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THE DISTRIBUTION OF THE TERRESTRIAL ISOPOD *HYLONISCUS ADONIS* (VERHOEFF, 1927) (ISOPODA: ONISCIDEA) IN CROATIA

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This paper presents the distribution of the terrestrial isopod *Hyloniscus adonis* (Verhoeff, 1927) in Croatia. It was recorded for the first time at the edge of Dubravica peat bog and the adjacent forest. Additionally, it was collected at the edges of Đon močvar peat bog. Revision of the terrestrial isopod collection of the Croatian Biospeleological Society revealed that this species also occurs in central and eastern part of Croatia. Our results reveal that *H. adonis* is a hygrophilic species inhabiting various types of forests in the colline and montane belts. It prefers humid soils with thick litter and humus layers and most probably seldom leaves its shelter. *H. adonis* is extremely rare in open bog habitats, most likely due to the harsh environmental conditions (e.g. high soil humidity, low pH values) and can be considered as a tyrphoxenous species. Additionally, it was also found in the entrance zones of caves, most likely due to the favourable microclimatic conditions. It seems to be a temporary cave dweller and can be classified as a trogloxenous species.

Key words: peat bog, Dubravica, Đon močvar, cave, tyrphoxenous species, trogloxenous species

Antonović, I., Brigić, A., Bedek, J. & Sedlar, Z.: Rasprostranjenost kopnenog jednakonošca *Hyloniscus adonis* (Verhoeff, 1927) (Isopoda: Oniscidea) u Hrvatskoj. Nat. Croat., Vol. 24, No. 1, 139–149, 2015, Zagreb.

U radu je prikazana rasprostranjenost vrste *Hyloniscus adonis* (Verhoeff, 1927) u Hrvatskoj. Ova vrsta je prvi puta zabilježena na cretu Dubravica i okolnoj šumi. Zabilježena je također i na rubnom staništu creta Đon močvar. Redeterminacija zbirke kopnenih jednakonožaca Hrvatskog biospeleološkog društva pokazala je da ova vrsta dolazi i na nekolicini drugih lokaliteta u središnjoj i istočnoj Hrvatskoj. Rezultati pokazuju da je *H. adonis* higrofilna vrsta koja nastanjuje različite tipove šuma brežuljkastog i brdskog pojasa. Preferira vlažna tla s gustim slojem listinca i humusa, te rijetko napušta svoje skrovište. Vrlo je rijetka vrsta na otvorenim cretnim staništima, najvjerojatnije zbog ekstremnih okolišnih prilika (npr. visoke vlažnosti tla, niskih pH vrijednosti) te se smatra tirfoksenom vrstom. Nadalje, ova vrsta je pronađena i u ulaznim zonama špilja, najvjerojatnije zbog povoljnih mikroklimatskih prilika. Najvjerojatnije je povremeni stanovnik špilja i može biti klasificirana kao trogloksena vrsta.

Ključne riječi: cret, Dubravica, Đon močvar, špilja, tirfoksena vrsta, trogloksena vrsta

INTRODUCTION

Terrestrial isopods (Isopoda Latreille, 1817; Oniscidea Latreille, 1802) are one of the main groups of soil macrofauna widely distributed in the Palaearctic region. However,

the terrestrial isopod fauna of Croatia is poorly explored and most of the data are from the first half of the 20th century (e.g. Csiki, 1926; Karaman, 1966; Potočnik, 1989). Recently, only karst areas have been systematically explored and new terrestrial isopod species have been described (Bedek & Taiti, 2009; Karaman *et al.*, 2009; Bedek *et al.*, 2011). Additionally, some papers dealing with isopod diversity in various habitats have recently been published (Farkas & Krčmar, 2004; Farkas & Vilisics, 2008; Antonović *et al.*, 2012). In Croatia 131 species have been recorded to date (Bedek *et al.*, 2011; Antonović *et al.*, 2012).

