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The biting midge *Forcipomyia paludis* (Macfie, 1936) (Diptera: Ceratopogonidae) in Slovenia, Bosnia and Herzegovina, Croatia and Sweden

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Abstract. Records of the biting midge *Forcipomyia paludis* (Macfie, 1936) from Slovenia and Bosnia and Herzegovina are reported herewith as the first finds of *F. paludis* in both countries, together with new records from Croatia and Sweden. This biting midge is a temporary ectoparasite of dragonfly imagines and the only ceratopogonid species known in Europe to feed specifically on this insect group. *Forcipomyia paludis* is already known in 18 European countries. Prior to this report, *F. paludis* was known to infest 67 dragonfly species in Europe. Thirteen dragonfly imagines from 11 sites in Slovenia, 27 imagines from 13 sites in Bosnia and Herzegovina and six imagines from two sites in Croatia having *F. paludis* on their wings were recorded. Additional data for 50 imagines from 15 sites in Sweden are also presented. In Slovenia, the species is known to occur in the Gorenjska, Goriška Brda, Vipava River Valley, Coastal-Karst region, Central Slovenia, Kočevska region and Bela krajina, while in Bosnia and Herzegovina it is known only from south Herzegovina (Ljubuški, Čapljina, Mostar and Stolac areas). In Croatia, the species is present in several parts of the country, while in Sweden it occurs only in the southern and middle parts of the country (Skåne, Öland, Gotland, Göteborg and Gävle). Six new dragonfly host species and the northernmost occurrence of *F. paludis* are also reported.

Key words: *Forcipomyia paludis*, Diptera, Ceratopogonidae, biting midge, parasite, Odonata, dragonflies, distribution

Izvleček. Kačjepastirska mušata *Forcipomyia paludis* (Macfie, 1936) (Diptera: Ceratopogonidae) v Sloveniji, Bosni in Hercegovini, na Hrvaškem in Švedskem – Za Slovenijo ter Bosno in Hercegovino so prvič predstavljene najdbe kačjepastirske mušate *Forcipomyia paludis* (Macfie, 1936), skupaj z novimi najdbami na Hrvaškem in Švedskem. Kačjepastirska mušata je začasen zunanji zajedavec na odraslih kačjih pastirjih (Odonata) in edina vrsta mušate v Evropi, ki se hrani specifično na tej skupini žuželk. Vrsta je doslej znana iz 18 evropskih držav. V Evropi je znanih že 67 vrst kačjih pastirjev, ki jih kačjepastirska mušata zajeda. Poročamo o najdbah *F. paludis* na 13 odraslih kačjih pastirjih z 11 lokacij v Sloveniji, 27 odraslih s 13 lokacij v Bosni in Hercegovini ter šestih odraslih z dveh lokacij na Hrvaškem. Zabeležene so tudi najdbe kačjepastirske mušate na 50 kačjih pastirjih s 15 lokalitet na Švedskem. V Sloveniji je vrsta znana z Gorenjske, iz Goriških Brd, Vipavske doline, obalno-kraške regije, osrednje Slovenije, Kočevske in Bele krajine. V Bosni in Hercegovini je bila zabeležena le v južni Hercegovini (Ljubuški, Čapljina, Mostar in Stolac), medtem ko je bila na Hrvaškem ugotovljena na več mestih po državi. Na Švedskem je bila zabeležena v južnem in osrednjem delu države (Skåne, Öland, Gotland, Göteborg in Gävle). Poročamo tudi o šestih novih vrstah kačjih pastirjev kot gostiteljev in najbolj severni najdbi kačjepastirske mušate.

Ključne besede: *Forcipomyia paludis*, Diptera, Ceratopogonidae, mušata, zajedavec, Odonata, kačji pastirji, razširjenost

Introduction

Small insects that seemed to be stuck on dragonfly wings were noticed for the first time in 2016 on photos of two dragonfly species taken in Slovenia in previous years. They were subsequently identified as dragonfly-biting midge *Forcipomyia paludis* (Macfie, 1936) (Diptera: Ceratopogonidae), and this encouraged the careful check of numerous other dragonfly photos for presence of these animals. This temporary ectoparasitic small insect species is known to suck haemolymph from the veins of the dragonfly wings (Wildermuth & Martens 2007). As *F. paludis* is not yet known to attack other insects, Martens et al. (2008) concluded that it is a parasite specific to the Odonata. With respect to their choice of host species, *F. paludis* is opportunistic (Wildermuth & Martens 2007). Their females have been reported to be attached to the wings or thorax of many dragonfly species (Martens et al. 2008). They mostly cling to near the wing bases, thus minimizing the centrifugal forces to which they are exposed during wing beats (Wildermuth & Martens 2007). Also, the main veins near the bases are thicker and contain more haemolymph than those in the distal sections, thus yielding a better food supply for the parasite (Wildermuth & Martens 2007). Usually, each dragonfly individual is harbouring a few to a dozen parasites (Manger & van der Heijden 2016), although strikingly, Clastier et al. (1994) reported from France 169 biting midges on a single *Libellula quadrimaculata* individual. Curiously enough, the feeding action of *F. paludis* does not seem to leave visible lesions on the host's integument (Wildermuth & Martens 2007). When catching dragonflies with the insect net, *F. paludis* commonly leaves its host (Martens et al. 2008).

