Entomofauna carpathica, 2018, **30**(2): 41-52

EPIGEIC BEETLES (COLEOPTERA) INDICATORS OF CHANGES IN MINING ACTIVITY (TEGHOUT, ARMENIA)

Oto MAJZLAN and Sophya GEGHAMYAN

Department of Landscape Ecology, Faculty of Natural Sciences, Comenius University, Ilkovičova 6, 842 15, Bratislava 4, Slovak Republic;
e-mail: majzlan@uniba.sk, geghamyan@gmail.com

MAJZLAN, O. & GEGHAMYAN, S. 2018. Epigeic Beetles (Coleoptera) Indicators of Changes in Mining Activity (Teghout, Armenia). *Entomofauna carpathica,* **30**(2): 41-52.

Abstract: In 2016, we have obtained the study material epigeic beetles (Coleoptera) by soil traps on three terrains at Teghout (Armenia). Overall we have gained 95 species of Coleoptera beetles. We chose two species of ground beetles (*Carabus varians* and *Carabus septencarinatus*) for chemical analysis of metals. Overall, I have determined 3 elements Pb, Cu and Zn. The highest values of Cu were found in the area of the forest, where the pollutants were affected by air currents.

Key words: indication, heavy metals, beetles, pollution, Armenia

INTRODUCTION

Mining activity produces several externalities to the surrounding nature. Those are heaps of processed rock, various pollutants dissolved in water (JURKOVIČ et al. 2011). Heavy metals and toxic elements are diffused into the surrounding nature. They contaminate biotic components where we define them and observe the way of deposition. Several studies dealt with the concentration of heavy metals in plants (STEFANOWICZ et al. 2016), in the bodies of ground beetles *Carabus* (TALARICO et al. 2014) and BUTOVSKY (2011).

The main objective of the contribution is the assessment of the nature of the biotic components in the mine area. First, based on the chemical analysis, particularly analysis of metallic element of epigeon species (Carabus), we determined the impact extent of the mining activity. Second, we determined the structure of the coenosis of epigeic beetles and assessed their structure.

The autors used the Carabidae to assess changes of the landscape structure. They selected *Nebria brevicollis* as a research sample (SAKINE, LUFF 2010). Detailed analyzes of metal elements of soil invertebrates were processed by MANU (2017). High concentrations of lead (Pb) were identified on earthworms, isopods and mollusk. The mercury (Hg) was identified only on few species of isopods and millipedes. The biomonitor groups for iron (Fe) are earthworms and beetles; for zinc (Zn): earthworms, springtails, beetles, spiders, millipedes, mites, pseudoscorpions and mollusks. Millipedes and mites are efficient biomonitors for copper (Cu).

Authors processed and analyzed also heavy metals in several species of Carabus. They got information on the ratio of metallic elements in bodies of beetles (JELASKA et al. 2007). The authors (SAMIR et al. 2016) studied heavy metals Cd, Zn, Cu, Ni and Pb in *Chlaenius olivieri*.

Similar analysis of metallic elements has been conducted on many species of beetles, such as. The variations of metallic elements during the vegetation season and for different genders were also compared (PURCHRT & KULLA 2007).

Carabid beetles are frequently used as the environment condition indicators. Main purpose of this study was to test if community structure parameters of carabids indicate the stress intensity of heavy metal contamination in the soil of temperate forests. Autors found strong division between assemblages from contaminated reference sites (SKALSKI et al 2015).

CONTI (2017) has worked on the analysis of metallic elements in one species of *Parallelomorphus laevigatus.*

First author examined the epigeic beetles in several disturbed areas in Slovakia (MAJZLAN 2011, 2013, 2014).

Study area

Teghout Mine is a major copper and molybdenum open-pit mine in Armenia's northern province of Lori in the village of Teghout (Fig. 1). Chalcocite (Cu_2S) is mined in the surface mine, and ores rich in molybdenum by the year 2001.

Teghout is located in Lori, a province of Armenia bordering with Georgia and Azerbaijan. The site lies 70 km to the northeast of the city of Vanadzor which is the main administrative centre of the region and 32 km to the south-west of the second largest city in the region Alaverdi. The closest residential areas are the villages of Shnogh and Teghout, located 6 and 4 km to the south-west of the site (Teghout Mine, Armenia, 2012).