The genus *Hyloniscus* Verhoeff, 1908 includes 26 species, distributed through the central and eastern parts of Europe. In Croatia, two species of the genus have been previously recorded (Verhoeff, 1930; Farkas & Krčmar, 2004; Farkas & Vilisics, 2008). *H. dalmaticus* Verhoeff, 1930 is a range-restricted endemic species, distributed in the vicinity of Split (Dalmatia) (Verhoeff, 1930), while *H. riparius* (C. Koch, 1838) is widely distributed across Central and Eastern Europe (Schmalfuss, 2003). It was reported for Croatia in Potočnik (1989); however, the cited literature data actually refer to the Slovenian part of Istria: Krain-Istrien (Wächtler, 1937; Strouhal, 1939, Schmalfuss, 2003). It was recently found in the Baranja region (Farkas & Krčmar, 2004) and in floodplain forests and river banks along the Drava River (Farkas & Vilisics, 2008).

H. adonis was originally described by Verhoeff (1927) from Planina village in the Municipality of Postojna in Slovenia. It is distributed in Austria (Strouhal, 1948, 1951), Bosnia and Herzegovina (Buturović, 1955), north-east Italy (Argano *et al.*, 1995) and Slovenia (Verhoeff, 1927; Strouhal, 1951). *H. adonis* was first recorded in Croatia in the Dubravica bog, Hrvatsko zagorje region (Antonović *et al.*, 2012). This species obviously prefers habitats with higher soil humidity and a thick layer of humus and leaves (Verhoeff, 1927; Méhelÿ, 1929; Strouhal, 1964; Antonović *et al.*, 2012). However, data on the distribution and ecology of *H. adonis* are rather scarce, due to the lack of terrestrial isopod specialists and the shortage of faunistic surveys. Therefore, the objectives of this study were: (1) to revise the genus *Hyloniscus* from terrestrial isopod collections in Croatia; (2) to present the current distribution of *H. adonis* in Croatia and (3) to give further information on the ecology and habitat preferences of this species.

MATERIAL & METHODS

Study area

The study was conducted at two acidophilous peat bogs: Dubravica bog (Fig. 1a) and Đon močvar bog (Fig. 1b) and their adjacent forest habitats (Tab. 1). Terrestrial isopods were collected also during cave and soil fauna inventories in Medvednica Nature Park (seven different localities evenly distributed on the mountain; 21 sites in total) (Fig. 1c), Papuk Nature Park (32 caves and springs and 10 sites for soil fauna), the Banija region (Pecka cave) and in the area of the Donja Dobra River (57 caves and springs) (Fig. 1d) (Tab. 1).

Sampling and identification

Several sampling methods were used in order to collect terrestrial isopods, e.g. pitfall traps, hand collecting, soil extraction using a Berlese funnel and a Winkler/Moczarski eclector.

