Carabids Rock! – their role in the ecosystem

Lucija Šerić Jelaska

UNITY THROUGH KNOWLEDGE FUND

When, who and why?
Ecological functions and bioindication
Food ecology
Ecosystem services – MEDITERA3

Photo: L. Seric Jelaska

D. Johan Kotze et al. / ZooKeys 100: 55–148 (2011)

The 1st ECM, 1969

Participants of the first European Carabidologist Meeting in Wijster, 1969. From left to right: Vlijm, Van der Aart, Lindroth, Stein, Wijmans, Hengeveld, Palmén, Van Dijk, Richter, Venema, Mook, Thiele, Tjallingii, Den Boer, Haeck, Neumann, Meijer.

19th

1969-2019
50th anniversary

European Carabidologists Meeting

16-20 September 2019

Primiero San Martino di Castrozza
Trento
Italy

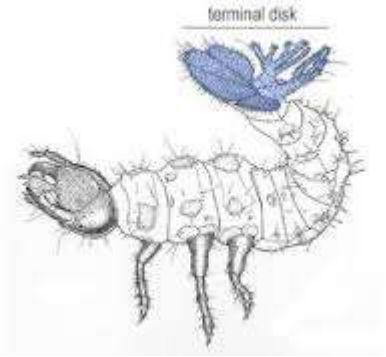
50 years after the 1st ECM

"Carabids in extreme environments"

Why study carabid beetles?

flickr.com

- cosmopolitan
- ~40000 species
- ~3000 species in Europe
  - *Bembidion* Latreille, 1802 with 1200 described species (Maddison 2012)
- Endemic species – in caves, mountains, bogs, …

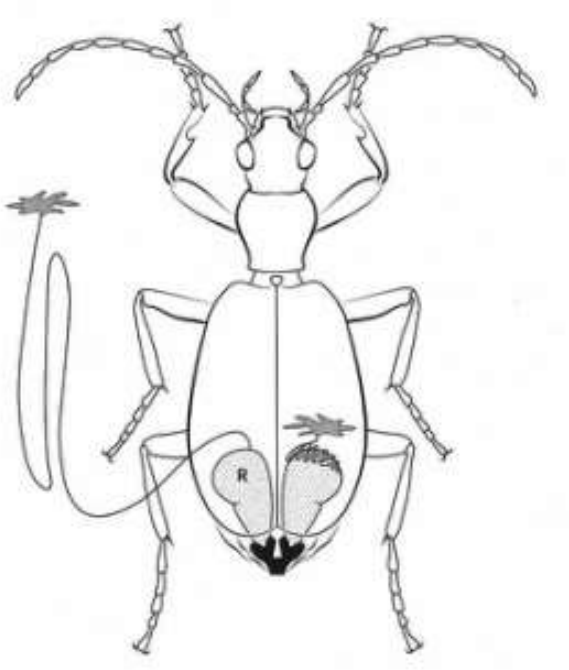


Paussinae

Ant nest beetles

[A burrow trapping beetle on the hunt]

Robertson, J. A., & Moore Brusca, W. (2017).
Systematic Entomology, *42*(1), 134-170.



defence

Structure of a Bombardier Beetles' Pygidial gland: T Eisner For Love of Insects, pg. 31. http://www.hycadventures.com/page66.php

Alpine-Dinaric mountain chain karst area

Dinarides

- Rich in geological history and in flora and fauna (Sket 1996)
- >200 mountains from the south of Italian Alps till Pindus mountains
- ~650-700 km long and 50-200 km wide mountain chain
- High species diversity and interspecific variations especially with low dispersal species

http://www.dinaridestrails.org/dinaridi/

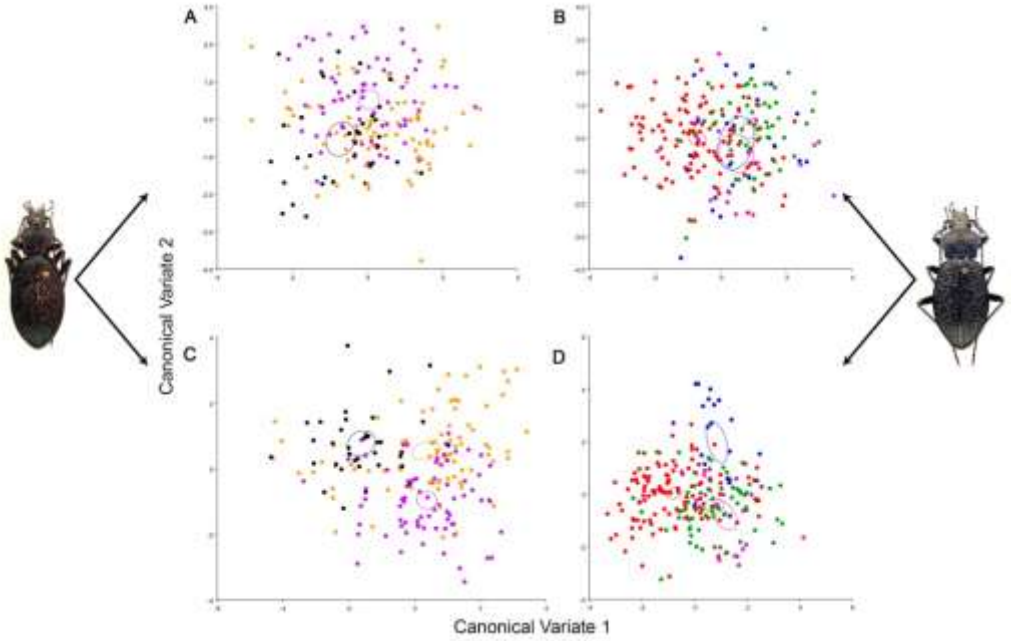
Carabus croaticus Dejean 1826

Carabus caelatus Fabricius 1801

Carabus croaticus Dejean 1826

Drovenik & Peks (1999)	Turine et al. (2003)	Deuve (2004)	Bousquet et al. (2017)
subsp. croaticus Dejean 1826	+	+	+
subs. frankenbergeri Obenberger 1914		+	
subsp. kobingeri Apfelbeck 1904	+	+	
subsp. pretneri Krätschmer and Drovenik 1977		+	
subsp. bosnicus Apfelbeck 1890a	+	+	+
subsp. durmitorensis Apfelbeck 1904	+	+	+
subsp. zepcensis Reitter 1902b		+	+
subsp. ljubetensis Apfelbeck 1918a	+	+	
subsp. babinjensis Apfelbeck 1919	+	+	
subsp. bosiljevici Drovenik and Pavićević 1985		+	
subsp. kraetschmeri Drovenik 1978		+	
subsp. mediterraneus Apfelbeck 1919		+	
subsp. droveniki Kraetschmer 1984		+	
subs. antoniocaldoni Rapuzzi 2014			+

