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CONTRIBUTION TO THE FAUNA OF SCARABAEOIDEA (COLEOPTERA) OF CRES ISLAND, CROATIA

Toni KOREN
Croatian Herpetological Society–Hyla, I. Lipovac 7, 10000 Zagreb, Croatia
E-mail: koren.toni1@gmail.com

Domen TRKOV
National Institute of Biology, Marine Biology Station Piran, SI-6330 Piran, Fornače 41, Slovenia

ABSTRACT

The first recent overview of the Scarabaeoidea of the Croatian island of Cres is presented. The material for this survey was collected during several field trips organized between 2011 and 2014. A total of 44 species were recorded, 21 of which represent first records for the area. With the records of 10 additional species found in the literature, the number of species known to occur on Cres is 54.

Key words: dung beetles, diversity, *Osmoderma eremita, Lucanus cervus*

CONTRIBUTO ALLA CONOSCENZA DELLA FAUNA DEGLI SCARABAEOIDEA (COLEOPTERA) SULL'ISOLA DI CHERSO, CROAZIA

SINTESI

L'articolo presenta una prima panoramica recente della fauna degli Scarabaeoidea sull'isola croata di Cherso. Per l'indagine il materiale è stato raccolto nel corso di diversi lavori sul campo organizzati tra il 2011 e il 2014. In totale sono state trovate 44 specie, di cui 21 sono state registrate per la prima volta in quest'area. Durante l'analisi della letteratura disponibile sul tema, gli autori hanno trovato le segnalazioni di 10 altre specie, pertanto il numero totale di specie confermate per l'isola di Cherso è al momento pari a 54.

Parole chiave: scarabei stercorari, diversità, *Osmoderma eremita*, *Lucanus cervus*

INTRODUCTION

The Scarabaeoidea (formerly known as Lamellicornia) is a superfamily of beetles belonging to the suborder Polyphaga. This diverse superfamily consists of more than 35 000 species described to date, distributed in all continents except Antarctica. The Scarabaeoidea can be easily recognized by the presence of clubbed antennae, the apical segments of which are in the form of lamellae of variable size (Ballerio *et al*., 2010).

A large part of this superfamily consists of dung beetles. Traditionally, dung beetles are defined as coprophagous members of the Coleopteran families Aphodiidae, Scarabaeidae and Geotrupidae (Halffter & Matthews, 1966). Most species consume dung as a primary source of food and utilize it as a nesting resource, and as such, they are key providers of several ecological services such as waste removal, secondary seed dispersal and vertebrate parasite suppression (Mathison & Ditrich, 1999; Andresen & Feer, 2005; Horgan, 2005). Feeding on vertebrate dung makes dung beetles likely to be influenced by changes in mammal communities, *e.g.* the abandonment of pastures has a big influence on communities of dung beetles (Estrada *et al*., 1999). Furthermore, veterinary treatments have one of the most harmful effects on dung beetle communities that feed on dung, especially the anti-parasitic compounds in the faeces of domestic livestock. In particular, Ivermectin, a broad-spectrum veterinary drug, reduces species diversity and increases the dominance of certain species (Wall & Strong, 1987; Lumaret *et al*., 1993; Lumaret, 1994; Krüger & Scholtz, 1996). Because of their ecology, dung beetles are useful as bioindicators for investigating the anthropogenic impact on ecosystems (Halffter & Matthews, 1966; Halffter & Edmonds, 1982; Hanski & Cambefort, 1991).

The beetle fauna of the Adriatic islands has been investigated as early as the beginning of the 19th century; however, most records were collected sporadically, and unsystematically. The best source of information for all the Adriatic islands is probably the masterwork of Petar Novak (Novak, 1952, 1964) who compiled all available published and unpublished references and manuscripts till the middle of the 20th century, along with a great number of data from his entomological collection, and the collections of his contemporaries. More than 60 years since then, his book still remains the richest source of information for most of the Adriatic islands (Novak, 1952). In the last few decades, new data about island beetle fauna have been published for only a few islands: Kornati and Murter (Vujčić-Karlo *et al*., 1995) and Kornat, Lavsa and Žut (Koren *et al*., 2010).

Here we present the results of the first recent survey of the superfamily Scarabaeoidea on the northern Adriatic island of Cres. Our goal is to: (i) present the results of the recent survey of the area, (ii) create a checklist of the Scarabaeoidea of the area and (iii) discuss new records of interesting or rare species. Overall, the main goal is to contribute to the knowledge of the superfamily Scarabaeoidea of Croatia.