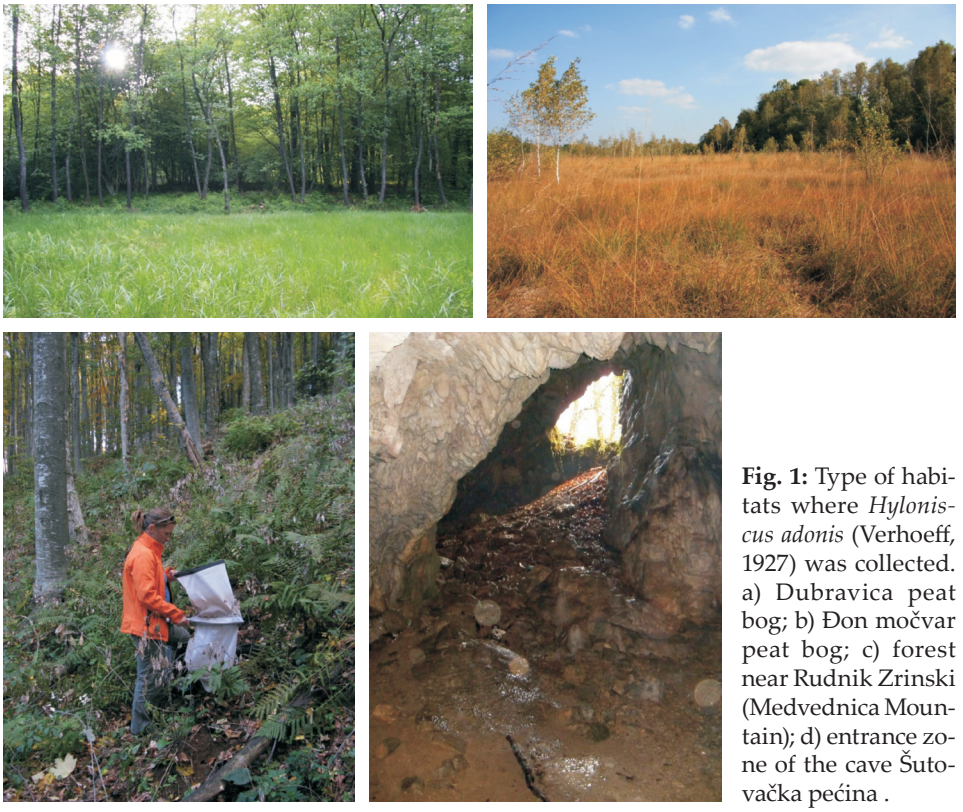

Fig. 1: Type of habitats where *Hylonisscus adonis* (Verhoeff, 1927) was collected. a) Dubravica peat bog; b) Đon močvar peat bog; c) forest near Rudnik Zrinski (Medvednica Mountain); d) entrance zone of the cave Šutovačka pećina .

Pitfall traps were used in order to collect soil arthropods in the peat bogs. Five pitfall traps of 0.3 dm^3 volume were used per site and 15 sites were sampled in total (three sites in Dubravica bog and 12 in Đon močvar bog). The traps were partially filled with saturated salt solution with a drop of neutrally-smelling detergent in order to reduce the surface tension of the liquid. A Styrofoam roof was placed above each trap to protect it from litter and rain. The trapping period covered the whole vegetation season of two years (2008-2009), from the end of April to the beginning of December at both the studied areas. Additional samplings were conducted during 2010 in Đon močvar bog. Pitfall traps were emptied once a month. However, when pitfall trapping is used, less active species and species associated with specific habitat types may not be recorded (Anonymous, 1998). Therefore, terrestrial isopods were also collected by hand using tweezers at each site (in both bogs studied) for a 15 minute period in May and June 2012.

A soil fauna inventory on Mt Medvednica was conducted from April to November 2008. Specimens were extracted from soil using Berlese funnels (25 cm in diameter, 27 cm height, with 2 mm mesh screens and holes 5 mm in diameter at the edges of the mesh screens, without a lamp; they were placed in flasks containing 96% ethanol for five days) and a Winkler/Moczarski eclector (4-6 mm coarse-mesh bags, a collection bottle containing 96% ethanol, left to dry at room temperature for seven days).

Tab. 1. Description of sampling sites where *Hyloniscus adonis* (Verhoeff, 1927) specimens were sampled. Legend: IA – Ivan Antonović collection, ITC (CBS) - the Isopoda Terrestria Collection (Croatian Biospeleological Society).