Zeljka Jambrosic-Vladic
PhD student
University of Zagreb



Zoomorphology
https://doi.org/10.1007/s00435-018-0428-5

ORIGINAL ARTICLE

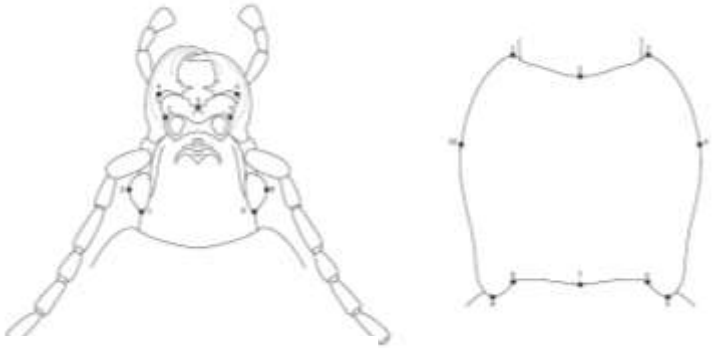
Variations in body shape of mountain habitat specialist *Carabus croaticus* and its sister species *Carabus caelatus* (Coleoptera: Carabidae) populations across Dinaric Alps

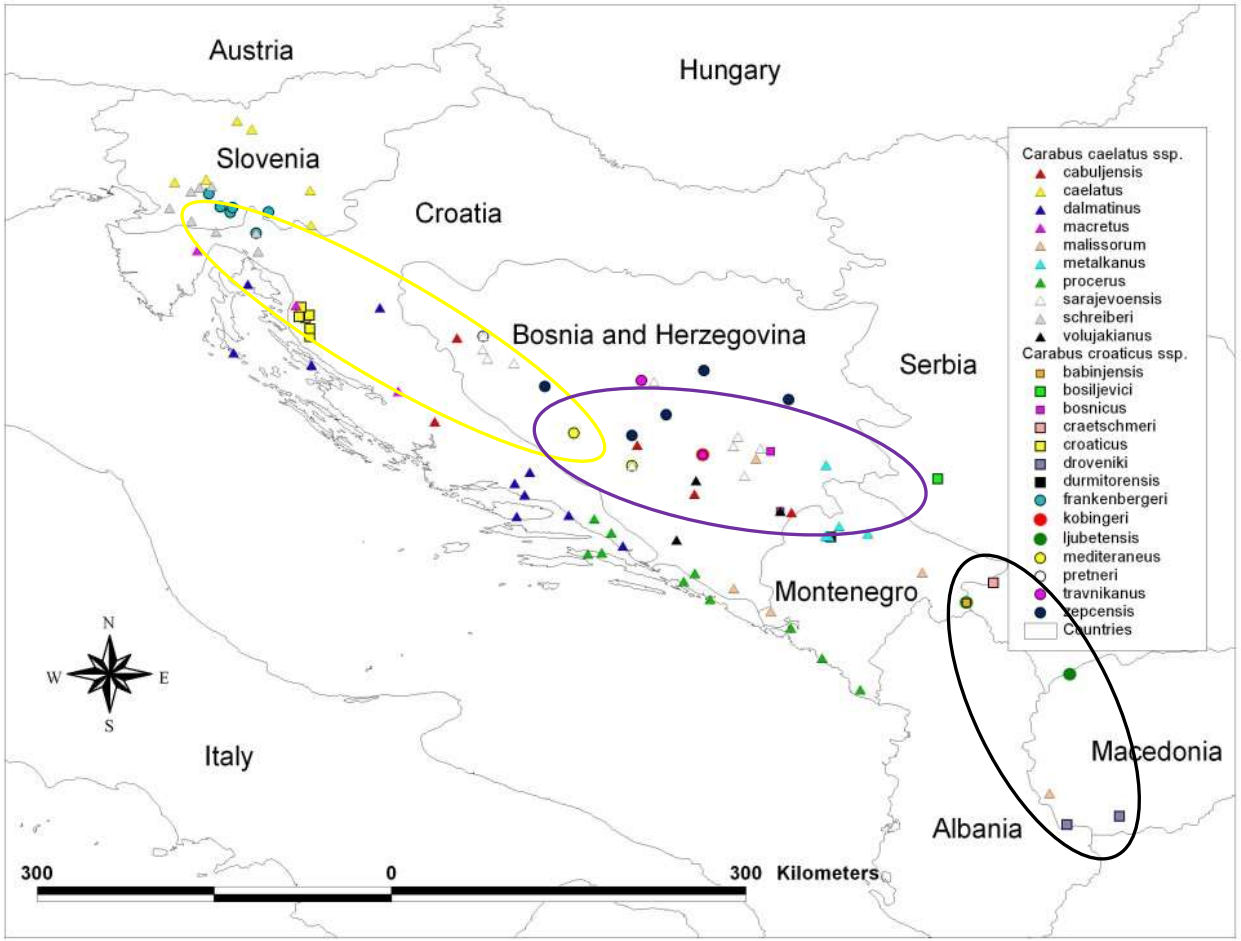
Željka Jambrošić Vladić[1] · Hugo A. Benítez[2] · Alja Pirnat[3] · Slavčo Hristovski[4] · Lucija Šerić Jelaska[5]

GMM

192 *C. caelatus* (91 ♂, 101 ♀)