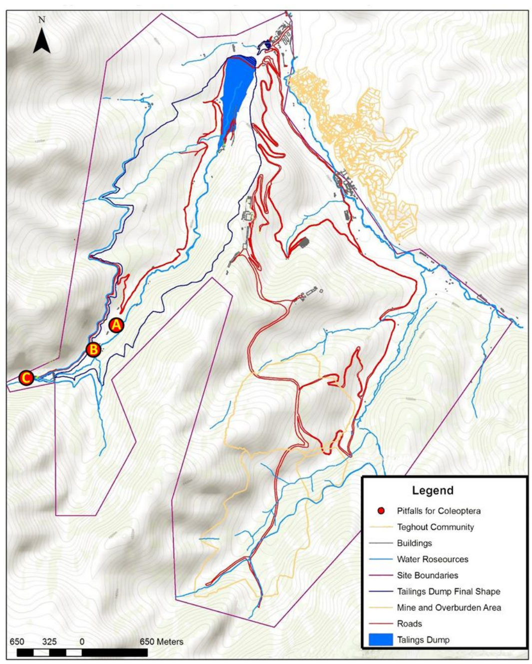

Fig. 1. Location of study areas in the North part of Armenia at the Teghout Copper-Molybdenum Mine, Lori Province.

Coordinates of the study areas are:

Study area A: N-41°04'23.00'', E- 44°50' 20.38'', 1162 m a.s.l.
Study area B: N-41°04'17.44'', E- 44°50' 22.37'', 1194 m a.s.l.
Study area C: N-41°04'11.65'', E- 44°50' 18.09'', 1237 m a.s.l.

The first study area (A) was in a rocky part of the mining center. This area was without vegetation and it covers the whole mining area of mines (Fig. 2).

The second area (B) is an ecotone between area A and a forest (Figure 3). The canopy of woody plants (*Fagus, Carpinus, Sambucus, Rubus*) is 40 %.

Area C is a beech forest with the dominance of *Fagus sylvatica*. The canopy of woody plants is 80 % (Fig. 4).

Fig. 2. The deforested area A of the surface mine surface (photo. O. Majzlan, 20.3.2016).

Fig. 3. Ecotone on the area B (photo. O. Majzlan, 20.3.2016).

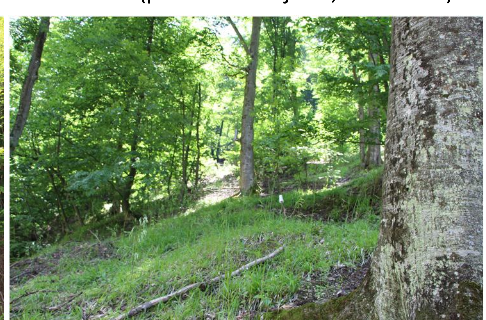

Fig. 4. Forest complex *Fagetum* near mines, area C (photo. O. Majzlan, 20.3.2016).

MATERIAL AND METHODS

Methods for Coleoptera

We set 4 ground traps in 3 areas of the mining center to track the structure of epigeic beetles (Coleoptera). The traps were set up on 20th June 2016. The preservative fluid was 8 % vinegar with 4 % formalin. The sampling interval was carried out monthly until September 2016. We collected more than 95 species of beetles (Coleoptera) from ground traps. For the chemical analysis, we have chosen two species of ground beetles (Coleoptera: Carabidae). These species *Carabus varians* (Fig. 5) and *Carabus septencarinatus* (Fig. 6) were processed to determine some elements.

Fig. 5. Monitored species of the ground beetle *Carabus varians*.

Fig. 6. Dominant species of the ground beetle in the epigeon *Carabus septencarinatus*.

Chemical analysis

Samples (ground beetles – *Carabus varians*, *Carabus septencarinatus*) were dried at 55˚C to constant weight in the dryer. Bugs were firstly homogenized in the mortar. Minimum 36 mg of beetle dry mass was mineralized in 5 ml of HNO_3:H_2O_2 mixture (4:1) overnight in the ZA-1 autoclaves (Czech Republic). The next day samples were mineralized at 180 ˚C for 1 hour in hot air oven YCO-010

(Gemmy Industrial Corp., Taiwan). After cooling, mineralized samples were diluted up to 25 ml with distilled water, and determined for chemical analysis of Cd, Cu, Pb, and Zn by potentiostatic dissolved chronopotenciometry on EcaFlow 150 GLP (Istran, Slovak Republic). The mentioned electrochemical method is comparable to the atomic absorption spectrophotometric (AAS) method in precision, accuracy, and sensitivity of measured results with concentration range 0.5-1000 µg $Pb.dm^{-3}$ and reproducibility 1.5 % at 50 µg $Pb.dm^{-3}$ metal ion in the measured solution. Samples were measured in triplicate and results in the graphs are shown as average values with standard deviation (SD) (MOLNÁROVÁ & FARGAŠOVÁ 2009).