Due to their small size of 1.8 mm (Wildermuth & Martens 2007), *F. paludis* is almost always overlooked during field work, but recognized later on the photographs of dragonflies (Manger & van der Heijden 2016). The midges are quite easily identified on the photographs. When they are attached to the underside of the dragonfly wings, a brown, or sometimes reddish brown, stain is visible. Their head is black and the brown abdomen covered by two colourless wings. The wings are not projected beyond the abdomen tip (Wildermuth 2012). Potential development sites of *F. paludis* larvae are swamp areas with larger water bodies (such as lakes), but also peat bogs (Martens et al. 2012). It is still unclear when *F. paludis* attach themselves to dragonflies, but possibly they prefer freshly hatched teneral and juvenile individuals, whose cuticle has not yet hardened (Wildermuth 2012). Apart from *F. paludis*, other groups of Diptera may also be associated with the dragonfly imagines (Martens et al. 2008).

This paper reports on the first records of *F. paludis* in Slovenia and Bosnia and Herzegovina. Additionally, new data for Croatia and Sweden are presented. New dragonfly species as host and the northernmost occurrence of *F. paludis* are also reported. We propose a Slovene vernacular name.

Materials and methods

This study is based on the inspection of photographs. As no biting midge other than *F. paludis* has so far been reported to be associated with European Odonata (Martens et al. 2008), all records of biting midge presence were included in the analysis as *F. paludis*. In search of both published and new records in Slovenia, the national odonatological bulletin Erjavecia, published by the Slovene Dragonfly Society, and three Slovenian public databases were investigated, together with personal archives of several colleagues. From Foto-narava (2017), 1954 dragonfly photos were investigated; further 1103 photos came from BioPortal (2016) and 326 photos from the Database of Invertebrate Pictures (2017). Also, the Facebook group Metulji in kačji pastirji / Butterflies & Dragonflies / Leptiri i vretenci (2017), where mostly authors from Slovenia and Croatia post their photos, was checked. The authors of photographs recording an apparent presence of *F. paludis* were asked to send their original photo with detailed locality information. None were aware of the presence of *F. paludis* in their photos. Additional photographs were taken by the first author or submitted by other colleagues, while four records are based on personal observations of the first author. From Bosnia and Herzegovina, several thousand photographs of dragonflies from all parts of the country were checked. These photographs were taken mainly by the second author, in the period between 2009 and 2016. For Sweden, besides the individual work of the first three authors, also more than 6000 photos (taken in the periods: June–August in 2013, 2014 and 2015, and all the photos taken in 2016) in the citizens' science Swedish Species Observation System – Artportalen (ArtDatabanken 2017), the Entomological Collections at the Swedish Natural History Museum in Stockholm (Naturarv 2017) and the archives of the Swedish Dragonfly Society were checked.

All material was analysed with respect to date, locality, host species and its sex, as well as number, orientation and position of biting midges on the host's body. The coordinates of the localities were taken from Google maps (2017), and their altitudes from DaftLogic (2017). The following orientations of *F. paludis* were differentiated: towards the host's body, facing the wing tip, parallel with the host's body (facing the costae), and facing the posterior edge of the wing. The position of midges was classified with respect to the fore- and hind wing, upper- or lower side of the wings, basal or distal half of the wings or the nodal part of the wings.

In English, we refer to the species with Latin name only, while in Slovenian, we use also vernacular name. We propose this new name to be »kačjepastirska mušata«, according to the biology of *F. paludis*, being specialized parasite of Odonata.

Results

In total, 95 new records of *F. paludis* attached to Odonata are provided (Tab. 1, 2), with additional two specimens from one site (L.40, Tab. 1) found in a museum collection. We also analysed five previously published records of *F. paludis* from three sites (L.27, L.28, L.38, Tab. 1) (see also below).

Slovene and Swedish public databases proved to be a valuable source of information: six records of *F. paludis*' presence were confirmed from Foto-narava and BioPortal combined, and further 39 records came from Artportalen. At least three records in Artportalen are the result of a blog post by the third author (Billqvist 2014) with the intention to raise awareness of *F. paludis* in Sweden. One additional record from Foto-narava from user AK (2016) with *Orthetrum brunneum* as a host of one *F. paludis* individual was established, but had to be excluded from further study as we were not able to obtain the locality information of the photo – allegedly it was taken in Slovenia. One record in Croatia was discovered on the photo published in the bulletin Erjavecia (Bedjanič 2015).