Location	Site	Coordinates	Altitude (m)	Cave length/ depth (m)	Plant association	Collection
Hrvatsko zagorje	Dubravica bog	N 45° 57′ 51.48″	160	–	bog: *Rhynchosporetum albae* W. Koch 1926	IA
		E 15° 45′ 15.48″			forest: *Epimedio-Carpinetum betuli* (Ht.1938) Borh. 1963	
Medvednica Mountain	Rudnik Zrinski	N 45° 53′ 14.1″	790	–	*Lamio orvalae-Fagetum* (Ht. 1938) Borh. 1963	ITC (CBS)
		E 15° 55′ 51.1″				
	Glavica	N 45° 50′ 50.9″	415	–	*Epimedio-Carpinetum betuli* (Ht.1938) Borh. 1963	ITC (CBS)
		E 15° 52′ 54.5″				
	Ponikve	N 45° 51′ 23.7″	490	–	*Epimedio-Carpinetum betuli* (Ht.1938) Borh. 1963	ITC (CBS)
		E 15° 52′ 56.0″				
	Veternica	N 45° 50′ 29.1″	350	7128/-	*Epimedio-Carpinetum betuli* (Ht.1938) Borh. 1963	ITC (CBS)
		E 15° 52′ 43.3″				
	Sljeme	N 45° 54′ 05.6″	980	–	*Festuco drymeiae-Abietetum* Vukelić et Baričević 2007	ITC (CBS)
		E 15° 57′ 47.0″				
Papuk Mountain	Suhodol	N 45° 30′ 16.6″	650	–	*Galio odorati-Fagetum sylvaticae* Sougnez et Thill 1959	ITC (CBS)
		E 17° 42′ 14.2″				
	Lijepa jama	N 45° 30′ 06.7″	725	15/ 7	*Galio odorati-Fagetum sylvaticae* Sougnez et Thill 1959	ITC (CBS)
		E 17° 42′ 48.1″				
Banija	Đon močvar bog		130	–	bog: *Drosero-Caricetum echinatae* Horvat (1950) 1962; *Rhynchosporetum albae* W. Koch 1926	IA
		N 45° 19′ 4.33″			edge: *Frangulo-Alnetum glutinosae* Rauš 1968	
		E 15° 54′ 32.83″			forest: *Epimedio-Carpinetum betuli* (Ht.1938) Borh. 1963	
	Pecka	N 45° 15′ 23.9″	200	6/ 0		ITC (CBS)
		E 15° 50′ 55.5″				
Donja Dobra River	Šutovačka pećina	N 45° 18′ 50.2″	200	26/ 15		ITC (CBS)
		E 15° 16′ 26.5″				
	Jama na Bertiji 2	N 45° 20′ 50.5″	275	unknown		ITC (CBS)
		E 15° 15′ 12.6″				
	Izvor špilja kod Trošmarije	N 45° 19′ 06.3″	170	unknown		ITC (CBS)
		E 15° 16′ 38.6″				

The cave fauna inventory on Mt Papuk was conducted from 2004 to 2010, at Donja Dobra River from June 2008 to December 2009 and in the Banija region during March 2009. Terrestrial fauna at these sites was collected by hand using tweezers.

Specimens of *H. adonis* were identified using the original description of Verhoeff (1927) and the identification key of Schmölzer (1965). Identifications were based on microscopic slides of specific male identifying features (first and second pleopods, seventh pereiopod, antenna and genital papilla). At each location or in the vicinity we collected at least one male. Due to the impossibility of distinguishing *Hyloniscus* females, they were associated based on comparisons with overall male morphology. Nomenclature is defined according to Schmalfuss (2003).

Specimens from Dubravica and Đon močvar bogs are deposited in the first author's private collection (Ivan Antonović, Zagreb, Croatia), while other specimens are kept in the Isopoda Terrestria Collection of the Croatian Biospeleological Society (deposited in the Croatian Natural History Museum, Zagreb, Croatia).

Environmental variables

Soil samples were taken at each site in the peat bogs in order to determine soil humidity and pH values. Soil humidity was determined using the gravimetric method. pH values were measured in a 1: 2.5 mixture of soil:water using a WTW pH 330i meter. These measurements were made according to Škorić (1982).

During soil and cave fauna inventories the air, soil and cave sediment temperature (ca. 10 cm deep) and relative air humidity were measured using TESTO Mini Thermometer and Kestrel 3000 Pocket Weather Meter.