RESULTS AND DISCUSSION

Chemical analysis

From the perspective of chemical analyses our focus was the results of concentration of Cu. The highest concentration of Cu was determined in the area C in *Carabus varians* (Figure 5). Low concentration of copper was found in both species of beetles in the area A, which is the closest location to mining activity. However, the highest concentration of Zn was determined in the area A and B (Table 1).

Table 1. Concentration values c (ug/g DM) mg/gr dry mass of the elements in the bodies of ground beetles on three areas (A, B C). (Cv – *Carabus varians*, Cs – *Carabus septencarinatus*).

Area		**A**	**A**	**B**	**B**	**C**	**C**
ground beetle		Cv	Cs	Cv	Cs	Cv	Cs
element	Pb	9.217	0.890	13.664	0.591	6.006	0.252
	Cu	7.481	5.367	10.714	6.829	19.492	4.354
	Zn	33.197	19.442	31.506	31.876	17.505	21.614

Coenological analysis

The basis for the evaluation of the cenological structure of epigeic beetles were the determined species. Table 2 shows dominant species of beetles. Overall, there were determined 95 species of beetles (Table 2). Based on the species identity, the beetles had the highest surface similarity A:C = 0.38. The lowest identity was between area A and B, A:B = 0.15. Community diversity was highest on area B – ecotone (3.35), which corresponds to the effect of ecotone. Equivalence on the observed areas was highest on area B (0.88).

The spread of pollutants (chemical dust) at the study area occurs through the air. Thereby, the chemical elements from the mine extraction enter into insects' bodies through the soil and food chain. Observed beetles are zoophagous and trophically bound to phytophagous as well as zoophagous animals. These animals are mainly from the soil – geobionts such as insect larvae, earthworms etc.

We compared the results of other authors' work with the values of the metal content in ground beetles.

Ground beetles (Coleoptera, Carabidae) are one of the most important soil groups in relation to heavy metals. BUTOVSKY (2011) investigated the content and accumulation of metals for the bioindication of environmental pollution in the species *Poecilus cupreus, Pterostichus melenarius, P. niger, Pseudophonus rufipes, Carabus nemoralis* and *Carabus granulatus*. According to him, accumulation of Zn and Cu in the ground beetles was specific regarding their species and sex. There were no significant differences in the content of metallic elements in carnivorous species. The use of ground beetles as indicators of accumulation is not essential for assessing changes of the environment.

TALARICO et al. (2014) researched the content of chemical elements in the ground beetles *Carabus lefebri*. In particular, the elements As and Hg in the body of the beetles in the municipal waste dumps have been investigated. Concentration of metals in the beetles can be used for the determination of soil contamination.

Similarly, we studied the content of heavy metals (Pb, Zn and Cu) in bodies of two ground beetles in the mining deposit of Teghout.

