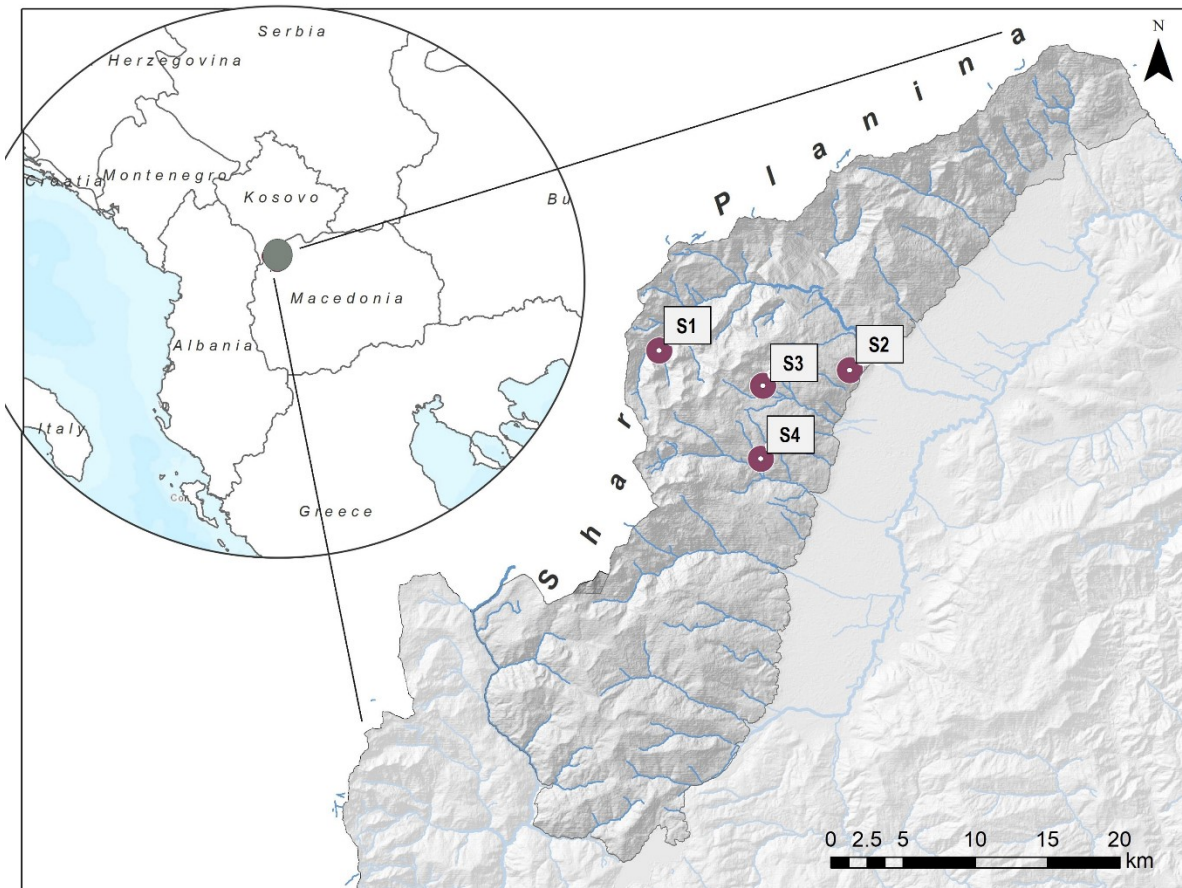


Figure 1. Map of the sampling localities (S1 – S4) on Shar Mountain (R. North Macedonia). Map prepared by Daniela Jovanovska, PhD.

Sampling site S4: Stream above v. Novo Selo is a spring region of one mountain stream located at 1344 meters altitude in the region known as Bogovinje (41°56'54.83" N, 20°51'43.04" E). It starts flowing down a steep rock, forming a little waterfall and continues as a narrow stream which is eventually ending up in a hydropower plant.