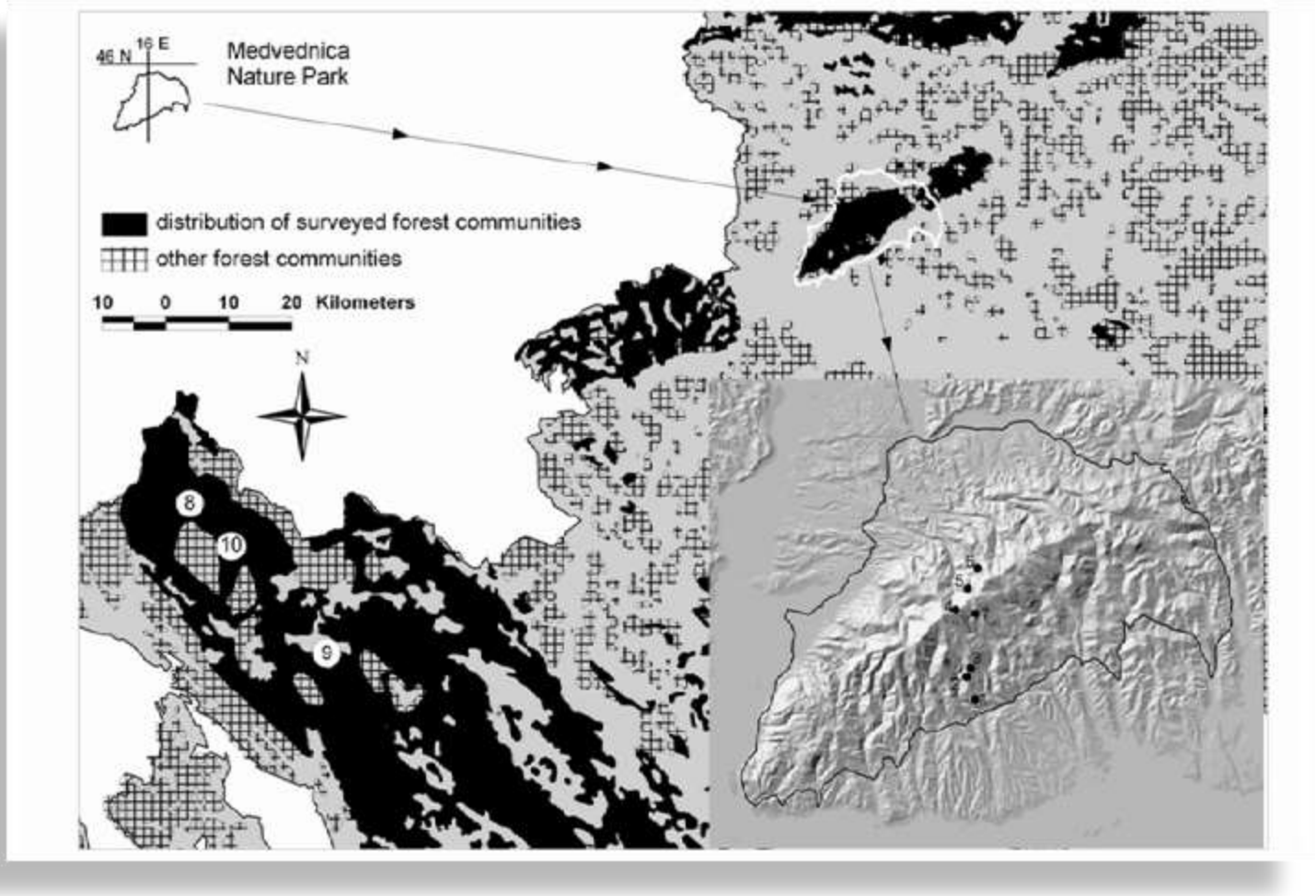
224 *C. croaticus* (115 ♂, 109 ♀)





Location of the nine landmarks on the head, and ten landmarks on the pronotum of the specimens of *Carabus* sp.

Ecological functions and bio-indication



Body size (2 mm -40 mm)

- Small
- Meadium
- Large

Wing morphology

- Brachypterous
- Macropterous
- Polypterous

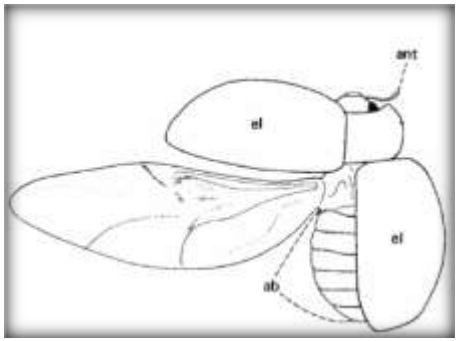
Overwintering

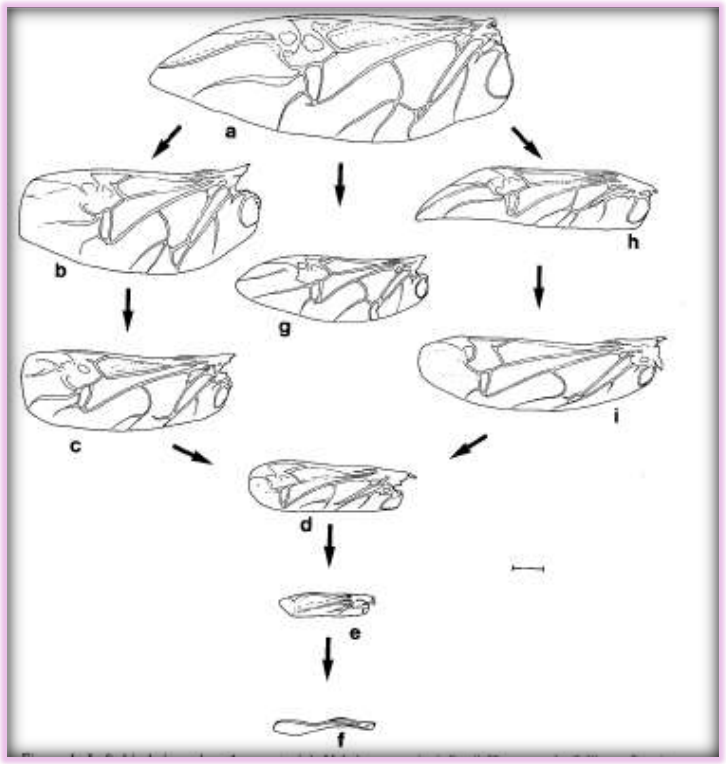
- As larvae (autumn active adults)
- As adults (spring active adults)