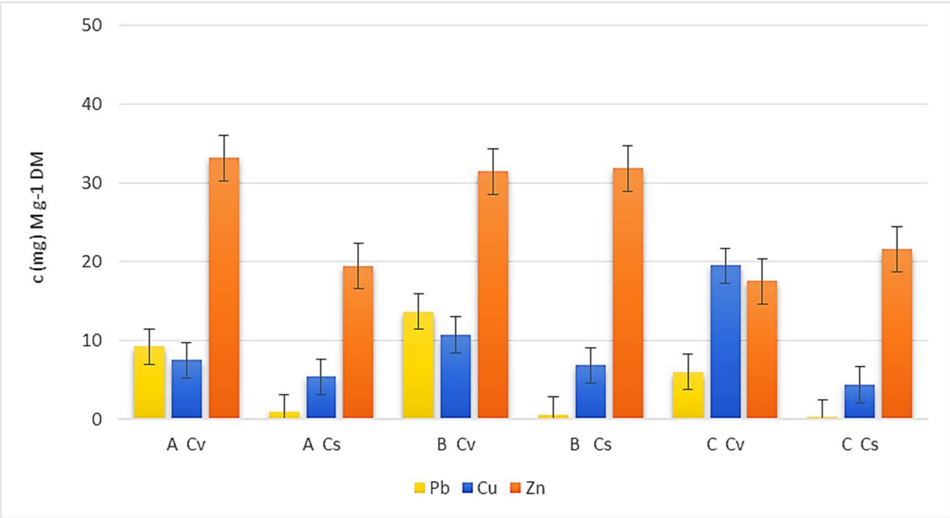

Fig. 7. Value changes of the monitored elements in the bodies of beetles in the selected 3 areas of Teghout mine center. (Cv – *Carabus varians*, Cs – *Carabus septencarinatus*)

Table 2. Diversity of epigeic beetles (Coleoptera) found on three areas in Teghout's mine in 2016, indicating the number of individuals (ex).

Family / Species	**Study areas**		
	A	B	C
Carabidae	ex	ex	ex
Brachinus crepitans (Linnaeus, 1758)	1		
Calathus ambiguus (Paykull, 1790)	3	5	4
Callistus lunatus (Fabricius, 1775)	2		
Carabus gotschi Chaudoir, 1846		1	
Carabus pushkini Adams, 1817		6	
Carabus septencarinatus Motschulsky, 1840	38	43	92
Carabus varians Fischer, 1827	17	2	28
Harpalus tenebrosus Dejean, 1829	2		
Laemostenus lederi (Reitter, 1885)	41		
Leistus fulvus Chaudoir, 1846		1	
Notiophilus rufipes Curtis, 1829			1
Ophonus rupicola (Sturm,1818)		1	
Oxypselaphus obscurus (Herbst, 1784)	1	1	
Poecilus versicolor (Sturm, 1824)	1		
Pseudoophonus rufipes (De Geer, 1774)	3		
Pterostichus strenuus (Panzer, 1797)		5	3
Stenochlaenius coeruleus (Steven, 1809)	97		66
Histeridae			
Paromalus parellelepipedus (Herbst, 1792)			1
Silphidae			
Phosphuga atrata (Linnaeus, 1758)			1
Necrophorus fossor Erichson, 1837	2		
Necrophorus humator Olivier, 1790		2	
Silpha carinata Herbst, 1783	3	1	
Leiodidae			
Agathidium seminulum (Linnaeus, 1758)			
Catops fuliginosus Erichson, 1837			6
Ptomaphagus sericatus (Chaudoir, 1875	10	10	47
Sciodrepoides watsoni (Spence, 1815)	5	2	3
Leptinidae			
Leptinus caucasicus Motschulsky , 1840		1	2
Staphylinidae			
Drusilla canaliculata (Fabricius, 1787)	9	4	
Medon castaneus (Gravenhorst, 1802)			

Family / Species	**Study areas**		
	A	B	C
Mycetoporus thoracicus (Fabricius, 1776)		3	
Ocypus ochripennis (Ménétries, 1832)	2		
Omalium caesum Gravenhorst, 1806	1		1
Othius grandis Hochhuth, 1849	1	1	2
Oxytelus sculpturatus (Gravenhorst, 1806)		2	
Philonthus cognatus (Stephens, 1832)			4
Philonthus pachycephalus Nordmann, 1837		1	5
Philonthus splendens (Fabricius, 1792)			3
Platydracus erythropterus Linnaeus, 1758			1
Platydracus chalcocephalus (Fabricius, 1801)			5
Platydracus stercorarius (Olivier, 1795)	1		13
Rugilus longicollis (Fauvel, 1900)		1	1
Tachinus laticollis Gravenhorst, 1802		4	
Tachyporus transversalis Gravenhorst, 1806		5	
Xantholinus khnzoriani Coiffait, 1966			4
Xantholinus variabillis Hochhuth, 1851		2	
Zyras humeralis (Gravenhorst, 1082)		3	
Pselaphidae			
Bryaxis corpulentus (Motschulsky, 1845)			
Byrhinus puncticollis (Denny, 1825)			
Bryaxis crassicornis (Motschulsky, 1835)		2	
Lucanidae			
Dorcus parallelipipedus (Linnaeus, 1758)		1	
Geotrupidae			
Geotrupes spiniger (Marsham, 1802)	1	1	
Scarabaeidae			
Onthophagus coenobita (Herbst, 1783)			2
Onthophagus furcatus (Fabricius, 1781)	1		
Onthophagus ovatus (Linnaeus, 1767)		5	1
Onthophagus verticicornis (Laicharting, 1781)		1	
Valgus hemipterus (Linnaeus, 1758)		1	
Lampyridae			
Lampyris noctiluca (Linnaeus, 1767)	1	1	7
Cleridae			
Necrobia violacea (Linnaeus, 1758)			2
Nitidulidae			
Epuraea binotata Reitter, 1872		3	
Epuraea pallescens (Stephens, 1830)		2	