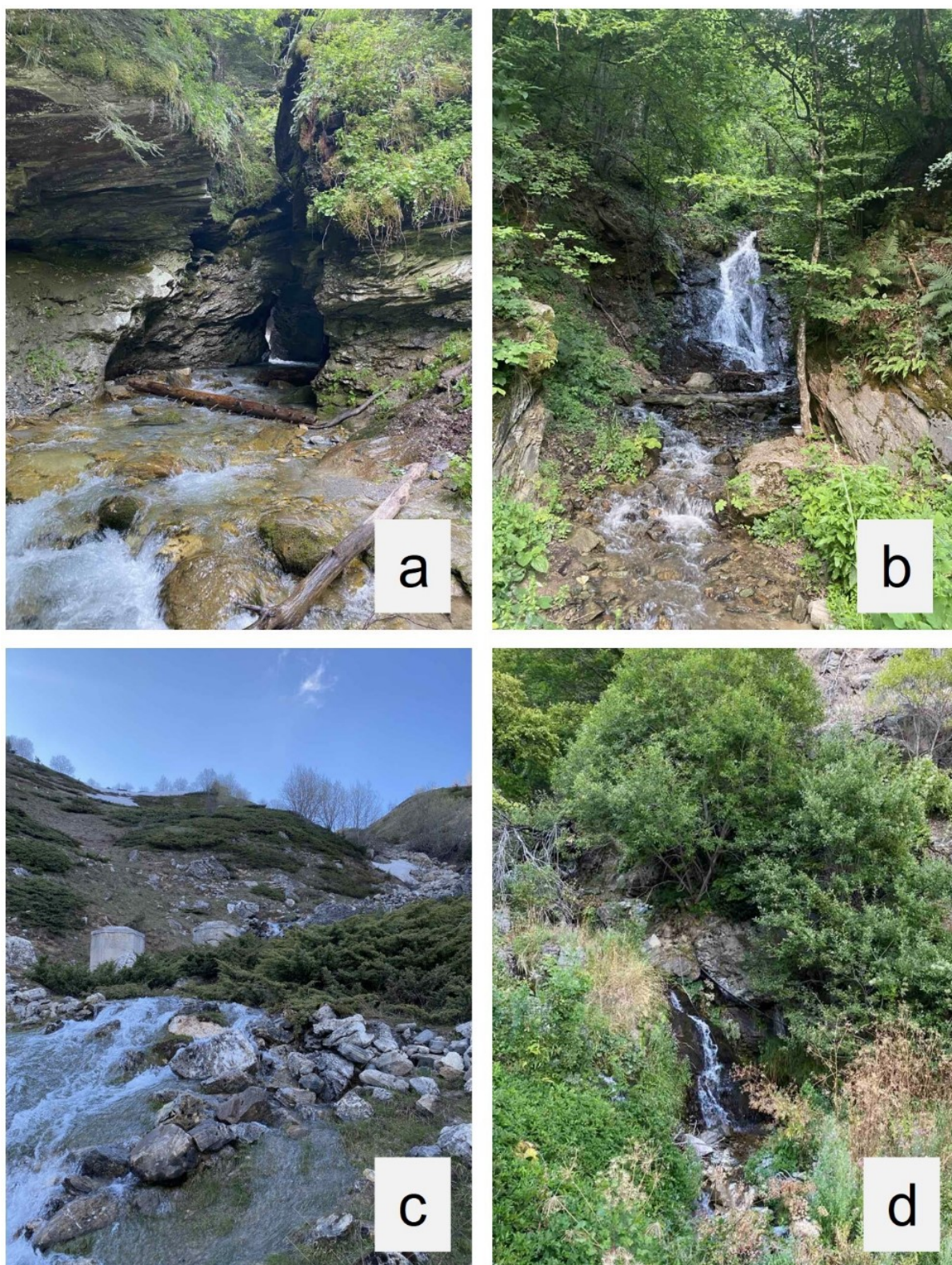


Figure 2. Photos of the localities where the new species were recorded: a) S1 - Stream in Leshnica; b) S2 - Waterfall before v. Gajre; c) S3 – Uliverica; d) S4 - Stream above v. Novo Selo.