Habitat affinity

- Forest specialists
- Generalists
- Open habitat species

To fly or not to fly





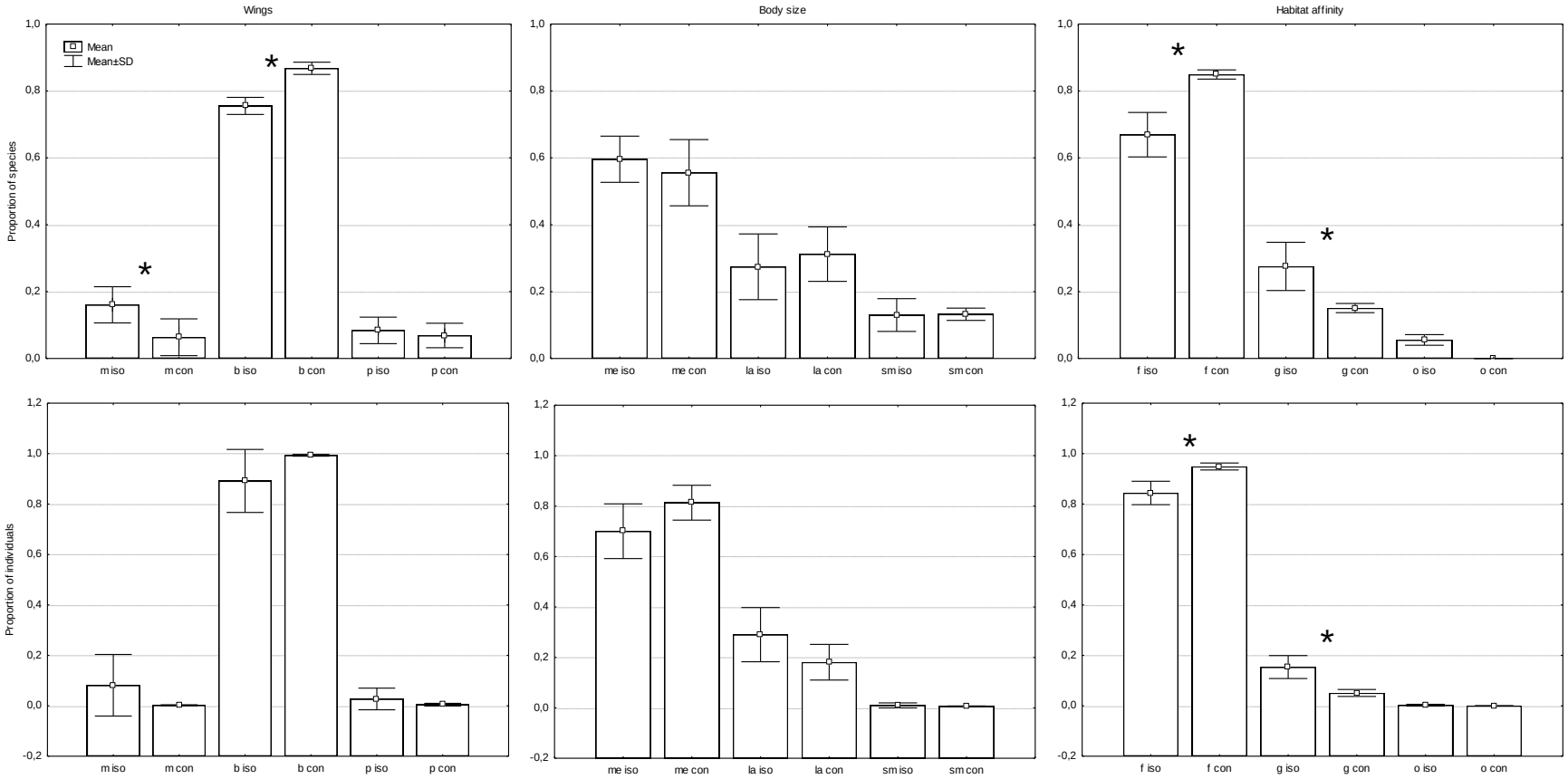
Winged species

- plesiomorphic character
- better at dispersal

Wingless species

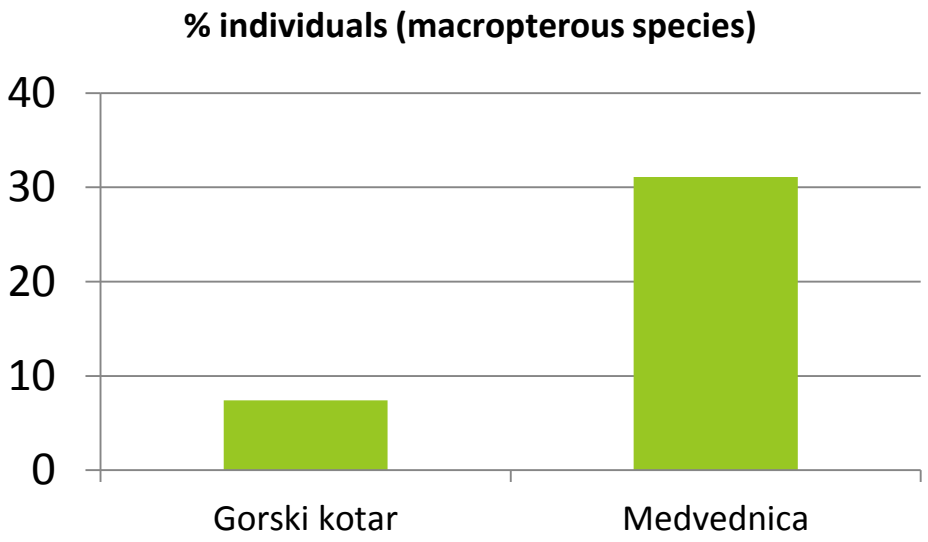
- descended from full-winged ancestors
- appearance of brachypterous individuals influenced by habitats, geography, phylogeny, ecological stability
- with brachyptery being favored in homogenous environments with high levels of stability.
- have a greater viability, simpler anatomy and physiology, and a lower energy requirement

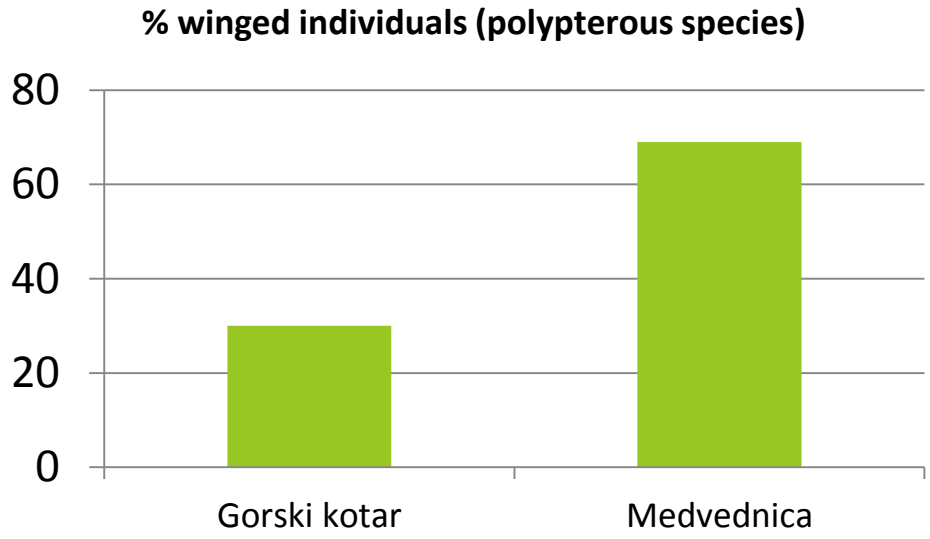
Polymorphic species



Body size	GK continuous mt forests	Med isolated mt forests
Large %	28	17
Medium %	54	57
Small %	18	26