Family / Species	Study areas		
	A	B	C
Glischrochilus quadrisignatus (Say, 1835)	1		
Rhizophagidae			
Rhizophagus bipustulatus (Fabricius, 1792)			3
Cucujidae			
Pediacus smirnovi Nikolsky- Belov, 1929	1		6
Cryptophagidae			
Atomaria linearis Stephens, 1830		1	
Atomaria nigrirostris Stephens, 1852		1	
Cryptophagus pallidus Sturm, 1845			2
Cryptophagus punctipennis Brisout, 1863			1
Sternodea lederi Reitter, 1876		4	
Endomychidae			
Endomychus armeniacus Motschulsky, 1835			1
Erotylidae			
Dacne semirufula Reitter, 1897		1	
Latridiidae			
Aridius nodifer (Westwood, 1839)		2	
Dienerella argus (Reitter, 1884)			1
Enicmus planipennis Strand, 1940			4
Lathridius anthracinus Mannerheim, 1844		1	
Sphindidae			
Aspidiphorus lareyniei Jacq.Val, 1859			2
Zopheridae			
Pycnomerus sulcicollis (Germar, 1824)	5		5
Ciidae			
Cis bidentatus (Olivier, 1790)			1
Octotemnus glabriculus (Gyllenhal, 1827)			2
Salpingidae			
Salpingus caucasicus Motschulsky,	1		
Lagriidae			
Lagria hirta (Linnaeus, 1758)		1	3
Tenebrionidae			
Mycetochara flavipes (Fabricius, 1792)			2
Scaphidema metallicum (Fabricius, 1792)		1	
Cerambycidae			
Morimus verecundus (Faldermann, 1836)	1		
Chrysomelidae			
Epithrix caucasica Heikertinger, 1950		1	

Family / Species	**Study areas**		
	A	B	C
Curculionidae			
Acalles denticollis (Germar, 1824)			2
Acalles reitteri Meyer, 1896			2
Curculio glandium Marsham, 1802	1		4
Otiorhynchus compressus Stierlin, 1861			1
Otiorhynchus elegantulus Germar, 1824	3	1	
Otiorhynchus lederi Stierlin, 1876			2
Pholicodes pancausasicus Davidyan, 1992		2	
Plinthus dolosus Reitter, 1884			1
Polydrusus mollis (Stroem, 1768)		2	
Pseudocneorhinus setosus Roelofs, 1879	2		
Urometopus asiaticus (Formanek, 1910)	3	34	164
Diversity Sahnnon	**2.27**	**3.35**	**2.36**
Ekvitability	**0.65**	**0.88**	**0.63**
Total species/specimens	**22/181**	**45/131**	**46/369**

CONCLUSION

By researching the mining site Teghout, we have gained valuable insight into the composition of Epigeic beetle fauna in three study areas. In 2016 we settled three sets of traps in the ground and obtained a total of 95 species of beetles, of which the dominant species were: *Carabus septencarinatus, Carabus varians, Laemostenus lederi, Stenochlaenius coeruleus, Ptomaphagus sericatus, Platydracus stercorarius, Urometopus asiaticus*. From these species, two species of beetles were selected for metal analyzes: *Carabus varians* and *Carabus septencarinatus.*

The greatest value of the species diversity was ecotone 3.35 (Shannon). The smallest value of the species spectrum as well as the diversity of beetle cenosis was in the area, which was located closest to the mining exploitation center.

The highest values of metallic elements – Zn, was found in *Carabus varians* 33.197 mg / g dry weight. From area A to area C, the values of metals in the bodies of monitored beetles gradually increase. This is related to the transmission of emissions through wind activity.