Five already published records of *F. paludis* from Croatia and Sweden (L.27, L.28, L.38, Tab. 1) lacked the data on the host' species or on the parasite's position/orientation in published sources (Sandhall 2000, Martens et al. 2008, Billqvist 2014) and are therefore included in this study with additional information. Furthermore, *F. paludis* also occurs on the island of Gotland, from where two specimens are stored in the Entomological Collections at the Swedish Natural History Museum in Stockholm (Naturarv 2017). Both individuals were collected at the same site (L.40, Tab. 1) on two separate occasions (12.6.2011, 10.7.2011). We were not able to check this museum collection ourselves and the information whether the individuals were collected alone or attached to the host was not available. Hence, these specimens were not included in further analyses.

On most sites, the biting midges were found on single dragonfly individuals (Tab. 1). Of the sites of *F. paludis* on the Balkan Peninsula, 11 are in Slovenia, 13 in Bosnia and Herzegovina, and two new sites in Croatia – on Pag Island and near the southern border with Bosnia and Herzegovina (Fig. 1). In Sweden, two sites are located in the Skåne province, one near Göteborg, one near Gävle at the northern border of the Uppsala province, nine localities are clustered on Öland Island and two on Gotland Island (Fig. 1). Records from Slovenia are from the end of May to late July, while those from Bosnia and Herzegovina are from early May to early July (Tab. 2). Data from Croatia were collected from the end of June to early September, while data from Sweden are from early June to early August.

Altitudinal distribution varied between 0 and 540 m above sea level. Data of *F. paludis* were recorded in or near 25 lentic and 16 lotic habitats, while other sites were not at water bodies. Habitats were diverse, as given in Tab. 1.

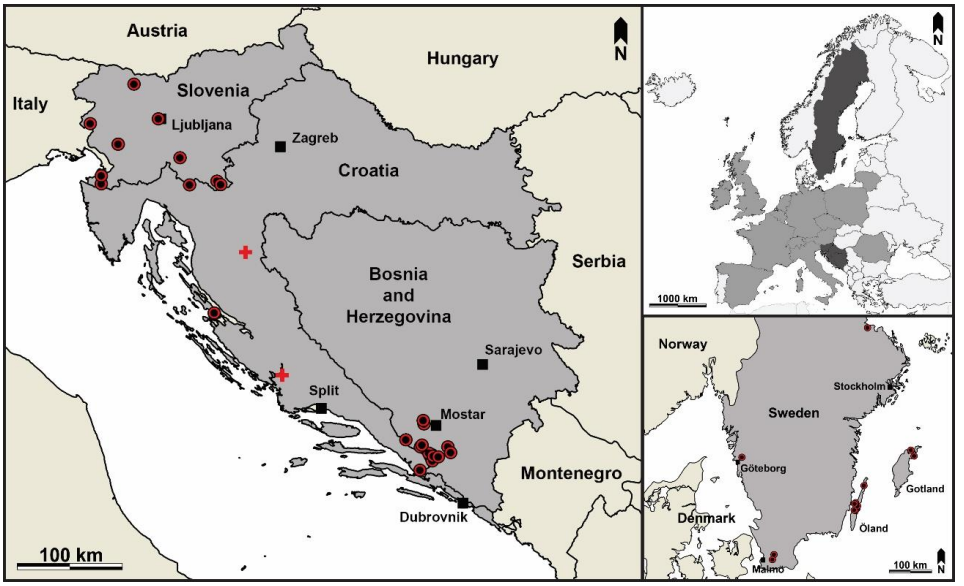

Figure 1. Known sites of *Forcipomyia paludis* in Slovenia, Bosnia and Herzegovina, Croatia (left) and Sweden (bottom right) with known European distribution (top right; countries with confirmed *F. paludis* presence are shaded). For the Balkans, new findings are shown with dots, and the previously published ones with crosses.

Slika 1. Lokacije kačjepastirske mušate (*Forcipomyia paludis*) v Sloveniji, Bosni in Hercegovini, na Hrvaškem (levo) in Švedskem (spodaj desno), z označeno razširjenostjo v Evropi (zgoraj desno: osenčene so države s potrjenimi najdbami kačjepastirske mušate). Za Balkan so s pikami označene nove najdbe, s križcem pa že znane iz objavljene literature.

Table 1. A list of the localities with records of *Forcipomyia paludis* in Slovenia, Croatia, Bosnia and Herzegovina and Sweden. For localities 4, 5, 27, 28 and 40, only approximate coordinates are given. Localities 27 and 28 are derived from Martens et al. (2008), locality 40 from Naturarv (2017). Abbreviations: L – number of locality, lat./lon. – latitude and longitude in WGS84 decimal degrees, Alt. – altitude, N_{Fp} – number of dragonflies infested with *F. paludis*.

Tabela 1. Seznam lokalitet v Sloveniji, na Hrvaškem, v Bosni in Hercegovini ter na Švedskem z najdbami kačjepastirske mušate (*Forcipomyia paludis*). Za lokalitete 4, 5, 27, 28 in 40 je podan približen geografski položaj. Lokaliteti 27 in 28 sta povzeti po Martens et al. (2008), lokaliteta 40 po Naturarv (2017). Okrajšave: L – številka lokalitete, lat./lon. – geografska širina in dolžina v WGS84 decimalnih stopinjah, Alt. – nadmorska višina, N_{Fp} – število kačjih pastirjev, okuženih s *F. paludis*.

