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New Records of *Dilar turcicus* Hagen, 1858 (Neuroptera: Dilaridae) on the Balkan Peninsula, with Notes on its Biology

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ABSTRACT

The pleasing lacewing *Dilar turcicus* Hagen, 1858 is well known on the Balkan Peninsula from taxonomic and faunistic aspects, but its ecology and phenology have been poorly studied. The paper summarizes the published and new data on the distribution, phenology, ecology and altitude preferences of *D. turcicus* in the area. Altogether 26 unpublished records of the species are presented and a map documenting the known distribution is provided. The collecting place of *D. turcicus* in Serbia is the first record in the country and the northernmost locality on the Balkan Peninsula. In addition, the findings on the islands of Brač and Hvar confirm the presence of the species in Croatia after a hundred years.

Keywords: Balkan countries, ecology, phenology, pleasing lacewings.

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INTRODUCTION

The pleasing lacewings (Dilaridae) is a small family of the order Neuroptera distributed on all continents apart from Antarctic, Australia, New Guinea and the Pacific islands.

Pectinate antennae in males (Figs. 1, 2), elongate ovipositors in females and reduced mouthparts are characteristic for adults (e.g., Monserrat, 2014, 2022; Liu, Aspöck, Winterton, Zhang, & Aspöck, 2017). The adult diet in pleasing lacewings is mostly unknown, but reduced mouthparts, particularly the labium and ligula, suggest a short life span and poor feeding capacity, if not complete starvation (Monserrat 1988a, 1988b, 2014, 2022; Devetak & Klokočovnik, 2016). Most adult pleasing lacewings are mainly crepuscular/nocturnal, being usually attracted by artificial light, especially the males (Monserrat, 2022).

Figure 1. *Dilar turcicus* Hagen, 1858, male; island Brač, Croatia. Photo T. Koren.

Figure 2. Pinned male of *Dilar turcicus*; Stolovi Mountain, Serbia. Pectinate antennae (*) are partly visible. Photo D. Devetak.

An ancestral diet based on nectar and pollen (pollino-glycophagous) has been suggested in some species of fossil relatives (Makarkin, 2017) and is also suggested in extant species (Zimmermann, Randolf, & Aspöck, 2019). Larvae are associated with soil or dead wood. The fact that they are blind and suffer from abdominal physogastria indicates that they require an accessible, regular, and abundant food source in their juvenile phase and do not actively search for prey (Monserrat, 2022). The larvae have

been suggested as generalist predators of small insects, particularly xylophagous beetles, although according to Minter (1992), these data tend to support the hypothesis that their development is associated with termite mounds. The larvae are well adapted to fossorial habits (Badano, Di Giulio, Aspöck, Aspöck, & Cerretti, 2021).

There has been a lot of research on dilarids in the last two decades. Since 1998, the number of species has increased from 67 to 140 (Oswald, 1998; Liu et al., 2017; Monserrat, 2022). In Europe 10 species of dilarids have been recorded so far, most of them on the Iberian Peninsula, and only one species inhabits the Balkan Peninsula - *Dilar turcicus* Hagen, 1858 (Aspöck, Liu, & Aspöck, 2015; Monserrat, 2022). According to Oswald (1998), Dilaridae are rare both in the field and in insect collections, yet *D. turcicus* occurs locally in large numbers (Aspöck, Aspöck, Hölzel, & Rausch, 1980).

The known distribution of *D. turcicus* (Fig. 3) includes large parts of the Balkan Peninsula (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Montenegro, North Macedonia), Turkey, Ukraine and Russia (review up to 2015: Aspöck et al., 2015; additional records: Onar, 2007; Devetak & Rausch, 2016; Devetak et al., 2019). In the literature (Aspöck et al., 2015), the species was mistakenly listed for Kosovo. Most of the findings were sporadic in individual countries, except for Greece and Bulgaria, where a much larger number of localities were recorded (Popov, 2007; Aspöck et al., 2015). A decade ago, two closely related species, *Dilar anatolicus* U. Aspöck, Liu & H. Aspöck, 2015 and *D. fuscus* U. Aspöck, Liu & H. Aspöck, 2015 were described from the neighboring region, Anatolia.