ACKNOWLEDGEMENT

We are grateful to Suren Yeritsyan and Ani Sargsyan, who guided and helped us during the field work at the Teghout mining centre. We thank M. Kalashian (Armenian Academy of Sciences) and R. Lohaj (Slovakia) for their help in the determination process of the species. We are also thankful M. Molnárová (Comenius University Bratislava, Slovakia) for her assistance and help to conduct chemical analysis of samples.

REFERENCES

BUTOVSKY, R. 2011. Heavy metals in carabids (Coleoptera, Carabidae). In: KOTZE, D.J., ASSMANN, T., NOORDIJK, J., TURIN, H., VERMEULEN, R. (Eds) Carabid Beetles as Bioindicators: Biogeographical, Ecological and Environmental Studies. *ZooKeys* 100: 215–222.

CONTI, E. 2017. Ecotoxicological Evaluation of *Parallelomorphus laevigatus* (Coleoptera, Carabidae) as a Useful Bioindicator of Soil Metal Pollution. *Advances Techniques in Biology and Medicine* 5: 228-231.

JELASKA, L.Š., BLANUŠA, M., DURBEŠIČ, P., JELASKA, S.D. 2007. Heavy metal concentrations in ground beetles, leaf litter, and soil of a forest ecosystem. *Ecotoxicology and Environmental Safety* 66: 74–81.

JURKOVIČ, Ľ., HILLER, E., VESELSKÁ, V., PEŤKOVÁ, K. 2011. Arsenic Concentrations in Soil Impacted by Dam Failure of Coal-Ash Pond in Zemianske Kostoľany. *Bull. Environ. Contam. Toxicol.* 86: 433-437.

MENU, M. 2017.Soil Invertebrates-a usefull Tool in Biominotoring of Heavy Metal Pollution. A Review. *Studia Universitatis “Vasile Goldiş”, Seria Ştiinţele Vieţii* 27(4): 247-258.

MAJZLAN, O. 2013. Diverzita chrobákov (Coleoptera) na ploche kontaminovanej arzénom pri Zemianskych Kostoľanoch. *Entomofauna carpathica* 25(1): 33-43.

MAJZLAN, O. 2014. Banské záťaže v prírode a biodiverzita chrobákov (Coleoptera). *Entomofauna carpathica* 26(1): 19-32.

MAJZLAN, O., MAJZLAN, J. 2011. Sociony chrobákov (Coleoptera) na halde lúženca z niklovej huti v Seredi. *Naturae Tutela* 15(1): 27-37.

MOLNÁROVÁ, M., FARGAŠOVÁ, A. 2009. Se (IV) phytotoxicity for monocotyledonae cereals (Hordeum vulgare L., Triticum aestivum L.) and dicotyledonae crops (Sinapis Alba L., Brassica napus L.). *Journal of Hazardous Materials* 172: 854-861

PURCHART, L., KULLA, E. 2007. Content of heavy Metals in Bodies Field Ground Beetles (Coleoptera, Carabidae) with respect to selected ecological Factors. *Polish Journal of Ecology* 55(2): 305-314.

SAKINE, S., LUFF, M.L. 2010. Ground Beetles (Coleoptera: Carabidae) as bioindicators of Human Impact. *Munis Entomology & Zoology* 5(1): 209-215.

SAMIR, G., ABDELHAFIDH, K., BADREDDINE, S., MONCEF, B. 2016. Assessment of heavy metal contamination in soil and Chlaenius (Chlaeniellus) olivieri (Coleoptera, Carabidae) in the vicinity of a textile factory near Ras Jbel (Bizerte, Tunisia). *Environ. Earth Sci.* 75: 442-449.

SKALSKI, T., KĘDZIOR, R., KOLBE, D., KNUTELSKI, S. 2015. Ground beetles as indicators of heavy metal pollution in forests. *Sylwan* 159(11): 905-911.

STEFANOWICZ, A.M., MAŁGORZATA, S., WOCH, M.W. 2016. High concentrations of heavy metals in beech forest understory plants growing on waste heaps left by Zn-Pb ore mining. *Journal of Geochemical Exploration* 169: 157-162.

TALARICO, F., BRANDMAYR, P, GIULIANINI, P.G., IETTO, F., NACCARATO, A., PERROTTA, E., TAGARELLI, A., GIGLIO, A. 2014. Effects of metal pollution on survival and physiological responses in Carabus (Chaetocarabus) lefebvrei (Coleoptera, Carabidae). *European Journal of Soil Biology* 61: 80-89.