L	Nearest city	Exact locality	Coordinates (lat./lon.)	Alt. [m]	N_{Fp}
Slovenia					
1	Bled	Šobčev bajer Lake, next to Šobec Autocamp	46.353804, 14.150758	425	1
2	Črnomelj	Meadow in Nerajske luge Nature Reserve	45.509402, 15.194878	150	1
3	Črnomelj	Kršeljivec Karst pond, near Hrast pri Vinici	45.477386, 15.240999	250	2
4	Kočevje	Hiking trail near Topli jarek Stream on Planina Kosa Mountain	45.476130, 14.853554	295	1
5	Kočevje	Ribnica River Valley	45.713331, 14.735428	485	1

L	Nearest city	Exact locality	Coordinates (lat./lon.)	Alt. [m]	N_{Fp}
6	Koper	Pinjevec Stream near Koštabona	45.477177, 13.759042	90	1
7	Koper	Brackish swamp in Škocjanski zatok Nature Reserve	45.548932, 13.755418	0	1
8	Ljubljana	Glinščica Stream	46.052821, 14.460757	300	1
9	Nova Gorica	Small pond at Podsabotin	46.002844, 13.607091	280	1
10	Vipava	Gacka Stream at Mlake pri Vipavi	45.827799, 13.962007	115	1
11	Vipava	Fishpond at Mlake pri Vipavi	45.827465, 13.962174	115	1
Bosnia and Herzegovina					
12	Čapljina	Nature Park Hutovo blato, Svitava	43.030278, 17.744167	5	4
13	Čapljina	Nature Park Hutovo blato, Karaotok near Hotel	43.063889, 17.755278	5	6
14	Čapljina	Nature Park Hutovo blato, Karaotok north-east from Hotel	43.068979, 17.755726	0	2
15	Čapljina	Nature Park Hutovo blato, above Lake Deransko	43.058619, 17.824150	55	2
16	Čapljina	Nature Park Hutovo blato, Škrka Lake	43.084431, 17.741653	5	3
17	Čapljina	Neretva River at Struge	43.094009, 17.707071	5	1
18	Ljubuški	Kravice Waterfall	43.156363, 17.608618	45	1
19	Ljubuški	Muratovac Canal at Ljubuško polje	43.216531, 17.436043	65	1
20	Ljubuški	Studenci, spring	43.169555, 17.627819	35	2
21	Mostar	Mostarsko blato, Lištica River and pond near the football camp	43.353056, 17.659167	235	1
22	Mostar	Mostarsko blato, Gnjilište, small lake	43.384167, 17.653333	280	1
23	Stolac	Hodovo, pond	43.147500, 17.935278	405	1
24	Stolac	Bregava River near Stolac	43.095556, 17.967500	80	2
Croatia					
25	Opuzen	Above Kuti Lake	42.951389, 17.595556	190	5
26	Pag	Velo blato Lake	44.356321, 15.156547	0	1
27	Plitvički Ljeskovac	Plitvička jezera National Park	44.879597, 15.617581	540	1
28	Šibenik	Krka National Park	43.803081, 15.964437	45	2

L	Nearest city	Exact locality	Coordinates (lat./lon.)	Alt. [m]	N_{Fp}
Sweden					
29	Öland, Färjestaden	Vanserums dammar Pond	56.689165, 16.654557	20	6
30	Öland, Färjestaden	Fishponds near Vanserum	56.691332, 16.640837	20	1
31	Öland, Färjestaden	Stream south from Spjutterumsvägen, near Vanserum	56.696767, 16.630516	20	1
32	Öland, Färjestaden	Tveta, Skogslund, stream	56.645941, 16.589547	30	1
33	Öland, Färjestaden	Meadows and forest edge at Hönstorp	56.658179, 16.547722	40	1
34	Öland, Högby	Several sites around Hornsjön Lake, the lake and its outflow	57.183654, 16.959556	5	18
35	Öland, Långlöt	Vitkärret Alby Pond	56.746978, 16.684886	25	2
36	Öland, Rälla	Greby stenbrott dammar Ponds	56.816323, 16.607173	35	2
37	Öland, Rälla	Forrest edge at Halltorps hage	56.794664, 16.570755	5	1
38	Skåne, Lund	Several sites close to Stensoffa by Krankesjön Lake	55.697734, 13.449883	20	13
39	Skåne, Lund	Peatbog south from Genarp	55.587637, 13.389524	60	1
40	Gotland, Fleringe	Bästeträsk Swamp	57.903233, 18.898806	10	NA
41	Gotland, Furilden	Furillen kalkbrott Ponds	57.772098, 19.011244	10	1
42	Göteborg, Angered	Lärjeåns dalgång, stream	57.773928, 12.068767	45	1
43	Gävle	Skandiavägen, stream	60.588166, 17.313653	25	1

Altogether, nine species of Zygoptera and 26 species of Anisoptera from nine families were found to harbour *F. paludis* (Tab. 2). The majority of these species are typical of lentic ecosystems. First evidences of six new dragonfly species being hosts are presented here: *Aeshna affinis*, *Lindenia tetraphylla*, *Cordulegaster heros*, *Libellula depressa*, *Selysiothemis nigra* and *Sympetrum flaveolum* (Tab. 2). Out of 98 host individuals, 63 were males and 33 females (the majority being mature imagines and only 11 juveniles, no parasitized teneral individual was found). Two parasitized females were caught in the mating wheel (copula), where only the females were infected. We were not able to identify the sex of two hosts as only a small portion of their body was visible on the photographs.