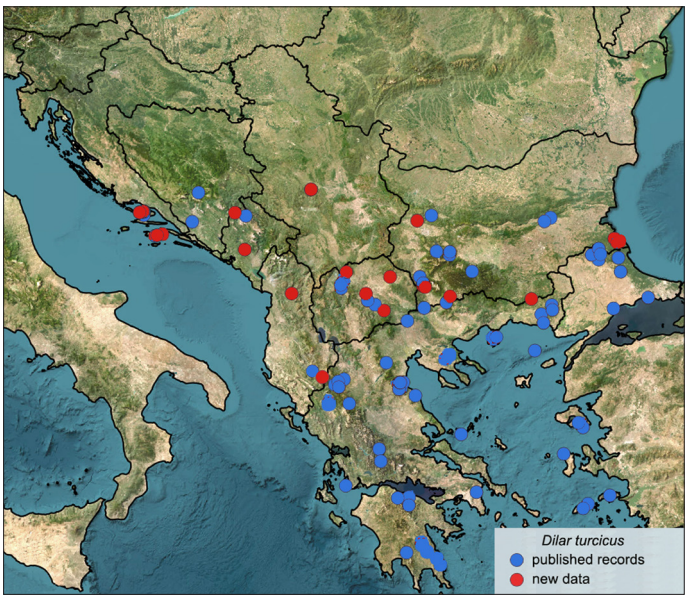

Figure 3. Known records of *D. turcicus* on the Balkan Peninsula. Orig. map by P. Kozel.

One of the oldest records of *D. turcicus* from the Balkan Peninsula dates back to the beginning of the 20th century when Klapálek (1906a, 1906b) listed the species for today's Bosnia and Herzegovina. Later, Navás (1909) listed it for Bosnia and

Herzegovina, Croatia, and Greece. In the same monograph, Navás (1909) described *Dilar corcyraeus* from Corfu which turned out to be a synonym of *D. turcicus*. These records were followed by a series of contributions. The chronology of investigations on *D. turcicus* on the peninsula is presented in Table 1.

The aims of the study are: (1) to present new faunistic data and map the localities of *D. turcicus*; and (2) to summarize the data on the ecology and phenology of this species.

Table 1. Chronology of faunistic investigations on *D. turcicus* on the Balkan Peninsula.

Year	References	Balkan Country
1906	Klapálek (1906a, 1906b)	Bosnia and Herzegovina
1909	Navás (1909)	Bosnia and Herzegovina, Croatia, Greece
1913	Pongrácz (1913)	Bosnia and Herzegovina
1914	Navás (1914)	Greece
1917	Klapálek (1917)	Bosnia and Herzegovina
1920	Werner (1920)	Croatia
1964	Popov (1964)	Bulgaria
	Zelený (1964)	Former Yugoslavia, Greece
1971	Zelený (1971)	Bulgaria
1980	Aspöck et al. (1980)	Albania, Bulgaria, Greece
1991	Devetak (1991)	Montenegro
1992	Devetak (1992a)	Croatia
	Devetak (1992b)	Bosnia and Herzegovina, Croatia, Montenegro, North Macedonia
1993	Popov (1993)	Bulgaria
2001	Aspöck et al. (2001)	Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Montenegro, North Macedonia
	Popov (2001)	Bulgaria
2004	Popov (2004)	Bulgaria
2005	Monserrat (2005)	Greece
2007	Onar (2007)	Turkey (European part)
2007	Popov (2007)	Bulgaria
2015	Aspöck et al. (2015)	Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Montenegro, North Macedonia
	Devetak, Klokočovnik, Rausch, & Janžekovič (2015)	North Macedonia
2016	Devetak & Rausch (2016)	Albania
2019	Devetak et al. (2019)	North Macedonia