MATERIAL AND METHODS

Study area

Cres is located in the northern part of the Adriatic Sea, and is the largest island in the Adriatic (405.70 km^2) (Duplančić *et al*., 2004). It is about 66 km long and 12 km wide at the widest part. The island is influenced by both the Mediterranean and continental climate (Stražičić, 1981). The northern part of Cres has a submediterranean climate, while the central and southern parts have the true Mediterranean climate, where hot, dry summers and wet winters prevail (Stražičić, 1981).

Geologically, Cres represents the unsubmerged part of the Mt. Učka mountain range, which decreases in altitude from the northern to the southern part of the island. The highest peak on the island is Gorice (648 m a.s.l.). In the central part of Cres, there is a freshwater lake known as Vransko jezero, which is the biggest freshwater lake in the Adriatic archipelago. The main geological basal rocks on the island consist of Cretaceous limestone and dolomites (Stražičić, 1981).

As regards vegetation composition, Cres can be divided into three parts. The northern part is covered by mixed deciduous forests of *Quercus pubescens*, *Carpinus orientalis* and *Ostrya carpinifolia* (Klepac *et al*., 1993). The largest forest on the island is named Tramuntana and is located in the northern part of Cres, from the village of Križić to cape Jablanac (Stražičić, 1981). In the central part, only forest fragments remain, and the habitat includes mostly karst and stony pastures. The southern part of the island is covered by Eu-Mediterranean evergreen forests and karst grasslands and pastures (Stražičić, 1981). Forests are the most common habitat type and cover 38% of the island's surface area. Pastures are grazed mostly by sheep, while horses and donkeys are also present on the island. Many large wild vertebrate species are present on the island, including the wild boar (*Sus scrofa*), roe deer (*Capreolus capreolus*), fallow deer (*Dama dama*) and muflons (*Ovis musimon*), most of which have been introduced on the island.

Scarabaeoidea survey

This field work took place throughout the island, particularly in the northern and central parts. We visited 16 sample sites between 2011 and 2014 (Fig. 1). Dung beetles were collected manually from vertebrate dung. Other scarabs were collected mostly unsystematically using hand and net collecting from flowers, trees, tree trunks and tree hollows. To collect additional species, pyramid light traps were used at several localities. Scarabaeid beetles that could not be identified in the field were sacrificed and later identified at the laboratory

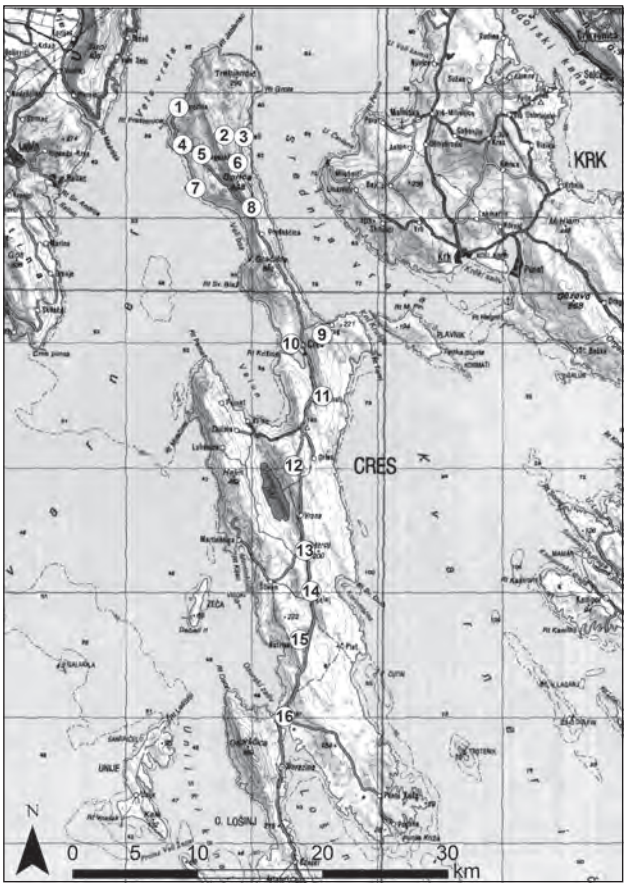

Fig.1: Map of surveyed localities on Cres Island.
Sl. 1: Zemljevid vzorčenih lokalitet na otoku Cres.

using standard identification keys (Mikšić, 1958; Baraud, 1992 and Ballerio *et al*., 2010). All the collected beetles are stored in the private insect collections of the authors. The nomenclature follows Ballerio *et al*. (2010), while zoogeographic affiliation is according to Brelih *et al*. (2010). Additional data about the Scarabaeoidea fauna of Cres was found in several papers (Müller, 1923; Novak, 1952, 1964; Pittino, 1991; Ranius *et al*., 2005; Harvey *et al*., 2011).