Table 2. A list of dragonfly species from Slovenia, Bosnia and Herzegovina, Croatia and Sweden with *Forcipomyia paludis* attached. Abbreviations: Fp – number of *F. paludis* parasitizing a dragonfly individual, L – number of locality in Tab. 1. Asterisk (*) denotes species included in Martens et al. (2008). Dragonfly species noted for the first time to host *F. paludis* are printed in bold.

Tabela 2. Seznam vrst kačjih pastirjev iz Slovenije, Bosne in Hercegovine, Hrvaške ter Švedske, ki so gostitelji kačjepastirske mušate (*Forcipomyia paludis*). Okrajšave: Fp – število kačjepastirskih mušat na posameznem osebku, L – številka lokalitete kot v Tab. 1. Z zvezdico (*) sta označeni vrsti iz Martens et al. (2008). Nove vrste kačjih pastirjev kot gostiteljev kačjepastirske mušate so zapisane v krepkem tisku.

Host species	Fp	L	Date	Dragonfly observed (photo) by
LESTIDAE				
Lestes sponsa	2	34	25.6.2014	Mats Aldrin
Sympecma fusca	2	29	19.7.2016	Damjan Vinko
CALOPTERYGIDAE				
Calopteryx splendens	3	38	NA	Sandhall (2000)
C. s. balcanica	2	12	19.5.2011	Dejan Kulijer
Calopteryx virgo	1	42	12.6.2014	Leif Andersson
	1	43	4.7.2015	Göran Persson
COENAGRIONIDAE				
Coenagrion ornatum	1	8	16.6.2016	Damjan Vinko
Coenagrion puella	1	5	11.6.2010	AK (2016)
	1	16	9.5.2012	Dejan Kulijer
Coenagrion pulchellum	1	13	15.5.2013	Dejan Kulijer
	1	29	19.7.2016	Dejan Kulijer
	1	34	7.7.2013	Mats Aldrin
Ischnura elegans	2	16	8.7.2012	Jan-Joost Mekkes
	1	29	19.7.2016	Dejan Kulijer
	1	41	7.7.2014	Raimo Neergaard
PLATYCNEMIDIDAE				
Platycnemis pennipes	1	2	25.7.2008	Dušan Klenovšek
*	1	28	July 2003	Roland Bönisch
*	1	28	July 2003	Roland Bönisch
AESHNIDAE				
Aeshna affinis	1	13	27.6.2013	Dejan Kulijer

Host species	Fp	L	Date	Dragonfly observed (photo) by
Aeshna cyanea	1	34	12.7.2013	Mats Aldrin
	3	37	2.7.2015	Gunnar Bohman
	18	38	25.7.2012	Raimo Neergaard
	3	38	11.7.2016	Sven Jönsson
	3	38	11.7.2016	Sven Jönsson
Aeshna grandis	46	29	14.7.2010	Staffan Kyrk
	2	30	19.7.2016	Damjan Vinko
	4	34	12.7.2014	Mats Aldrin
	16	34	12.7.2014	Mats Aldrin
	5	38	14.6.2014	Sven Jönsson
	8	38	14.6.2014	Sven Jönsson
Aeshna isoceles	3	9	25.7.2014	Bojan Zadravec
	2	13	27.6.2013	Dejan Kulijer
	1	13	27.6.2013	Dejan Kulijer
	5	34	7.7.2013	Mats Aldrin
	3	34	12.7.2013	Mats Aldrin
	2	34	27.6.2014	Mats Aldrin
	2	36	28.6.2016	Leif Dehlin
	7	36	28.6.2016	Leif Dehlin
Anax imperator	3	1	5.6.2015	Bojan Bratož
	4	7	16.7.2013	Miroslav Kastelic
	1	11	31.5.2015	Damjan Vinko
	1	23	10.6.2011	Dejan Kulijer
	2	25	30.8.2012	Dejan Kulijer
Brachytron pratense	2	15	26.5.2014	Damjan Vinko
	4	24	7.6.2012	Dejan Kulijer
GOMPHIDAE				
Gomphus vulgatissimus	1	12	1.5.2017	Dejan Kulijer
	6	18	5.6.2008	Ilija Šarčević
Onychogomphus forcipatus	1	6	22.6.2013	Miroslav Kastelic
Lindenia tetraphylla	5	25	30.8.2012	Dejan Kulijer
	2	26	27.6.2015	Bedjanič (2015)