Habitat affinity	GK continuous mt forests	Med isolated mt forests
Forest specialist %	86	59
Generalists %	14	30
Open habitat sp %	0	11





Polypterous species:

N. biguttatus, S. vivalis and

L. rufomarginatus

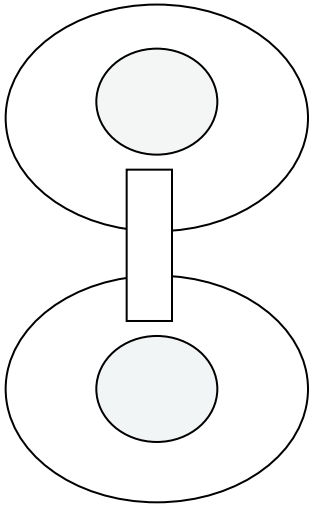
30% winged ind in continuous forests

69% winged ind in isolated mt forest

– smaller dispersal ability, longer development

- continuous habitats

- with stable ecosystems



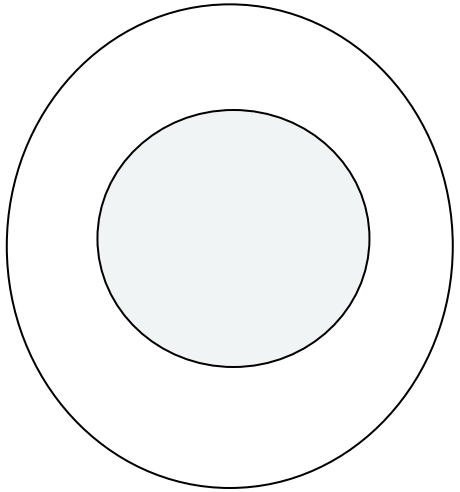
✓ **Size matters!**

Bruhl et al. 2003 study on ants

Keller et al. 2005, Koivula & Vermuelen 2005, Oates et al. 2005, Gaublomme et al. 2008, Šerić Jelaska & Durbešić 2009 ect.

✓ **unique ecology of continuous habitats;**

Desender 2005 – for conservation purposes –advances of enlarging the existing habitats than connection few smaller



Fran Kostanjšek
PhD student
University of South Bohemia

Insect Conservation and Diversity

Insect Conservation and Diversity (2018) doi: 10.1111/icad.12295

Size matters! Habitat preferences of the wrinkled bark beetle, *Rhysodes sulcatus*, the relict species of European primeval forests

FRAN KOSTANJSEK,[1,2] PAVEL SEBEK,[1] BEATA BARANOVA,[3] LUCIJA SERIC JELASKA,[4] VLADAN RIEDL[5] and LUKAS CIZEK[1,2] [1]Institute of Entomology, Biology Centre of the Czech Academy of Sciences, Ceske Budejovice, Czech Republic, [2]Department of Zoology, Faculty of Science, University of South Bohemia, Ceske Budejovice, Czech Republic, [3]Department of Ecology, Faculty of Humanities and Natural Sciences, University of Presov, Presov, Slovakia, [4]Department of Zoology, Faculty of Science, University of Zagreb, Zagreb, Croatia and [5]Nature Conservation Agency of the Czech Republic, Southern Moravia Office, Brno, Czech Republic

Rhysodes sulcatus

Foto L.S. Jelaska

- Relict species of of primeval forests
- rare and vanishing
- major lack of information on habitat requirements
- discontinuous distribution in Europe
- “NATURA 2000” species - **Annex II species**
- status unfavorable or unknown within EU

Foto F. Kostanjsek

… materials and methods

Foto L.S. Jelaska

- fence traps (only on one site) from April till end of June
- window traps (on all sites 10 traps) from April till end of June
- night survey of the tree trunks
- searching through the dead wood

After 177 logs searched …

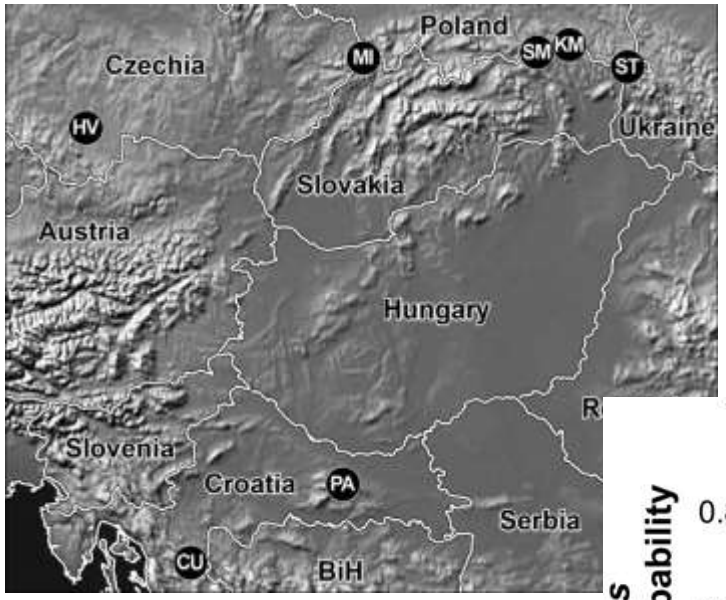


Fig. Location of sites where the data on habitat requirements of Rhysodes sulcatus were collected (HV for Hluboka nad Vltavou, MI for Mionsi, SM for Stebnicka magura, KM for Komarnicka jedlina, ST for Stuzica, CU for Corkova uvala, PA for Papuk).

Photo: Lucija Šerić Jelaska

- diameter of log is the most important variable
- moderate moisture increases probability of occurrence
- beetle doesn't care about host tree species