MATERIAL AND METHODS

Pleasing lacewings were collected using an insect net or were picked from a light source. Light trapping involved 2-3 portable light traps with an 8 Watt actinic (368 nm) and 8 Watt “Blacklight” luminescent tubes, both powered by 12 Volt batteries, as well as a Finnish “tent trap” with a 160 Watt MV bulb at the top of the pole and a 20 Watt (368 nm) black light lamp over the catching pot below. An additional 20 Watt (368 nm) lamp was also positioned about 70 m from the tent trap for a better coverage. It was powered by the same generator as the tent trap and far enough not to be competitive with it. All traps ran throughout the night. Specimens (pinned and dried or preserved in ethanol) on which this study is based are deposited in the following collections: Collection of Dušan Devetak, Maribor, Slovenia (Coll DD), Collection of Ana Nahirnić-Beshkova, Sofia, Bulgaria (Coll ANB) and Collection of Toni Koren, Zagreb, Croatia (Coll TK).

Data on phenology and altitudinal distribution were collected from the literature (Aspöck et al., 2015 - Supplementary material; Devetak, Klokočovnik, Rausch, & Janžekovič, 2015; Devetak & Rausch, 2016) and the unpublished data presented in the current study. Graphs of phenology and altitudinal distribution were created using GraphPad Prism 6 software.

The map was created with the QGIS version 3.14.15-Pi program.

RESULTS

During the period 2015-2024, dilarids were collected in 25 new locations and six countries, with only one unpublished record dating back to 1985. The updated distribution of *D. turcicus* on the Balkan Peninsula is shown in Fig. 3.

Dilar turcicus Hagen, 1858

New records

Albania

Lezhe county: Bjeshka e Oroshit, Kurbnesh, Kthellë village S, 893m, 41.797306° N, 20.066806° E, 8.7.2019, leg. A. Nahirnić & S. Beshkov; coll. DD.

Korçë county: Gramoz Mt., Borovë village above, 1085 m; 40.297778° N, 20.658333° E, 21.7.2022, leg. A. Nahirnić-Beshkova & S. Beshkov, coll. DD.

Bulgaria

Kostinbrod; Beledie Han village N, 837 m, 42.899722° N, 23.166667° E, 8.8.2021, leg. A. Nahirnić & S. Beshkov, coll. DD.

Kresna town, Melo, 515 m; 41.730278° N, 23.200278° E, 03.06.2022, light traps, leg. A. Nahirnić-Beshkova & S. Beshkov, coll. DD.; 25.05.2024, light traps, leg. A. Nahirnić-Beshkova & S. Beshkov, coll. ANB.

Pirin Mt. Novo Leski above, Gorno Leski, 966 m, 41.521667° N, 23.759167° E, 13.6.2023, leg. A. Nahirnić-Beshkova & S. Beshkov, coll. DD.

Eastern Rhodopes Mts, Egrek, light traps, 555 m, 41.319107° N, 25.6332590° E, 5.6.2024, leg. A. Nahirnić-Beshkova & S. Beshkov, coll. ANB.

Standzha Mt.,Popovi Skali, light traps, 66 m, 42.163833° N, 27.736111° E , 9.7.2024, leg. A. Nahirnić-Beshkova & S. Beshkov, coll ANB.

Standzha Mt., Dyado Valcho, light traps, 273 m, 42.092400° N, 27.790000° E, 10.7.2024, leg. A. Nahirnić-Beshkova & S. Beshkov, coll. ANB.

Strandzha Mt., Papiya, light traps, 33 m, 42.10435° N, 27.845206° N, 11.7.2024, leg. A. Nahirnić-Beshkova & S. Beshkov, coll. ANB.

Croatia

Island Brač. Dol, light traps, 131 m, 43.3484° N, 16.6276° E, 8.6.2023, leg. Toni Koren; coll. TK.

Island Brač. Dol, Zala strana, light traps, 129 m, 43.3433° N, 16.6277° E; 8.6.2023; leg. Toni Koren; coll. TK.

Island Brač. Dol, Velo Brdo, S of St. Mihovil church, light traps, 328 m, 43.33794° N, 16.617896° E; 8.6.2023; leg. Toni Koren; coll. TK.