Host species	Fp	L	Date	Dragonfly observed (photo) by
CORDULEGASTRIDAE				
Cordulegaster heros	5	4	6.7.2015	Bojan Bratož
	1	10	12.7.2011	Damjan Vinko
	4	20	21.6.2014	Ivana Sučić
	3	20	7.7.2012	Jan-Joost Mekkes
CORDULIIDAE				
Cordulia aenea	2	34	12.7.2013	Mats Aldrin
Somatochlora flavomaculata	3	34	7.7.2013	Mats Aldrin
	2	38	9.7.2010	Magnus Persson
LIBELLULIDAE				
Crocothemis erythraea	9	14	25.5.2014	Ana Tratnik
Libellula quadrimaculata	4	34	7.7.2013	Mats Aldrin
	5	39	13.7.2012	Sigvard Svensson
Libellula depressa	1	22	8.6.2012	Dejan Kulijer
Libellula fulva	35	15	26.5.2014	Damjan Vinko
	2	19	21.6.2014	Dejan Kulijer
Orthetrum albistylum	1	3	23.7.2015	Damjan Vinko
	6	12	19.5.2011	Dejan Kulijer
Orthetrum cancellatum	1	3	28.7.2015	Damjan Vinko
	1	14	25.5.2014	Ana Tratnik
	1	17	24.6.2014	Dejan Kulijer
	1	21	8.6.2012	Dejan Kulijer
	1	34	7.7.2013	Mats Aldrin
	8	34	27.6.2014	Mats Aldrin
	1	38	1.6.2014	Stefan Cherrug
Orthetrum coerulescens	12	12	24.5.2017	Dejan Kulijer
*O. c. anceps**	1	27	July 2003	Roland Bönisch
Leucorrhinia pectoralis	1	35	18.6.2013	Ingemar Alenäs
	2	35	18.6.2013	Ingemar Alenäs
	1	38	16.7.2006	Erland R. Nielsen
	3	38	20.6.2008	Billqvist (2014)
	15	38	18.6.2016	Magnus Billqvist

Host species	Fp	L	Date	Dragonfly observed (photo) by
Selysiothemis nigra	1	25	29.8.2012	Dejan Kulijer
Sympetrum danae	1	31	19.7.2016	Damjan Vinko
Sympetrum flaveolum	2	32	4.7.2005	Jörg Adelmann
	1	33	30.6.2015	Gunnar Bohman
	1	34	2.8.2013	Lars Bergendorf
Sympetrum fonscolombii	2	25	30.8.2012	Dejan Kulijer
Sympetrum sanguineum	3	13	27.6.2013	Dejan Kulijer
	1	34	7.7.2013	Mats Aldrin
	3	34	7.7.2013	Mats Aldrin
	1	34	8.7.2013	Mats Aldrin
	1	34	11.7.2014	Lars Bergendorf
	3	38	12.7.2011	Martin Andersson
	6	38	21.6.2014	Sven Jönsson
Sympetrum striolatum	6	12	24.5.2017	Dejan Kulijer
	1	16	25.5.2014	Damjan Vinko
	1	24	7.6.2012	Dejan Kulijer
	1	25	7.9.2012	Dejan Kulijer
	5	29	19.7.2016	Dejan Kulijer
	1	29	19.7.2016	Dejan Kulijer

In Zygoptera, the maximum number of midges per host individual was three, whereas in Anisoptera the number reached 35 (Fig. 2) and 46 midges per host. The parasite load proved to be mostly low; 44% of infested individuals were harbouring one parasitic midge. Only in rare cases (14%) more than five midges were observed on a single host. With one exception, all midges were attached to the host's wings. One individual was positioned on the male secondary genitalia and was not considered as attached. As the picture of an infested *Aeshna grandis* from 14.7.2010 was not acquired in high resolution, not all of *F. paludis* were accounted for in the analysis of the parasites' position, as possible wrong outputs could be made. In both suborders, the majority of midges (95%) were facing towards the wing base, 3% faced towards the posterior edge of the wing. The position on the wings differed between the suborders. In Anisoptera the upper side of the wing and the hind wing was predominant (62% of the midges were found on the upper side of the wings and 56% on the hind wings), while in Zygoptera the fore wing was favoured (91% of the midges were found on the front wings) and 88% of the midges were found on the upper side of the wing. In Anisoptera, 89% of the midges were located in the basal half of the wings, 3% were in the distal half and 8% were around the nodus. In Zygoptera, almost half of all midges were located in the basal half of the wing (46%) (Fig. 3), while the other two positions on the wings were more equally represented (distal half 25% and around the nodus 29%).