RESULTS AND DISCUSSION

During this survey we recorded a total of 44 species belonging to the superfamily Scarabaeoidea, of which 31 species belong to dung beetles (Scarabaeidae: Aphodiinae, Scarabaeinae and Geotrupidae). With the records of additional species found in the literature, the known number of species is 54 (Tab. 2). Most recorded species have a Turanic-European (8), Palearctic (7) or Asian-European (6) distribution. As many as 22 recorded species have some kind of Mediterranean distribution patterns (*e.g.* strictly Mediterranean, east Mediterranean etc.).

The recorded number of species represents about 25% of the known members of the superfamily Scarabaeoidea known from Croatia (Mikšić, 1970). With this in mind, more species records are to be expected, but with no complete overview of the Scarabaeoidea of the Adriatic islands, it is impossible to guess how many species on average inhabit each island. How poorly Cres was surveyed in the past is revealed by the fact that 21 species recorded during this survey represent first records for the island. What is necessary to emphasize is that during this survey we concentrated mostly on the dung beetle fauna and all other species were collected only occasionally and unsystematically; and this is visible in the results as some of the common species (*e.g. Amphimallon solstitiale* (Linnaeus, 1758)) were not recorded during this study. However, we found that the inclusion of additional records from the family Scarabaeoidea would be beneficial, and give a more comprehensive picture about the beetle fauna of the island. With only limited literature data about the Scarabaeoidea of Cres (Müller, 1923) any meaningful comparison with the historical data is not plausible. For some species, this area represents their northern distribution border, and they are accordingly rarer (*e.g. Bubas bison* (Linnaeus, 1767), *Scarabaeus* (*Scarabaeus*) *typhon* (Fischer von Waldheim, 1823). One such species, *S. typhon*, was recorded only once during this survey, and the record was based on a dead individual. This is one of the largest species of the genus *Scarabaeus* in Croatia. It is primarily coprophagous, but occasionally also necrophagous (Ballerio *et al*., 2010). Adults are active from early spring to autumn. We searched for this species in the same locality several times, at different vegetation seasons but we were unsuccessful. In Croatia, it is distributed from the southern part of Istria, across the Adriatic islands to the southernmost parts of Dalmatia (Mikšić, 1970). Based on our experience, this species is presently very local and rare in Croatia, but can also be relatively common in some localities (*e.g.* the surroundings of river Zrmanja or on the island of Pag). For any meaningful conclusions, the current knowledge about the distribution of the genus *Scarabaeus* in Croatia needs updating, as many species records are based on a very small number of observations (see Mikšić, 1958, 1970), most of which are not confirmed.

Based on our results, it appears that the dung beetle fauna of Cres is very diverse. The major food source for the scarab beetles on the island is sheep dung. Since sheep dung is usually very small in surface area, it is greatly influenced by high temperatures. As a result, sheep dung dries rapidly. This prevents most of the dung beetles from feeding on sheep dung. This is most obvious during the summer months (June-August), when we visited many locations, but were unable to find any dung beetles due to the fact that all the excrements were dry. As a result, in summer months we were able to collect at only three of more than ten visited locations. And since sheep are the

Tab. 1: List of surveyed localities.
Tab. 1: Seznam vzorčenih lokalitet.