Data sampling and processing

Adult caddisfly specimens were collected with entomological nets during the day, as well as with ultraviolet (UV) pyramid light traps during the night. UV light traps were placed on the stream bank after dusk and operated for app. 60 minutes. Samplings were conducted during the period of May 2021 to June 2023. The collected material was preserved in 96% ethanol. Adult specimens were identified using a Nikon SMZ745 stereomicroscope with appropriate identification keys (Kumanski 1985, 1988; Malicky 2004). In order to provide photographs of the male genitalia of *Crunoecia bosniaca* (the reasons are explained in the Results and Discussion), specimens were cleared using KOH solution 10% - treatment. All collected specimens are deposited in the Macedonian National Collection of Invertebrates (MNCI) Skopje. Systematic presentation follows Morse (2024).

Results and Discussion

The findings outlined in this paper provide a summary of the recent discoveries of three rare species out of which two are discovered in R. North Macedonia for the first time. Despite the fact that this research included revisiting 35 sampling sites, only 4 of them (Figure 1) have been shown to be inhabited by species previously unknown to the Macedonian fauna or the fauna of Shar Mountain. The remaining 31 sampling sites were inhabited by species already documented within the country. The newly found species belong to three families: Limnephilidae (1 species), Lepidostomatidae (1 species) and Psychomyiidae (1 species). Detailed presentation of the results is provided in Table 2.

Table 2. Systematic list of caddisflies collected from the sampling sites on Shar Mountain. Abbreviation: Legator names: leg. - legator(s); Valentina Slavevska Stamenković - VSS; Mladen Kučinić - MK; Jelena Hinić-Jordanovska - JHJ; Ajten Rushiti-Dauti - ARD. Other abbreviations: m - male specimen(s); f - female specimen(s); UV – ultraviolet light trap; EN – entomological net. Species noted for the first time in R. North Macedonia are marked with asterisk (*). Species noted for the first time on Shar Mountain are marked with square (▪).

Family: LIMNEPHILIDAE	
Genus: <i>Drusus</i> Stephens, 1833	
1. <i>Drusus sharrensis</i> Ibrahim, Previsic & Vitecek, 2016*	Material examined: S1. (EN). 07.06.2023. 2m, 1f; leg. MK. S3. (EN). 09.06.2023. 3m; leg. MK.
Family: LEPIDOSTOMATIDAE	
Genus: <i>Crunoecia</i> McLachlan, 1876	
2. <i>Crunoecia bosniaca</i> Marinkovic-Gospodnetic, 1970*	Material examined: S4. (UV). 17.06.2021. 2m; leg. VSS, JHJ.
Family: PSYCHOMYIIDAE	
Genus: <i>Tinodes</i> Curtis, 1834	
3. <i>Tinodes kimminsi</i> Sykora, 1962*	Material examined: S2. (UV). 18.06.2021. 2m; leg. VSS, JHJ, ARD.

Lateral, ventral and dorsal view of male genitalia of *Crunoecia bosniaca* is given in Figure 3.

Among the rare caddisfly species reported in this study, the Balkan endemic *Crunoecia bosniaca* was known only from Bosnia and Herzegovina and Kosovo (Marinković-Gospodnetić 1970; 1971; 1980; Borko *et al.* 2023), so the discovery of this species in R. North Macedonia expands its distribution range on the Balkan Peninsula. However, the fact that this species was recorded from the springs of White Drim and Rugova gorge in Kosovo only once by Marinković-Gospodnetić (1980) and never again (Ibrahim & Sejdiu, 2018) regardless of the intensive caddisfly research (Ibrahim *et al.* 2014, 2015a, b; 2016a, b, 2017, 2018, 2019a, b, c, 2021; 2023; Ibrahim & Vehapi 2017; Ibrahim & Sejdiu 2018; Karaouzas *et al.* 2018; Oláh *et al.* 2015, 2018), is indicative towards this species' high risk of extinction. This remark goes alongside with the observations in this study, as only two male specimens of *C. bosniaca* were collected only from the sampling site S4 only in June 2021, although the same locality was visited monthly during the summer period from May 2021 to June 2023. Additionally, this sampling site is a part of the hydro system "Sharski vodi" catchment that carries water to the hydroelectric power plants, making it symptomatic that this species population may have already