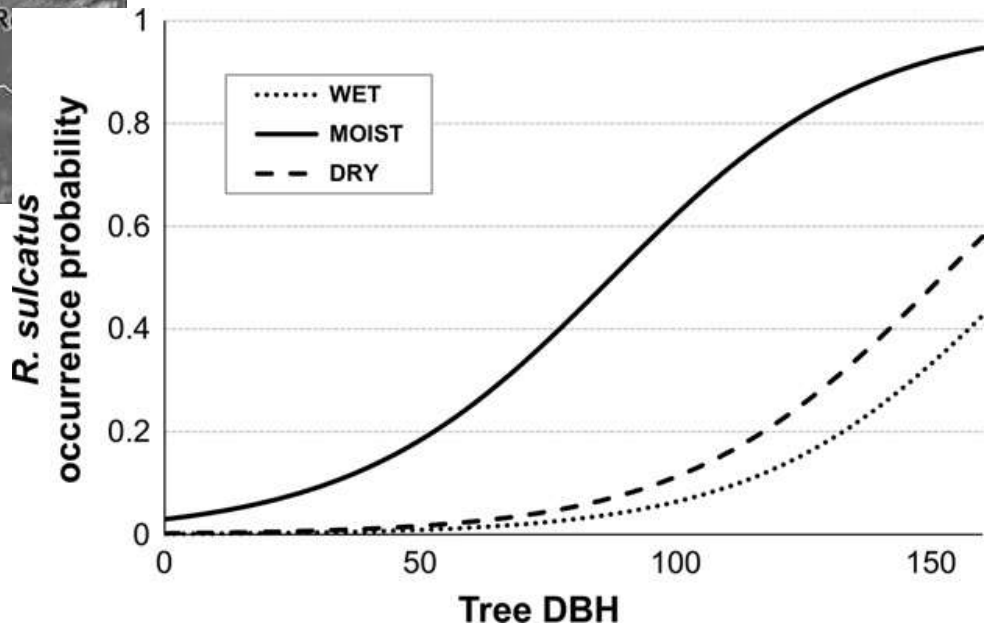
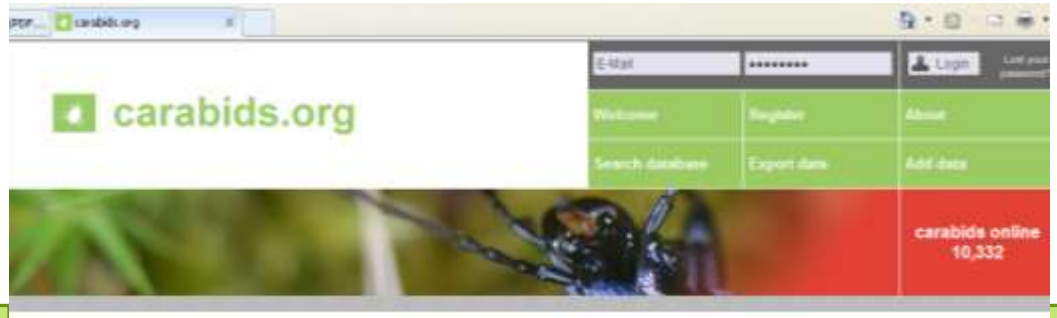


Fig. Probability of *Rhysodes sulcatus* occurrence in a deadwood unit depending on its diameter and wood humidity. The sigmoid curves represent the occurrence prediction probability by logistic regression.

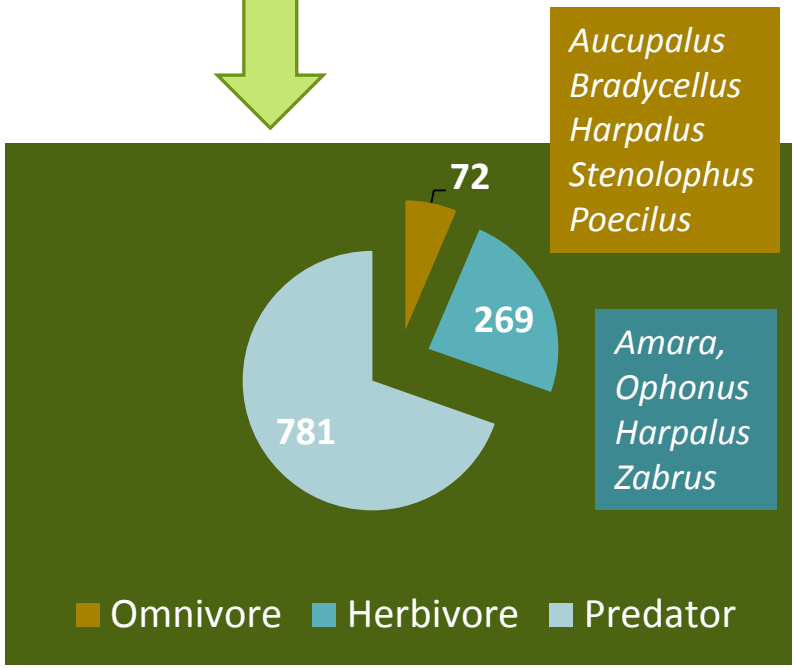
Carabid beetles – trophic ecology

Assessing trophic networks helps to understand how ecosystems function and how to improve ecosystem services

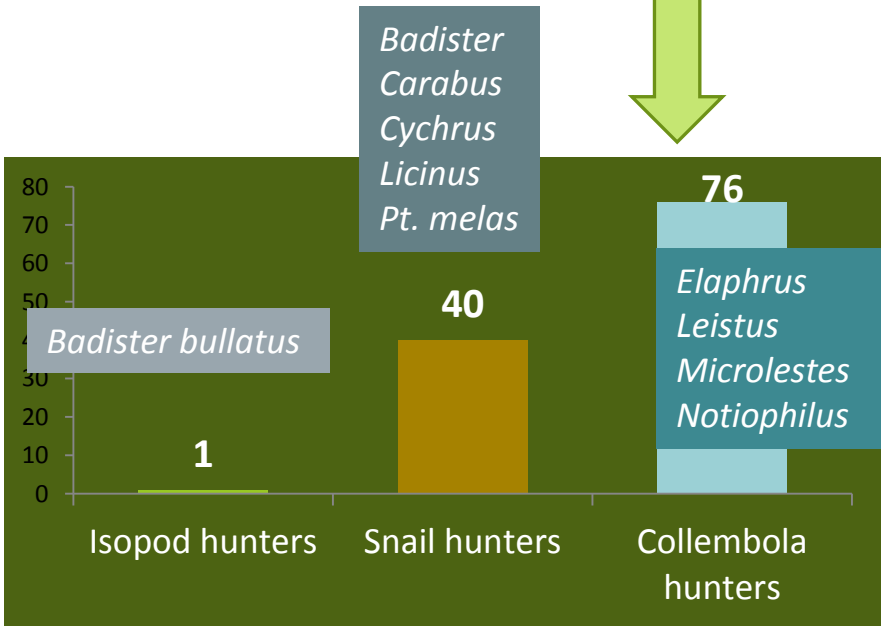
Carabid beetles – trophic ecology



Trophic levels:



Hunting abilities:



Visual hunters: 465 items

- crepuscular/ night active
- ground active, mainly generalist predators
- soft prey tissue

- direct observation in the field not easy
- microscopic screening of gut content not easy
- using PCR with primers that allow the detection of semi-digested prey DNA in predator gut samples