No.	Locality	Habitat	Dung type	Dates of findings	Lat. (N)	Long. (E)
1.	Porozine harbour	xerotermophilous slopes and forest edge	/	21.5.2011	45.132588	14.288063
2.	Beli, Tramuntana forest	grassland surrounded by mixed forest, with occasional bushes	sheep	17.4.2011, 21.4.2011, 15.6.2011, 7.7.2011, 14.4.2012, 17.4.2013, 30.8.2013, 3.10.2013, 21.11.2013	45.112663	14.334926
3.	Beli village surroundings	rocky pasture with bushes	sheep	17.4.2011, 19.4.2011, 15.6.2011, 14.4.2012	45.111634	14.354582
4.	Filozići village	stony karst grassland with small patches of trees	sheep	19.3.2014	45.105544	14.292301
5.	Dragozetići village	karstic pasture	sheep	19.3.2014	45.098815	14.312048
6.	Sv. Petar village	forest path with small grassland clearings	sheep	21.5.2011	45.092853	14.348487
7.	Predošćica village	karst grassland	sheep	9.5.2012	45.074421	14.306250
8.	Road to Beli, near the clifs	rocky pasture with bushes	sheep	21.11.2013	45.060790	14.363079
9.	Merag, 1,5 km SW of the harbour	karstic pasture	sheep, horse	17.4.2013, 11.5.2013	44.969600	14.435610
10.	Cres city surroundings	olive grows with grassy undergrowth	sheep	21.5.2011, 19.3.2014	44.962874	14.404268
11.	Loznati, 200 m E of the village	rocky karstic pasture	sheep	11.5.2013, 19.3.2014	44.925439	14.436275
12.	Zbišina, 1 km N of the village	karstic pasture	sheep	20.6.2013	44.875213	14.407711
13.	Hrasta village	karstic pasture	sheep	19.3.2014	44.814127	14.419507
14.	Belej village surroundings	karstic pasture	sheep	20.3.2014	44.784898	14.426039
15.	Ustrine village	karstic pasture	sheep	20.3.2014	44.750044	14.414820
16.	Osor, near the village	dry karstic pasture, bushy vegetation	donkey	20.3.2014	44.694649	14.400351

main source of dung on the island, this could present a problem for the survival of dung beetles.

In the past, other livestock such as cows, donkeys and horses were more common on Cres, as well as on other Adriatic islands, but are now rapidly disappearing. The only exceptions are the islands offering significant tourism services, where such animals are still kept for meat or cheese production. Also, on some islands, horses are becoming more common, again because of tourism. These practices may indeed conserve dung beetle populations on the Adriatic islands, but for the populations on some of the smaller islands (*e.g. Šćedro*, *Čiovo*) the livestock has almost completely disappeared. On the other hand, the situation on the island of Cres there is even more interesting, due to the several large herbivores that were introduced to the island (mentioned in the introduction). These species, along with the present livestock, should allow for the survival of dung beetles on the islands.

Negative practices that are becoming common in Dalmatia (*e.g.* destruction of entire karst pastures and grasslands and converting them into arable land or vineyards) were not observed on Cres.

Apart from the dung beetles, two other interesting members of the Scarabaeoidea superfamily were recorded during this survey; both were previously recorded for the island (Ranius *et al.*, 2005; Polak, 2006; Harvey *et al.*, 2011). These two species are of a particular in-

Tab. 2: Species recorded on the island of Cres (* Species recorded in the area for the first time; **Numbers of localities correspond to those given in Tab. 1.).
Tab. 2: Zabeležene vrste na otoku Cres (* prvič zabeležene vrste na raziskanem območju; ** število lokalitet ustreza številom v Tab. 1.).