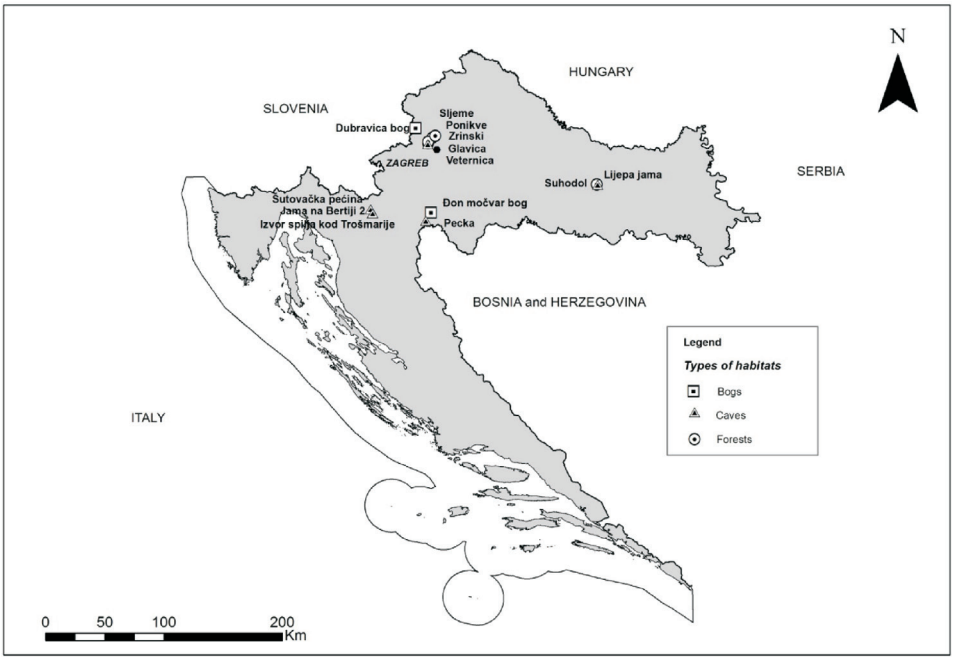

Fig. 2. Distribution of *Hyloniscus adonis* (Verhoeff, 1927) in Croatia.

RESULTS AND DISCUSION

Distribution

Hyloniscus adonis is distributed in the central and eastern parts of Croatia (Tab. 1, Fig. 2).

It was recorded in Hrvatsko zagorje region, the surroundings of the Donja Dobra River, Medvednica Mountain, the Banija region and Papuk Mountain. Like most other *Hyloniscus* species, *H. adonis* has a relatively restricted distribution range (Schmalfuss, 2003), which is confined to Central Europe and the western part of the Balkan Peninsula.

Ecology and biology

According to current knowledge, *H. adonis* (Fig. 3) inhabits peat bogs, in particular their edges and adjacent forest habitats. It occurs in mixed forests dominated by the sessile oak and the common hornbeam (association *Epimedio-Carpinetum betuli*), but also by montane neutrophilic beech forests and acidic mixed beech and fir forests of *Aremonio-Fagion* Horvat 1938 alliance (Tab. 1). This species was also found in the entrance zones of several caves (Tab. 2). Regarding altitude, it was found from 130 m a.s.l. up to 980 m a.s.l (Tab. 1). In general, it lives in humid and shaded places, in thick layers of leaves and humus. Other authors found this species in a thick layer of litter (Verhoeff, 1927; Méhelÿ, 1929). Furthermore, Strouhal (1964) recorded it in beech-maple forest (subassociation *Aceri-Fagenion* Ellenberg 1963), where the soil is characterised by a thick humus layer and high soil humidity.

Activity density of *H. adonis* was extremely low in the open bog areas (Tab. 2). These habitats are characterised a by thick layer of *Sphagnum* mosses, high soil humidity (season mean ± SD: Dubravica bog: centre - 80.44% ± 10.19; Đon močvar bog: centre - 92.8% ± 2.15) and low pH values (Dubravica bog: centre - 4.47 ± 0.77; Đon močvar bog: centre - 4.82 ± 0.58). Although *Hyloniscus* species are generally highly hygrophylic, it seems that

Fig. 3. *Hyloniscus adonis* (Verhoeff, 1927) collected from the Dubravica peat bog (photo: J. Bedek).

Tab. 2. Abundance of the terrestrial isopod *Hyloniscus adonis* (Verhoeff, 1927) at studied sites. Legend: PT - pitfall trapping; HC - hand collecting; BF - Berlese funnel extractions; W/M - Winkler/Moczarski eclector; Leg. - legator; AB - Andreja Brigić; AK - Alen Kirin; HCV - Hrvoje Cvitanović; IA - Ivan Antonović; JB - Jana Bedek; ML - Marko Lukić; NM - Nataša Matoš; RO - Roman Ozimec.