become endangered due to hydrological alterations. The S4 sampling site where we collected *C. bosniaca* is a spring region of one mountain stream above v. Novo Selo (Figure 1d). Similarly, Marinković-Gospodnetić (1970) recorded this species in the springs at the confluence with river Klobucarica, Chemerno osoje, streams next to the road to Churevo, springs and streams around Perucica and near Pribojski bridge and the small forest springs of tributaries of the Sutjeska on the Maglic mountain (Marinković-Gospodnetić 1971). Therefore, it seems that this species prefers mountain springs and streams. All previous records date back from the seventies of the last century and the species has not been noted again in Bosnia and Herzegovina since then. Some newly conducted investigations (Borko *et al.* 2023) mention this species from the tributaries and springs of upper Neretva River basin. However, due to the absence of precise information regarding the sampling locality, number of collected specimens and location of the deposited material, the validity of this record remains uncertain. Additionally, since the collection with all collected *C. bosniaca* specimens (Marinković-Gospodnetić 1970, 1971, 1980) is no longer available, the newly collected specimens from Shar Mountain deposited in the Macedonian National Collection of Invertebrates (MNCI) become the only available and deposited material of this species. Bearing in mind that only pencil drawing illustrations are available for the species (Marinković-Gospodnetić 1971), this paper also provides the first photographs of male genitalia (Figure 3). Noteworthy detail is that *C. bosniaca* is the second species from genus *Crunoecia* known from the country. Namely, Botosaneanu (1960) introduced this genus in R. North Macedonia by describing the adult stage *Crunoecia monospina* Botosaneanu, 1960 from mountain brook towards Bitola at altitude of 1800 – 2500 meters. To date, no other species from this genus have been recorded, and *C. monospina* has not been documented from its type - or any other - locality.

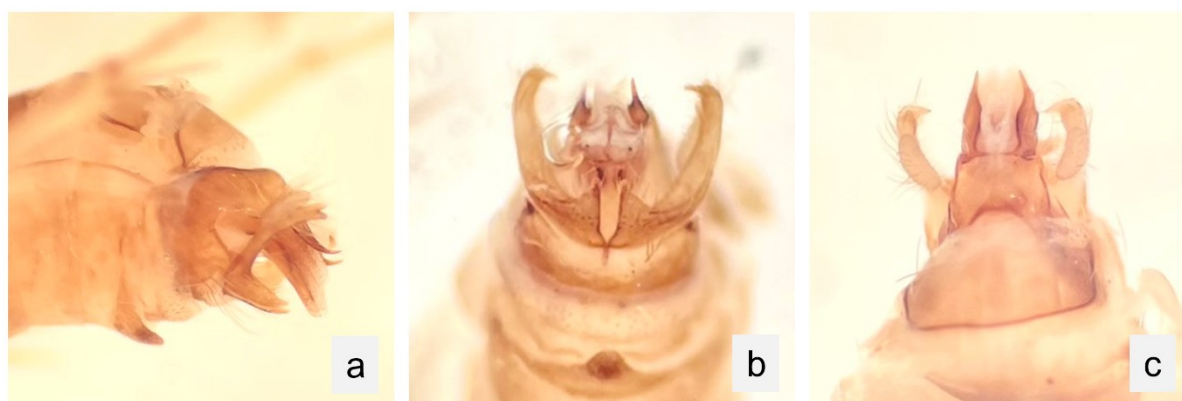


Figure 3. Male genitalia of *Crunoecia bosniaca* a) lateral view b) ventral view c) dorsal view.