Island Brač. Dračevica village, Vela Glava, light traps, 274 m, 43.332993° N, 16.520349° E, 7.6.2023, leg. Toni Koren; coll. TK.

Island Brač. S from Dračevica village, light traps,258 m, 43.321836° N, 16.522938° E, 7.6.2023, leg. Toni Koren; coll. TK.

Island Brač. S of Škrip, 397 m, 43.344564° N, 16.595287° E, 7.6.2023, leg. Toni Koren, coll. TK.

Island Brač. SW from Dračevica village, light traps, 280 m, 43.329459° N, 16.518429° E, 6.6.2023, leg. Toni Koren, coll. TK.

Island Korčula. S from Smokvica, Gornji Brig, light traps, 104 m, 42.912° N, 16.8805° E, 10.6.2023, leg. Toni Koren, coll. TK.

Island Korčula. SE from Pupnat, light traps, 324 m, 42.937821° N, 17.053181° E, 10.6.2023; leg. Toni Koren, coll. TK.

Island Korčula. Zavalatica, Runjeva glavica, light traps, 72 m, 42.920373° N, 16.928528° E, 9.6.2023, leg. Toni Koren, coll. TK.

Montenegro

Maglič Mt., above Piva lake, above Mratinje vill., Štrbina, light traps, 1162 m, 43.268611° N, 18.820000° E, 8.8.2015, leg. A. Nahirnić-Beshkova & S. Beshkov, coll. DD.

Danilovgrad municipality, Bogmilovići village, 468 m, 42.613611° N, 19.013889° E, 30.6.2017, leg. S. Beshkov & A. Nahirnić; coll. DD.

North Macedonia

Istochen region. Kočani, Kočansko ezero (Ezero Gratče), 500 m, 41.963642° N, 22.405022° E, 1.6.2018, leg. F. & B. Janžekovič, coll. DD.

Skopski region. Skopska crna gora, Banjane, 528 m, 42.108778° N, 21.384944° E, 19.7.1985, leg. P. Jakšić, coll. DD.

Vardar Region. Demir Kapija. Besvica village E, a gorge of Besvički dol river, 255 m, 41.382778° N, 22.195833° E, 5.5.2017, leg. A. Nahirnić & S. Beshkov, coll. DD.

Vardar Region. Veles, above Sv. Ilija monastery, 458 m, 41.703889° N, 21.807500° E, 11.5.2016, leg. S. Beshkov & A. Nahirnić, coll. DD.

Serbia

Stolovi Mt., Veliki Čukar, 669 m, 43.602222° N, 20.685556° E, 1.7.2019, leg. S. Beshkov & A. Nahirnić, coll. DD.; 29.6.2024, leg. A. Nahirnić-Beshkova & S. Beshkov, coll. ANB. New for Serbia.

Northernmost locality on the Balkan Peninsula

During this research, a considerable number of finds of *D. turcicus* were collected in the northern part of the Balkan Peninsula. This is particularly true for the areas of southern Croatia, Montenegro, Albania, and Serbia, for which there were very few records in the past (Fig. 3).

The record from Serbia, on Stolovi Mountain, is the first record for Serbia and the northernmost locality on the Balkan Peninsula. This indicates that the species has a much wider distribution in the region than it was previously known, and additional records are expected from Serbia in the future. In addition to those mentioned, the findings from Montenegro and Albania are also significant, as they represent the second records of this species in these countries and considerably expand its known distribution there.

In some locations, such as Brač Island (Croatia) and Stolovi (Serbia), *D. turcicus* was found in high numbers, with more than 15 individuals captured per night during light trapping indicating numerous populations.

Habitats

Data from the literature and new records are summarized in Table 2. Typical habitats are shown in Figs. 4-5. *Dilar turcicus* was collected in or near habitats ranging from dry rocky grassland, stony slopes, and maquis to oak forest, Moesian mountainous beech forest and forest with Macedonian pine (Table 2).

Table 2. Ecology of D. *turcicus* on the Balkan Peninsula including the collecting locality, sampling method, habitat description and altitude.