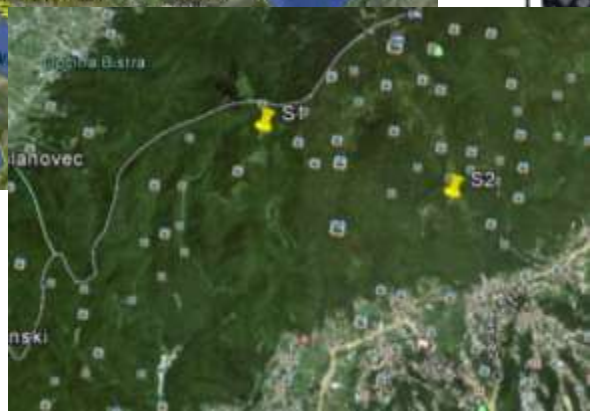
- ✓ The prey spectrum of carabid beetle assemblages in Croatian and Wales woodlands
- ✓ Seasonal changes in their diet
- ✓ Evidence for prey selection among main prey groups
- ✓ The effect s of trophic relationships on transmission of xenobiotic elements (Cd, Hg, and Pb)

Study sites





- 4 metalliferous and one control site (2 in Croatia nad 3 in UK)
- High Pb, Cd and Hg concentrations in the soil
- Deciduous woodlands






Seasonal changes within the species :

- higher Cd concentrations in carabid species *Calathus melanocephalus* in autumn (Janssen 1991)

- species active in autumn accumulate more Cd (ANOVA, p=0.05)

Šerić Jelaska et al 2007. Ecotoxicology and environmental safety

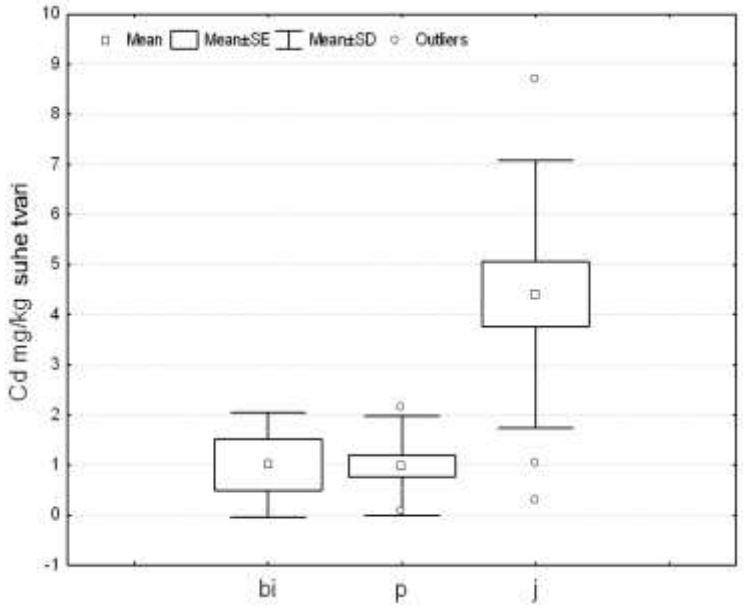


Fig. Šerić Jelaska et al 2007. Ecotoxicology and environmental safety

MDTI

- diagnostic PCR

species-and group-specific primers

- sequence-based identification

NGS
barcoding primers
metabarcoding

Group specific primers:

- ✓ Earthworms 12S rRNA (Harper et al 2005)
  Size 225-236 bp
- ✓ Collembola 18S rDNA (Kusk & Agusti 2008)
  Size 177 & 272 bp
- ✓ *Arion* species (Dodd 2004)
  Size 208-221 bp
- ✓ Isopods 18S rDNA(Jarman et al 2006)
  Size 201-278 bp
- ➢ Lepidoptera 12S rRNA (Sutterland, PhD thesis)

Species specific primers:

Earthworms:

- ✓ *Allobophora chlorotica,* COI (King et al 2010)
  Size 152-261 bp for 5 lineages
- ✓ *Aporrectodea longa,* COI
  Size 213 bp
- ✓ *Lumbricus castaneus,* COI
  Size 189 bp
- ✓ *Lumbricus rubellus,* COII
  Size 164 bp
- ✓ *Lumbricus terrestris,* COII
  Size 256 bp

Slugs:

- ✓ *Deroceras reticulatum* (Dodd 2004)
  Size 109 bp
- ✓ *Limax cinereoniger* (Šerić Jelaska 2011)
  Size 198 bp



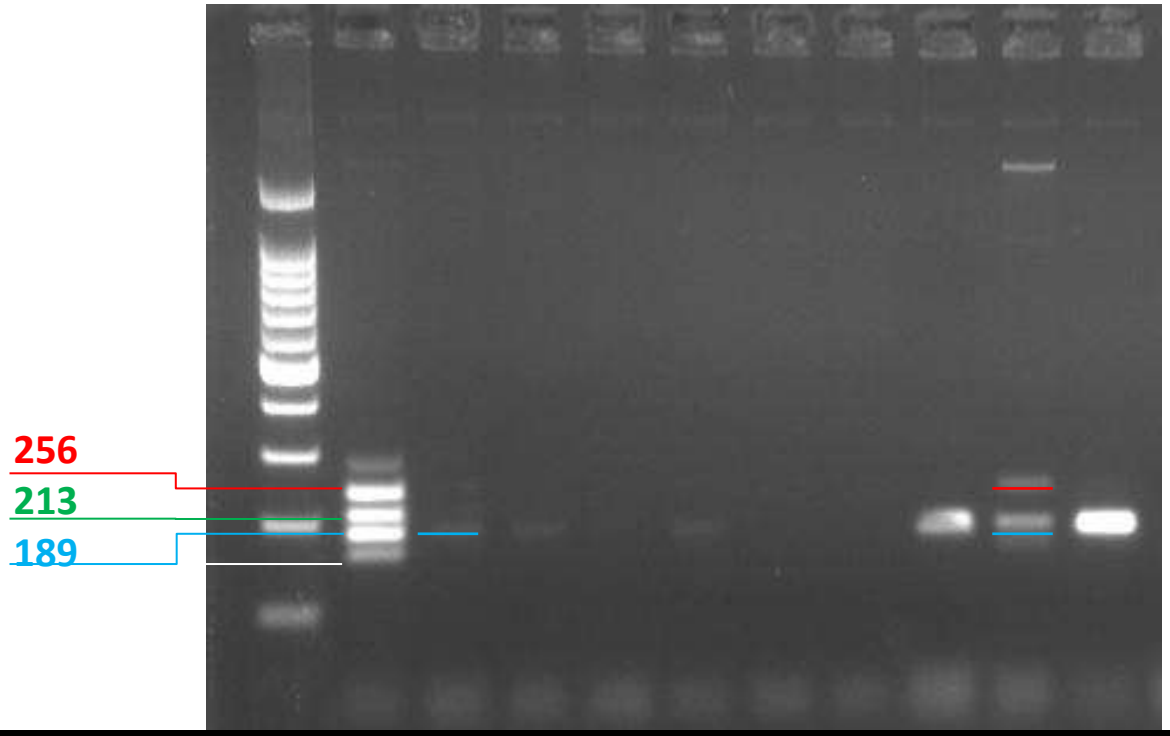
Carabid gut content	Earthworms general Harper et al. 2005	Springtails Kuusk et al. 2008	Slugs Arion & Deroceras Dood 2004	Lepidoptera Sutherland 2000	Woodlice Jarman et.al 2006.	Earthvorms specis specific King et al. 2010	Earthvorms specis specific King et al. 2010.	Lim. Cin. & max. Jelaska 2011	Arthropods general Folmer et al. 1994
Plates	2x	2x	2x	2x	2x	2x	2x	2x	1x
Neg. control									1x