Figure 2. Three *Forcipomyia paludis* on *Sympetrum sanguineum* (L.13, Tab. 1) (top left), 15 on *Leucorrhinia pectoralis* (L.38, Tab. 1) (top right), 35 on *Libellula fulva* (L.15, Tab. 1) (bottom left) and 12 on *Orthetrum coerulescens* (L.12, Tab. 1) (bottom right) (photos: D. Kulijer, M. Billqvist, D. Vinko).
Slika 2. Tri kačjepastirske mušate (*Forcipomyia paludis*) na krilih krvavordečega kamenjaka (*Sympetrum sanguineum*) (L.13, Tab. 1) (zgoraj levo), 15 na dristavičnem spreletavcu (*Leucorrhinia pectoralis*) (L.38, Tab. 1) (zgoraj desno), 35 na črnem ploščcu (*Libellula fulva*) (L.15, Tab. 1) (spodaj levo) in 12 na malem modraču (*Orthetrum coerulescens*) (L.12, Tab. 1) (spodaj desno) (foto: D. Kulijer, M. Billqvist, D. Vinko).

Figure 3. Two *Forcipomyia paludis* on *Sympecma fusca* on Öland Island in Sweden (L.29, Tab. 1) (photo: D. Vinko).
Slika 3. Kačjepastirski mušati (*Forcipomyia paludis*) na prisojnem zimniku (*Sympecma fusca*) na otoku Öland na Švedskem (L.29, Tab. 1) (foto: D. Vinko).

Discussion

The known distribution of *F. paludis* in Europe is still scattered, since observations are made by chance encounters such as the reports in this paper. However, *F. paludis* is already known from several European countries, with most records coming from the areas between southern France, Switzerland and southern and eastern Germany (Martens et al. 2008, 2012, Wildermuth 2012), from where more than 50 observations are reported from each respective country. In the rest of Europe, except for the countries examined in this report, the records are scarcer. The species has been recorded in France, Germany, England, Austria, Sweden, Switzerland and Croatia (Martens et al. 2008, 2012, Martens 2012, Telfer 2009, Wildermuth 2012) as well as in Poland (Dominiak & Michalczuk 2009), the Czech Republic (Černý 2014), Ireland (Donnithorne 2010), the Netherlands (Manger & Martens 2013, Manger & van der Heijden 2016), Belgium (Claerebout 2013), Lithuania (Leuthold & Wildermuth 2014), Sardinia in Italy (Dell'Anna et al. 1995) and the Balearic Islands in Spain (Nielsen et al. 2014). In Sweden, two published records from Krankesjön in the southwestern part of the country exist (Sandhall 2000, Billqvist 2014). *Forcipomyia paludis* was also recorded in Romania, although as an individual and not as a parasite on a dragonfly's body (Remm 1988). Prior to this report, the known European distribution of *F. paludis* as a parasite on dragonflies is shown by Manger & van der Heijden (2016).

In Slovenia, the species is currently known from seven different (micro)regions spreading from the northwest to the southeast of the country: Gorenjska, Goriška Brda, Vipava River Valley, the Coastal-Karst region, Central Slovenia, Kočevska region and Bela krajina. Interestingly enough, despite the fact that the dragonfly photographs from all parts of Bosnia and Herzegovina were examined, only records from southern Herzegovina, a Mediterranean part of the country, have been known so far. In Croatia, *F. paludis* is known from three sites in Dalmatia and one in continental Croatia. In Sweden, it is known from the southern provinces of Skåne and Västergötland, from Öland and Gotland Islands, and from the middle part of the country from the northern border of Uppsala province. From this site near Gävle (L.44, Tab. 1), the northernmost siting of *F. paludis* in Europe comes from. In seven sites (L.12, L.13, L.16, L.20, L.29, L.34, L.38, Tab. 1), *F. paludis* was between the years discovered on several occasions, therein we conclude it successfully reproduces in at least those sites.

Our results represent the first evidence of six additional dragonfly species as hosts. In Europe up to now, 67 dragonfly species have been known as hosts of *F. paludis* (Martens et al. 2008, Martens 2012, Wildermuth 2012, Manger & van der Heijden 2016). Among them, 53 species are also represented in the fauna of Slovenia and 48 in Bosnia and Herzegovina. In Slovenia, nine dragonfly species are currently proven to be hosting biting midges, 18 species in Bosnia and Herzegovina and in Sweden, and seven in Croatia. Although no significant preference for any dragonfly taxon as host of *F. paludis* can be demonstrated (Martens et al. 2008), new host species will certainly be included in future reports. In Europe, a total of 73 dragonfly species are now documented with *F. paludis* attached to their body.

Forcipomyia paludis has been observed in Europe from the beginning of May until the beginning of September, although one record in March exists (Wildermuth 2012). This corresponds to the main flight season of dragonflies in the greater part of Europe, which lasts from early May to late September. Our findings coincide with this period. The frequencies of different positions and orientations of midges on the dragonfly wings observed in this study are similar to those described by Martens et al. (2008), where the reasons for these positions and orientations are also described briefly.