Location	Study area	Habitat	Method	Total number of individuals	Male	Female	Juvenile	Leg.	Date
Hrvatsko zagorje	Dubravica peat bog	bog	HC & PT	1	–	1	–	AB	VII; 2008.
		edge		15	8	7	–		V, VI, VIII, IX, X, XI; 2008.
		forest		3	1	2	–		VII, XI; 2008
Banija	Đon močvar peat bog	bog	HC & PT	1	–	1	–	IA	VI; 2012.
		edge		–	–	–	–		
		forest		–	–	–	–		
	Pecka	cave entrance zone	HC	1	1	–	–	NM;HCV	III; 2009.
Mt Medvednica	Rudnik Zrinski	forest	BF	1	1	–	–	ML;JB	X; 2008.
	Glavica	forest	BF & W-M	3	–	1	2	ML;RO	VI; 2008.
	Ponikve	forest, spring bank	BF	3	–	–	3	ML	VI; 2008.
	Veternica	cave entrance zone	W-M	1	–	1	–	ML;JB	VI; 2008.
	Sljeme	forest	W-M	1	1	–	–	ML;RO	VII; 2008.
Mt Papuk	Suhodol	forest	HC	1	–	1	–	RO	X; 2008.
	Lijepa jama	cave entrance zone		2	1	–	1	JB	X; 2008.
Donja Dobra River	Šutovačka pećina	cave entrance zone	HC	2	2	–	–	HCV;JB	XII; 2008.; V; 2009.
	Jama na Bertiji 2	cave entrance zone		1	–	1	–	JB	V; 2009.
	Izvor špilja kod Trošmarije	cave entrance zone		1	1	–	–	AK	V; 2009.

H. adonis does not prefer open bog habitats. Most likely this is due to the specific environmental conditions, characterized by high ground water table and low pH values, factors that limit the spatial distribution of isopods (Sutton, 1972; Wolters & Ekschmitt, 1997; Hornung, 2011; Antonović *et al*., 2012). Also, peat bogs are characterized by a low level of nutrients and presence of *Sphagnum* sp. mosses which contain polyphenols that are not favourable to isopods (Cameron & LaPoint, 1978; Zimmer & Topp, 1997; Rydin & Jeglum, 2006). Interestingly, this species was not recorded in basophilous fens (Jarak and Plaški) where conditions are more suitable (Antonović, unpublished data). There-

Tab. 3. Measured environmental variables at studied sites.

Location		Habitat	t (air) / °C	t (cave sediment / oil) / °C	RH (air) / %	Date
Mt Medvednica	Rudnik Zrinski	forest	13.7	10.1	85.3	X; 2008.
	Glavica	forest	–	17.5	–	VI; 2008.
	Ponikve	forest, spring bank	–	17.7	–	VI; 2008.
	Veternica	cave entrance zone	–	12.1	–	VI; 2008.
	Sljeme	forest	–	13.8	–	VII; 2009.
Mt Papuk	Lijepa jama	cave entrance zone	10.8	9.6	100	X; 2008.
Donja Dobra River	Šutovačka pećina	cave entrance zone	8.1	–	97.6	XII; 2008.
			9.6	–	100	V; 2009
	Jama na Bertiji 2	cave entrance zone	11.1	10.9	–	V; 2009.
			10.6	–	100	V; 2009.
			11.0	–	100	XII; 2008.
	Izvor špilja kod Trošmarije	cave entrance zone	14.0	–	96.5	V; 2009.

fore, *H. adonis* could be considered a tyrphoxenous species (vagrants, species that cannot live in bogs) (Peus, 1932; Roubal, 1934). Nevertheless, it seems that *H. adonis* prefers the edges of peat bogs (Tab. 2). The edge of Dubravica bog is covered with strong *Rubus* sp. plants that have formed a thick root system. The edge area is rich with humus, a litter layer and parts of decaying wood. The area is characterised by high soil humidity (season mean ± SD: Dubravica bog: edge – 74.47% ± 4.64) and low pH values (Dubravica bog: edge – 4.1 ± 0.51). However, oscillations in soil humidity were lower at the edge site than at the bog site which could also affect the spatial distribution of this species (Antonović *et al.*, 2012). Like other terrestrial arthropods, e.g. carabid beetles (Brigić *et al.*, 2009) and some ants (Bujan *et al.*, 2010) it preferred bog edges. The edge area possibly offers more suitable microhabitats and more food sources for terrestrial isopodssothan the bog itself.