No.	List of species	Locality numbers**	Literature records	Biogeography
GEOTRUPIDAE Latreille, 1802				
1.	*Anoplotrupes stercorosus* (Scriba, 1791)*	2, 14	/	European-Siberian
2.	*Geotrupes* (*Geotrupes*) *mutator* (Marsham, 1802)	/	Müller (1923), Novak (1952)	Turanic-European
3.	*Geotrupes* (*Geotrupes*) *puncticollis* Malinowsky 1811	2, 11	Novak (1964)	Turanic-European
4.	*Jekelius* (*Jekelius*) *brullei* (Jekel, 1866)	2, 4, 5, 14	Müller (1923), Novak (1952)	Mediterranean
5.	*Trypocopris* (*Trypocopris*) *vernalis* (Linnaeus, 1758)*	2, 3, 4, 5, 11	/	European species
SCARABAEIDAE Latreille, 1802				
SCARABAEINAE Latreille, 1802				
6.	*Bubas bison* (Linnaeus, 1767)	/	Müller (1923), Novak (1952)	West Mediterranean
7.	*Caccobius schreberi* (Linnaeus, 1758)	2	Müller (1923), Novak (1952)	Turanic-European-Mediterranean
8.	*Copris lunaris* (Linnaeus, 1758)	11	Müller (1923), Novak (1952)	Asian-European
9.	*Euonthophagus amyntas* (Olivier, 1789)	10, 11	Müller (1923), Novak (1952)	Asian-European
10.	*Euoniticellus fulvus* (Goeze, 1777)*	2, 4, 5, 6, 12, 14	/	Palearctic
11.	*Gymnopleurus geoffroyi* (Fuessly, 1775)*	11	/	European-Mediterranean
12.	*Onthophagus coenobita* (Herbst, 1783)	2, 9, 10, 11	Müller (1923), Novak (1952)	Turanic-European
13.	*Onthophagus fracticornis* (Preyssler, 1790)	2, 3, 4, 5, 9, 10, 11, 12, 15	Müller (1923), Novak (1952)	Siberian-Turanic-European
14.	*Onthophagus grossepunctatus* Reitter, 1905*	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16	/	Southern and central European
15.	*Onthophagus lemur* (Fabricius, 1781)	2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16	Müller (1923), Novak (1952)	Turanic-European
16.	*Onthophagus ruficapillus* Brullé, 1832*	6	/	Turanic-European
17.	*Onthophagus verticicornis* (Laicharting, 1781)*	2, 6, 7, 9, 11	/	Turanic-European
18.	*Onthophagus medius* Kugelan 1792*	10, 11, 13, 14	/	Asian-European
19.	*Onthophagus furcatus* (Fabricius, 1781)	2, 7, 9 ,11	Müller (1923), Novak (1952)	Turanic-European-Mediterranean
20.	*Onthophagus taurus* (Schreber, 1759)*	2, 3, 8, 11, 12	/	Palearctic
21.	*Scarabaeus variolosus* Fabricius, 1787	6, 9	Müller (1923), Novak (1952)	Mediterranean

22.	*Scarabaeus* (*Scarabaeus*) *typhon* (Fischer von Waldheim, 1823)*	6	/	Asian-southern European
23.	*Sisyphus schaefferi* (Linnaeus, 1758)	2, 6	Müller (1923), Novak (1952)	Turanic-European-Mediterranean
APHODIINAE Leach, 1815				
24.	*Acrossus luridus* (Fabricius, 1775)	2, 3, 4, 5, 7, 8, 9, 10, 11, 13, 14, 15, 16	Müller (1923), Novak (1952)	Palearctic
25.	*Amidorus thermicola* (Sturm, 1800)*	2, 5, 13, 15	/	Turanic-European
26.	*Aphodius fimetarius* (s.l.)	2, 9, 10	Müller (1923), Novak (1952)	Subcosmopolitan
27.	*Calamosternus granarius* (Linnaeus, 1767)	/	Müller (1923), Novak (1952)	Palearctic
28.	*Chilothorax paykulli* (Bedel, 1907)*	2, 5, 8, 11	/	European-Mediterranean
29.	*Colobopterus erraticus* (Linnaeus, 1758)	2, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15, 16	Müller (1923), Novak (1952)	Asian-European-Mediterranean
30.	*Esymus merdarius* (Fabricius, 1775)	/	Müller (1923), Novak (1952)	Central Asian-European-Mediterranean
31.	*Eudolus quadriguttatus* (Herbst, 1783)*	2, 3, 7, 11	/	Palearctic
32.	*Melinopterus consputus* (Creutzer, 1799)*	2	/	Turanic-European-Mediterranean
33.	*Melinopterus prodromus* (Brahm, 1790)	2, 3, 9, 11, 12	Müller (1923), Novak (1952)	Asian-European-Mediterranean
34.	*Nimbus johnsoni* (Baraud, 1976)*	2, 5	/	South European
35.	*Volinus sticticus* (Panzer, 1798)*	2	/	Turanic-European
36.	*Oxyomus sylvestris* (Scopoli, 1763)	/	Müller (1923), Novak (1952)	Turanic-European-Mediterranean
DYNASTINAE MacLeay, 1819				
37.	*Pentodon bidens* (Pallas, 1771)	2	Müller (1923), Novak (1952)	Asian-European-Mediterranean
38.	*Oryctes nasicornis* (Linnaeus 1758)*	2	/	Palearctic
CETONIINAE Leach, 1815				
39.	*Tropinota hirta* (Poda, 1761)*	1 - 16	/	Asian-European-Mediterranean
40.	*Oxythyrea funesta* (Poda, 1761)	1 - 16	Müller (1923), Novak (1952)	European-Mediterranean
41.	*Cetonia aurata* (Linnaeus, 1761)	1 - 16	Müller (1923), Novak (1952)	Asian-European
42.	*Valgus hemipterus* (Linnaeus, 1758)*	2	/	Palearctic
43.	*Protaetia angustata* (Germar, 1817)	1, 11	Müller (1923), Novak (1952)	Mediterranean
44.	*Protaetia cuprea* (Fabricius, 1775)	2, 3	Müller (1923), Novak (1952)	Asian-European
45.	*Osmoderma eremita* (Scopoli, 1763)	2	Ranius *et al*. (2005); Polak (2006)	European