Except for four records from Slovenia and two from Sweden, all sightings of *F. paludis* in Slovenia, Bosnia and Herzegovina, Croatia and Sweden are based on photographs. Reference material still has to be collected and stored into 70% ethanol. In the near future, we hope to sample *F. paludis* from dragonflies to formally identify the species and to store specimens in museum collections. As observations of *F. paludis* are mostly coincidental, the species is likely to be found in more areas. We suspect that checking additional dragonfly photo archives will yield additional records of *F. paludis*. Thanks to our report, we are approaching the complete picture of the species distribution in Europe, where reports from Norway, Denmark, Finland, Estonia, Latvia, Belarus, Ukraine, Hungary, Slovakia, other countries on the Balkan Peninsula, Portugal as well as from other regions with already confirmed presence of *F. paludis* are still anticipated. Therefore, we invite everyone to carefully re-examine their photographic archives.

Povzetek

Kačjepastirska mušata *Forcipomyia paludis* (Macfie, 1936) (Diptera: Ceratopogonidae) je začasen zunanji zajedavec na odraslih kačjih pastirjih in edina vrsta mušate v Evropi, katere samice se hranijo s hemolimfo specifično na tej skupini žuželk (Martens et al. 2008). Na posameznem kačjem pastirju največkrat najdemo od par do ducat kačjepastirskih mušat. Zaradi njihove majhnosti (1,8 mm) jih pri terenskem delu pogosto spregledamo. Večino podatkov o njihovi razširjenosti tako dajejo fotografije, kar velja tudi za našo raziskavo. Kačjepastirske mušate na fotografijah prepoznamo kot ovalne temnejše pike na krilih kačjih pastirjev. Njihov abdomen je temno rjav, s spodnje strani pa rjav do rdečkasto-rjav. Imajo črno glavo in dvoje nepigmentiranih kril, ki bistveno ne presegajo dolžine zadka. Antene so krajše. Na krilih kačjih pastirjev lahko sicer najdemo tudi druge dvokrilce (Diptera) in pršice (Acarina).

Na podlagi terenskih in fotografskih podatkov avtorjev ter pregleda javno objavljenih fotografij ali zbirk podatkov (Foto-narava, BioPortal, Podatkovna zbirka fotografij nevretenčarjev, Artportalen, Naturarv, ipd.) poročamo o 95 novih podatkih o kačjepastirski mušati v štirih državah. Vrsto smo zabeležili na 11 lokacijah v Sloveniji, 13 v Bosni in Hercegovini, kjer je vrsta nova za favni držav, ter na 15 lokacijah na Švedskem in na dveh novih lokacijah na Hrvaškem. Podajamo tudi natančnejše informacije o petih že objavljenih podatkih vrste za Hrvaško in Švedsko. Osebki kačjih pastirjev so na sebi imeli od enega do 46 zajedavcev. V Sloveniji smo kačjepastirsko mušato zabeležili na Gorenjskem, v Goriških Brdih, Vipavski dolini, obalno-kraški regiji, osrednji Sloveniji, na Kočevskem in v Beli krajini. Navkljub pregledu več tisoč fotografij kačjih pastirjev s celotnega območja Bosne in Hercegovine smo kačjepastirsko mušato zabeležili le v južni Hercegovini. Na Švedskem je bila vrsta najdena v več delih na jugu države (Skåne, Göteborg, otoka Öland in Gotland) in v njenem osrednjem delu (Gävle), iz Hrvaške pa je znana s treh lokacij v Dalmaciji in ene v celinskem delu države. O pojavljanju kačjepastirske mušate poročajo še iz Anglije, Irske, Belgije, Nizozemske, Francije, Nemčije, Poljske, Češke, Litve, Švice, Balearskega otočja v Španiji, Romunije, Sardinije v Italiji in iz Avstrije (Martens et al. 2008, Manger & van der Heijden 2016). Poročamo o najbolj severnem pojavljanju vrste, ki se sicer po Evropi pojavlja med majem in septembrom.

Pred tem poročilom je bilo v Evropi znanih 67 vrst kačjih pastirjev, ki jih zajeda ta mušata (Martens et al. 2008, Martens 2012, Wildermuth 2012, Manger & van der Heijden 2016). V okviru prispevka poročamo o šestih novih gostiteljskih vrstah – višnjevi devi (*Aeshna affinis*), veliki peščenki (*Lindenia tetraphylla*), velikem studenčarju (*Cordulegaster heros*), modrem ploščcu (*Libellula depressa*), temnem slaniščarju (*Selysiothemis nigra*) in rumenem kamenjaku (*Sympetrum flaveolum*). V Sloveniji smo zabeležili devet vrst gostiteljev, 18 v Bosni in Hercegovini, enako število na Švedskem in sedem na Hrvaškem. Ker kačjepastirska mušata zajeda kačje pastirje vrstno neznačilno, so najdbe novih gostiteljskih vrst pričakovane. V prispevku poročamo tudi o položaju zajedavcev na krilih kačjih pastirjev.

Ob pregledu dodatnega fotografskega gradiva in večji pozornosti pri terenskem delu lahko pričakujemo še večje število podatkov o razširjenosti te vrste. Za Slovenijo, Bosno in Hercegovino, Hrvaško ter Švedsko je treba nabrati tudi referenčno gradivo.

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