Collection place	Sampling method	Habitat	Altitude	References
Albania. Gjirokastër County: National Park »Bredhi i Hotovës-Dangelli«, lodge;	sweep net	Moesian mountainous beech forest, with *Quercus, Picea, Abies*.	1170 m	Devetak & Rausch (2016)
Albania. Korçë county: Gramoz Mt., Borovë village above	light traps	Meadows with stream and stony slopes with *Astracantha*, *J. oxycedrus* and *Quercus pubescens* near *Pinus nigra* forest (Fig. 4A)	1085 m	this paper
Bulgaria. Kresna town, Melo	light traps	Dry grasslands and thickets with *Juniperus oxycedrus, J. excelsa, Quercus pubescens, Paliurus spina-christi, Pistacia terebinthus*, on sandy limestone (Fig. 4B)	515 m	this paper
Bulgaria. Kostinbrod; Beledie Han village N	light traps	Dry rocky grasslands on limestone (Fig. 4C)	837 m	this paper
Bulgaria. Eastern Rhodopes Mts, Egrek	light traps	Dry rocky grasslands on limestone and *Quercus-Carpinus orientalis* forest (Fig. 4D)	555	this paper
Bulgaria. Standzha Mt., Popovi Skali	light traps	Stony slopes near river with *Paliurus, Phyllirea*, etc. (Fig. 4E)	66 m	this paper
Bulgaria. Standzha Mt., Dyado Valcho	light traps	Thickets with *Cystus, Calluna vulgaris, Quercus*, etc.	273 m	this paper
Bulgaria. Strandzha Mt., Papiya	light traps	*Quercus* forest with *Phyllirea, Cystus* (Fig. 4F)	33 m	this paper
Croatia. Island Brač. Dol	light traps	Open karstic grasslands	131 m	this paper
Croatia. Island Brač. Dol, Zala strana	light traps	Open karstic grasslands (Fig. 5A)	129 m	this paper
Croatia. Island Brač. Dol, Velo Brdo, S of St. Mihovil church	light traps	Karstic grassland and edge of *Pinus* forest	328 m	this paper
Croatia. Island Brač. Dračevica village, Vela Glava	light traps	Karstic grassland partially overgrown in garrigue	274 m	this paper
Croatia. Island Brač. S from Dračevica village	light traps	Open karstic grassland with garrigue and single *Pinus* trees	258 m	this paper
Croatia. Island Brač. S of Škrip	light traps	Maquis and small grassland patches	397 m	this paper
Croatia. Island Brač. SW from Dračevica village	light traps	Maquis and small grassland patches	280	this paper
Croatia. Island Korčula. S from Smokvica, Gornji Brig	light traps	Maquis with small grassland patches	104 m	this paper
Croatia. Island Korčula. SE from Pupnat	light traps	Maquis with small grassland patches	324 m	this paper
Croatia. Island Korčula. Zavalatica, Runjeva glavica	light traps	Maquis with small grassland patches	72 m	this paper
Montenegro, Maglič Mt., above Piva lake, above Mratinje vill., Štrbina	light traps	Limestone area with *Fagus sylvatica, Quercus, Fraxinus, Acer, Juniperus communis*, etc.	1162 m	this paper
Montenegro. Durmitor National Park, Durmitor Mts., Tepca	sweep net	Cliff walls made of limestone, with Austrian pine (*Pinus nigra*).	900 m	Devetak (1991)
Montenegro, Danilovgrad municipality, Bogmilovići village	light traps	Limestone slopes with *Juniperus oxycedrus, Punica granatum, Fraxinus ornus, Acer monspessulanum, Pistacia terebinthus, Thalictrum, Paliurus spina-christi.*	468 m	this paper
North Macedonia. Istochen region. Kočani, Kočansko ezero (Ezero Gratče)	sweep net	Mixed forest	500 m	this paper
North Macedonia. Matka, Treska	sweep net	Deciduous forest on north-facing slopes above lake with *Ramonda nathaliae* (Fig. 5B)	350 m	Devetak et al. (2015)
North Macedonia. Vardar Region. Demir Kapija. Besvica village E, gorge of Besvički dol river	light traps	Pseudomaquis and rocky grasslands with sporadic shrubs	255	this paper
North Macedonia. Pelagoniski region. National Park Pelister. Kopanki	sweep net	Forest with Macedonian pine (*Pinus peuce*) (Fig. 5C)	1629 m	Devetak et al. (2019)
Serbia. Stolovi Mt., Veliki Čukar	light traps	*Quercus* spp. and *Juniperus oxycedrus*, meadows; the bedrock is harzburgite (Fig. 5D)	669 m	this paper