MELOLONTHINAE Leach in Samouelle, 1819				
46.	*Holochelus fraxinicola* (Hope, 1825)	/	Müller (1923), Novak (1952)	Eastern-European-Mediterranean
47.	*Amphimallon solstitiale* (Linnaeus, 1758)	/	Müller (1923), Novak (1952)	Asian-European
48.	*Haplidia transversa* (Fabricius, 1801)	2	Müller (1923), Novak (1952)	Eastern Mediterranean
RUTELINAE MacLeay, 1819				
49.	*Anisoplia flavipennis* (Brullé, 1832)	/	Müller (1923), Novak (1952)	Eastern European
50.	*Anisoplia monticola* (Erichson, 1848)	/	Müller (1923), Novak (1952)	Central-Mediterranean
LUCANIDAE Latreille, 1804				
51.	*Dorcus parallelipipedus* (Linnaeus, 1785)*	2	/	Turanic-European-Mediterranean
52.	*Lucanus cervus* (Linnaeus, 1758)	1, 2, 3	Harvey *et al*. (2011)	Turanic-European
TROGIDAE MacLeay, 1819				
53.	*Trox litoralis* Pittino, 1991	/	Pittino (1991)	Eastern Mediterranean
54.	*Trox scaber* (Linnaeus, 1767)*	2	/	Subcosmopolitan

terest as both are listed in the Annexes of the Habitat Directive; *O. eremita* is listed in both Annexes II and IV, while *L. cervus* is listed in Annex IV (COUNCIL DIRECTIVE 92/43/EEC). During this survey, we recorded *L. cervus* in great numbers at dusk across the Tramuntana forest during the summer months of each year. Also, a large number of dead as well as live individuals were recorded on tree barks and on the ground during the day. With many old trees, and an extensive forest area, the survival of this species is probably not threatened here. On the other hand, we recorded only a single adult specimen of *O. eremita* in the same forest, but this is probably due to lack of systematic surveying on our part. The larvae of this species use hollows in old trees. The Tramuntana forest is known for the large number of very old *Quercus* trees, and as such probably represents a suitable habitat for this species, which was also noted by Polak (2006) who recorded a large number of species in the forest. A more extensive survey of this species on the island is needed to access the current distribution, population structure and conservation status. Our record represents the second recent record of this species in Croatia (Koren *et al*., 2011).

The island of Cres is still rich in diverse habitats. Tramuntana forest in the north represents an ideal habitat for the development of saproxylic beetles such as *O. eremita* and *L. cervus*. On the other hand, pastures scattered across the island represent suitable habitats for many dung beetle species. While this survey contributed to the knowledge of dung beetles and other scarabs of the islands, the knowledge is far from complete and additional surveys are needed.

PRISPEVEK K POZNAVANJU FAVNE SCARABAEOIDEA (COLEOPTERA) OTOKA CRES, HRVAŠKA

Toni KOREN
Croatian Herpetological Society–Hyla, I. Lipovac 7, 10000 Zagreb, Croatia
E-mail: koren.toni1@gmail.com

Domen TRKOV
National Institute of Biology, Marine Biology Station Piran, SI-6330 Piran, Fornače 41, Slovenia

POVZETEK

Predstavljamo prvi recentni pregled favne Scarabaeoidea hrvaškega otoka Cres. Material za raziskavo smo zbrali v času *terenskega dela med letoma 2011 in 2014. Skupno smo zabeležili 44 vrst, od katerih jih je bilo 21 prvič zabeleženih za to območje. V literaturi najdemo podatke še za 10 vrst, ki pa jih v času raziskave nismo našli.* Število *znanih vrst za otok Cres se je tako dvignilo na 54.*

Ključne besede: koprofagni hrošči, pestrost, *Osmoderma eremita, Lucanus cervus*

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