The recently described *Drusus sharrensis* Ibrahim, Previsic & Vitecek, 2016 was known only from Shar Mountain in Kosovo (Ibrahim *et al.*, 2016a). The finding of this species in sites S1 – Lesnica and S3 - Uliverica, expands the distribution range of this species in R. North Macedonia. Regardless of its presence in both Kosovo and R. North Macedonia, populations of this species are still limited to Shar Mountain, meaning it should still be considered as a stenoendemic species. The fact that this species was not recorded anywhere else despite the undertaken caddisfly investigations at the neighboring mountain regions such as Karadak Mountain (Bilalli *et al.* 2018, 2019, 2024; Ibrahim *et al.* 2019; Musliu *et al.* 2020) and Bistra Mountain (Slavevska-Stamenković and Hinić-Jordanovska, *unpublished data*), strongly supports this constatation. According to the original description (Ibrahim *et al.* 2016a) this species inhabits springs and mountain streams between 1410 and 2141 m above sea level. During the conducted research presented in this paper *D. sharrensis* was recorded in June 2023 at altitudes of 1548 m.a.s.l. near a mountain stream in Lesnica and 1745 m.a.s.l. at the sampling locality Uliverica spring (Table 2). Unlike S3 – Uliverica where no signs of anthropogenic pressures were found, populations of this stenoendemic species may be seriously threatened in the sampling site S1 - Lesnica due to ongoing activities of small hydropower plants installation. The discovery of *D. sharrensis* at two locations in the Republic of North Macedonia marks this species as the eleventh in a series of *Drusus* species found within the country (Hinić *et al.* 2020). Given the limited distribution area on Shar

Mountain as well as the already identified potential threats, this species is of an urgent need of conservational activities.

The third species recorded for the first time on Shar Mountain, *Tinodes kimminsi* is a rare species, distributed in Central Europe (Komzák and Chvojka 2005), originally described from a small brooklet with waterfalls, leading into the Slapy-reservoir on the river Vltava near the village of Merin in Central Bohemia, Czech Republic (Sykora 1962). According to Komzák and Chvojka (2005) the type locality is still the only location in Czech Republic where population of this species is present. The first record of this species' presence only on the Macedonian side of Shar Mountain is from the sampling site S2 - Waterfall before v. Gajre. Bearing in mind that the locality is a narrow mountain stream with a waterfall, seems that this species has a strong preference with such habitats. Additionally, the species was found in June during the early summer, which is exactly in line with the description provided by Sykora (1962), who collected the species on June 17, 1960. The results obtained during this investigation extends this species' distribution range to another mountain region in the country, since it was reported for the Macedonian fauna for the first time in 2020 from locality above v. Brodec on Karadak Mountain (Musliu *et al.* 2020). Similarly, to *C. bosniaca* and *D. sharrensis*, this species is prone to anthropogenic impacts. Information provided by the local community report wastewater discharges in this mountain stream which may lead to sudden changes in water quality, which may compromise the existence of *T. kimminsi*.

The findings of the uncommon species in this study such as *C. bosniaca*, *D. sharrensis* and *T. kimminsi* emphasizes the significance of aquatic biodiversity and entomological research, especially in areas lacking thorough investigation. Such studies can enrich protection and conservation actions and strategies, safeguarding the existence of these pivotal species. Finally, given their rarity and susceptibility to environmental shifts and disruptions, these species can significantly be affected by anthropogenic impacts, including climate warming. Hence, discovering new populations can contribute valuable insights for conservation tactics and management schemes of biodiversity hotspots. Particularly in R. North Macedonia there are ongoing activities for reassembling National lists for strictly protected and protected wild species where inclusion of the Balkan endemic *C. bosniaca* and stenoendemic *D. sharrensis* is proposed.

To conclude, this study contributes significantly to the knowledge of the caddisfly fauna of R. North Macedonia and the Balkan Peninsula in general. It highlights the importance of protecting and conserving freshwater ecosystems in the Shar Mountain which is a vital habitat of rare and endemic species.

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