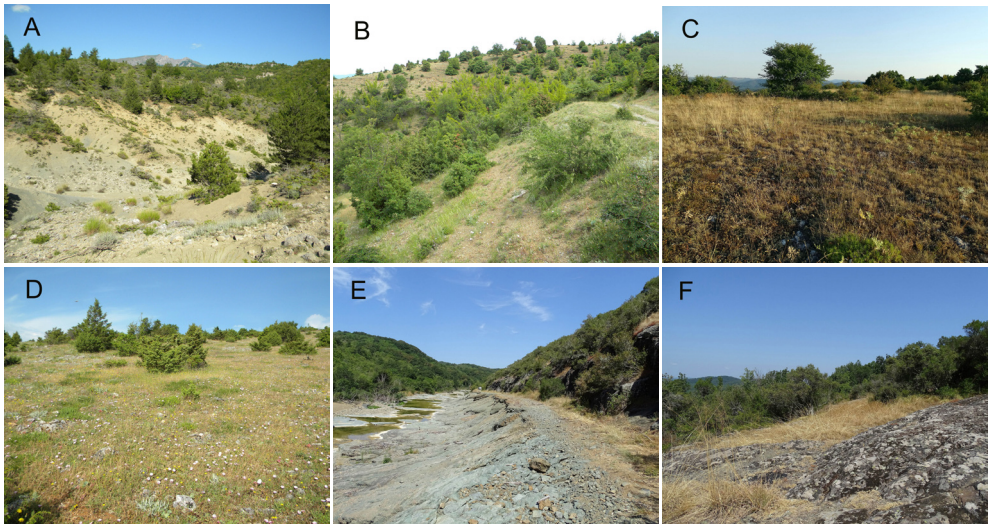

Figure 4. Habitats of *D. turcicus*: A) Gramoz Mt., Albania: meadows with stream and stony slopes with *Astracantha, J. oxycedrus* and *Quercus pubescens* near *Pinus nigra* forest. B) Melo near Kresna, Bulgaria: dry grasslands and thickets with *Juniperus oxycedrus, J. excelsa, Quercus pubescens, Paliurus* and *Pistacia terebinthus*. C) Beledie Han near Kostinbrod, Bulgaria: dry rocky grasslands on limestone. D) Eastern Rhodopes Mts., Egrek, Bulgaria: dry rocky grasslands on limestone and *Quercus-Carpinus orientalis* forest. E) Standzha Mt., Popovi Skali, Bulgaria: stony slopes near river with *Paliurus* and *Phyllirea*. Photo S. Beshkov. F) Strandzha Mt., Papiya, Bulgaria: *Quercus* forest with *Phyllirea* and *Cystus*. Photo all except (E) A. Nahirnić-Beshkova.

Figure 5. Habitats of *D. turcicus*. A) Island Brač, Dol, Zala strana, Croatia: open karstic grasslands. Photo T. Koren. B) Matka, Treska, North Macedonia: deciduous forest by lake. Photo D. Devetak. C) Pelister, North Macedonia: forest with Macedonian pine (*Pinus peuce*). Photo D. Devetak. D) Stolovi Mt., Veliki Čukar, Serbia: meadows with *Quercus* spp. and J*uniperus oxycedrus*. Photo A. Nahirnić-Beshkova.