H. adonis was also found in small caves and the entrance zones of large ones. Most likely these sites are inhabited due to their high humidity levels (locatios mean ± SD: 85.59% ± 5.38.) and lower air temperatures (locatios mean ± SD: 10.02 °C ± 2.11; Tab. 3), both favourable for isopods (Buturović, 1957) (Tab. 3). However, this could also be the result of the speciess natural cryptozoic behaviour in order to find suitable shelters with optimum ecological conditions (Hassall *et al.*, 2005; Hornung, 2011). This species is highly hygrophylic and can survive in caves for shorter or longer periods, but it does not belong among typical cave-dwelling fauna. Therefore, it could be considered a trogloxenous species (a species that uses caves as a shelter but is unable to establish a subterranean population) (Sket, 2008). Since the collection of trogloxenous species was not the main aim of the cave inventories, this could explain the low abundance (Tab. 2)

and low occurrence of *H. adonis* in cave samples (e.g. one cave out of 32 researched on Mt Papuk; three caves out of 57 researched at the Donja Dobra River area).

Most of the specimens were collected at the side of Dubravica bog while at Đon močvar bog only one female was collected by hand, despite the larger number of pitfall traps. It seems that this species, like the related *H. riparius* (Strouhal, 1948; Farkas & Vilisics, 2008) rarely leaves its shelter. No seasonal activity density could be observed due to the low number of caught specimens that were uniformly collected during the whole season (months: V – 4, VI – 3, VII – 3, VIII – 3, IX – 2, X – 1, XI – 3).

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SAŽETAK

Rasprostranjenost kopnenog jednakonošca *Hyloniscus adonis* (Verhoeff, 1927) (Isopoda: Oniscidea) u Hrvatskoj

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Fauna kopnenih jednakonožaca Hrvatske slabo je istražena i većina podataka potječe iz prve polovice 20. stoljeća (Csiki, 1926; Karaman, 1966; Pljakić, 1970; Potočnik, 1989). Dosadašnjim radom je ukupno zabilježena 131 vrsta kopnenih jednakonožaca u Hrvatskoj (Bedek *et al*. 2011.; Antonović *et al*., 2012).

Vrsta *Hyloniscus adonis* izvorno je opisana iz sela Planina u općini Postojna, Slovenija (Verhoeff, 1927). Vrsta ima ograničen areal rasprostranjenosti te je do sada utvrđena u Austriji (Strouhal, 1964), Bosni i Hercegovini (Buturović, 1955), Italiji (Argano *et al*., 1995) i Sloveniji (Verhoeff, 1927; Méhelÿ, 1929). Prvi puta je zabilježena u Hrvatskoj na cretu Dubravica (Hrvatsko zagorje) i šumi koja okružuje cret, a naknadno je sakupljena i na cretu Đon močvar (Banija) (Antonović *et al*., 2012). Redeterminacija zbirke kopnenih jednakonožaca Hrvatskog biospeleološkog društva, pokazala je da ova vrsta dolazi još i na nekolicini drugih lokaliteta na području središnje i istočne Hrvatske.

Na temelju dosadašnjih spoznaja, ova vrsta nastanjuje rubove cretova, različite tipove šumske vegetacije te ulazne zone špilja. Pronađena je na različitim nadmorskim visinama, od 130 m nv do 980 m nv. Preferira vlažna tla, bogata listincem i humusom. Vrlo je rijetka vrsta otvorenih cretnih staništa, što je najvjerojatnije posljedica ekstremnih prilika na takvim staništima (npr. visoke vlage tla i niskog pH tla). Međutim, u većem broju dolazi na rubovima cretova, što je moguće posljedica većeg broja povoljnih mikrostaništa i izvora hrane, te manje izraženih sezonskih oscilacija u vlazi tla. Zbog svega navedenog ovu vrstu možemo klasificirati kao tirfoksenu vrstu, tj. kao vrstu koja povremeno može doći na otvorenim cretnim staništima, ali koja tamo ne može živjeti.

Vrsta *H. adonis* je također zabilježena u ulaznim zonama špilja. Ekološka obilježja tih zona je visok udio relativne vlažnosti zraka, niže temperature u odnosu na temperature izvan špilje te velika količina listinca i humusa, što ova staništa čini povoljnim za kopnene jednakonošce (Buturović, 1957; 1958). Kako niti jedna jedinka nije nađena u dubljim dijelovima špilja, možemo zaključiti kako je ovo i trogloksena vrsta koja ulazne zone špilja koristi isključivo kao zaklon.