Altitudinal preference and phenology

Seventy-two records of *D. turcicus* with altitudinal data are presented in this paper, and almost half of them (30 records, i.e. 42%) originates from altitudes between 600 and 1000 m (Fig. 6). The lowest altitude was 33 m while the highest was 2100 m. *Dilar turcicus* occurs from May to September (Fig. 7). From 116 records total, most specimens, i.e. 72% of all records, were caught in June and July.

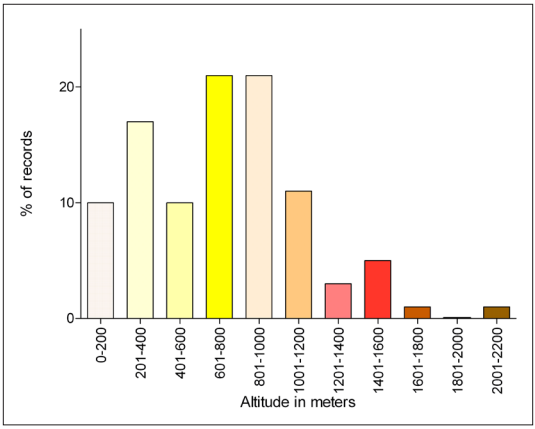

Figure 6. The altitudinal preference of *Dilar turcicus* on the Balkan Peninsula.

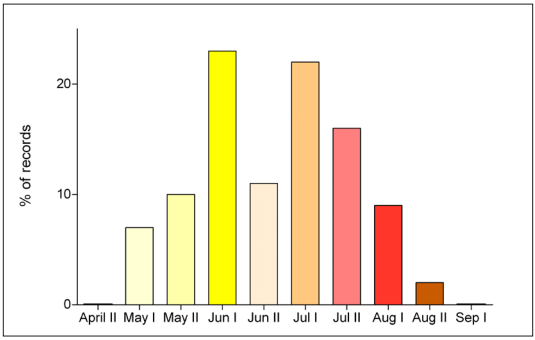

Figure 7. The phenology of *Dilar turcicus* on the Balkan Peninsula. The data were arranged in a half a month periods.

DISCUSSION

Dilar turcicus is the only pleasing lacewing species that occurs on the Balkan Peninsula. Prior to this study, it was noted in all Balkan countries except for Serbia and Slovenia (Table 1).

The records from Croatia and Serbia are especially interesting. The discoveries on the islands of Brač and Korčula represent new records for Croatia after 100 years. Although the presence of the species on Brač is already documented in the literature (Werner 1920), the findings from the island of Korčula represent only the second location or island where this species is found in Croatia. Interestingly, the species has

not been recorded at other coastal locations in Croatia, despite the extensive field efforts of the third author, who trapped moths across the country during the last ten years. It is worth mentioning that almost a hundred specimens were collected from the island of Brač. Additionally, research using light traps has proven to be an effective method for recording this species, and we recommend its use in future studies.

The ecology of *D. turcicus* is poorly known (Aspöck et al., 2015). The characteristic habitat seems to be shady places with abundant low vegetation, bushes and trees, often near stone walls with numerous crevices convenient for pupation (Aspöck et al., 2015 and this paper).

Never before has such a large number of records been analyzed to study the phenology and altitudinal preferences of *D. turcicus* as in our study here. By comparison, among 6 Iberian dilarid species, two species, namely *Dilar meridionalis* Hagen, 1866 and *D. pumilus* Navás, 1903 have a very similar altitudinal occurrence (15-2500 m; 10-2300 m) and phenology (from May to September; from May to July) (Monserrat, 2014, 2022).

CONCLUSION

The study on *Dilar turcicus* significantly expands the knowledge of its distribution, ecology, and phenology on the Balkan Peninsula. During this research, 26 new localities were recorded across six countries, including the first record for Serbia and new locations in Croatia after more than 100 years. The findings highlight the species' preference for shaded habitats with low vegetation and rocky areas, with most specimens collected at altitudes between 600 and 1000 m and during June and July. High population densities observed at certain sites confirm the existence of stable populations, while light trapping proved to be an effective method for studying this rare species. Further research focusing on habitat specificity and seasonal occurrence could provide additional insights and contribute to the conservation and understanding of this species.

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