Gel after PCR using earthworms general primers

To avoid false negatives

Positive on worms

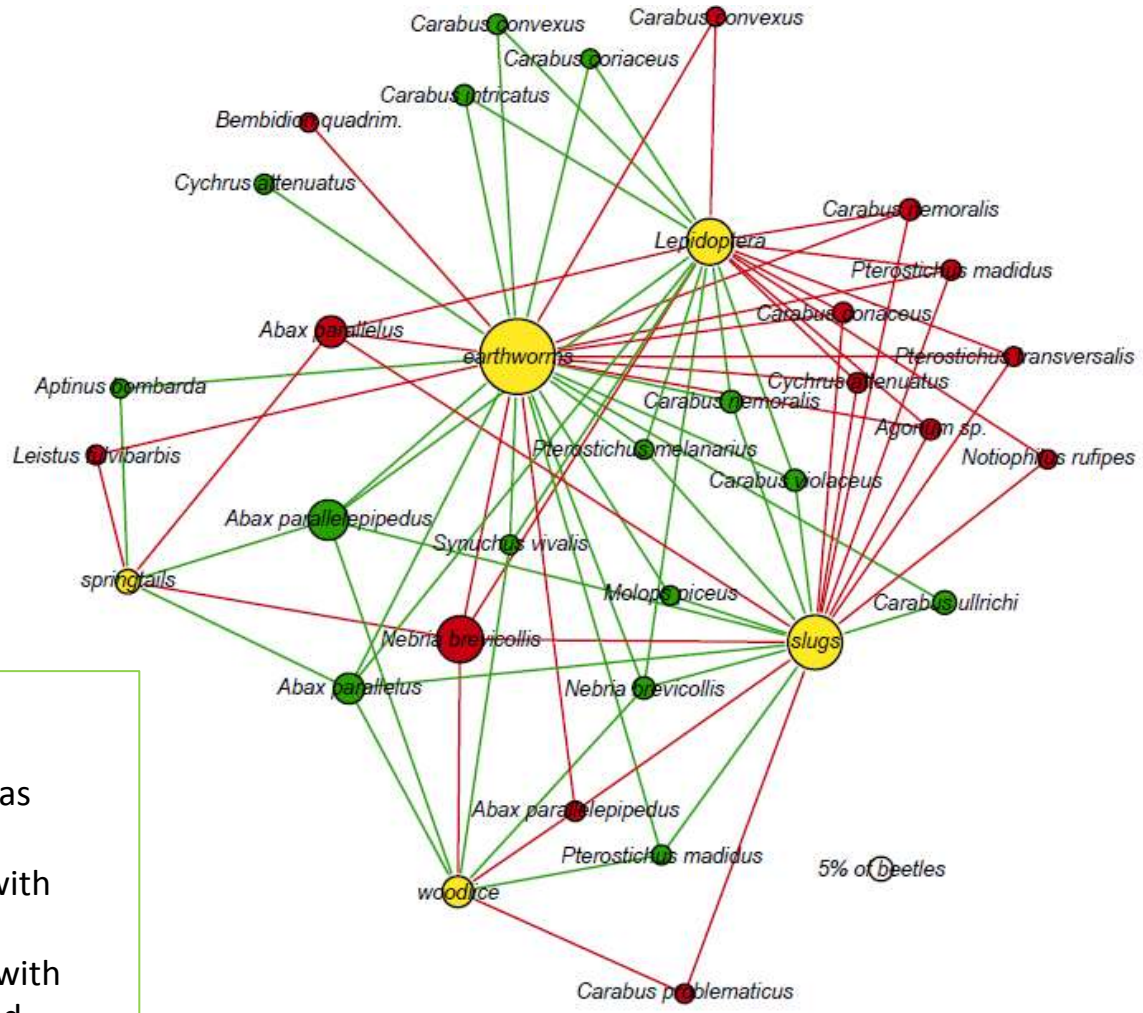
Led ,+contr,CA1 CA2 CA3 CA4 CA5 CA6 CA7 CA8 CA9



Detected in gut samples

	+con	CA1	CA2	CA3	CA4	CA5	CA6	CA7	CA8	CA9
L.terrestris	+								+	
Apo. longa	+									
L. castanea	+	+	+		+			+	+	+
L. rubellus	+									

- Beetles caught in spring
- Beetles caught in autumn
- Prey group

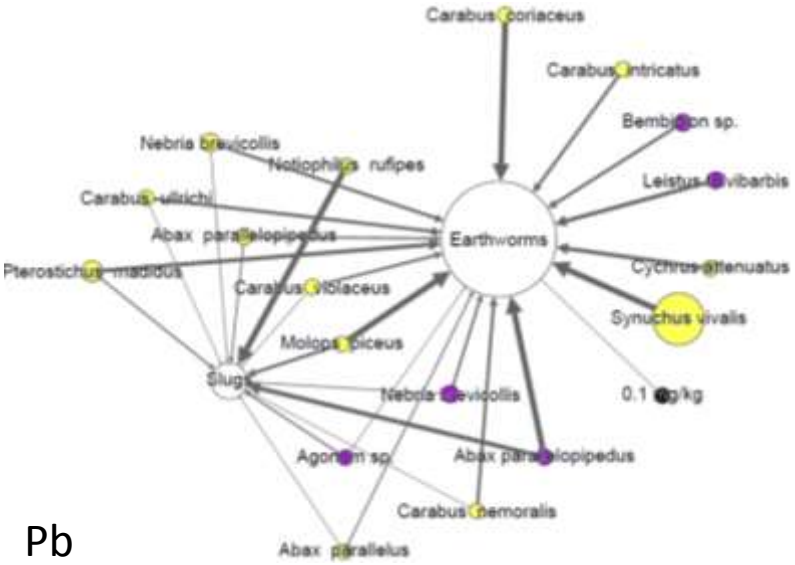


✓The diet changes with season

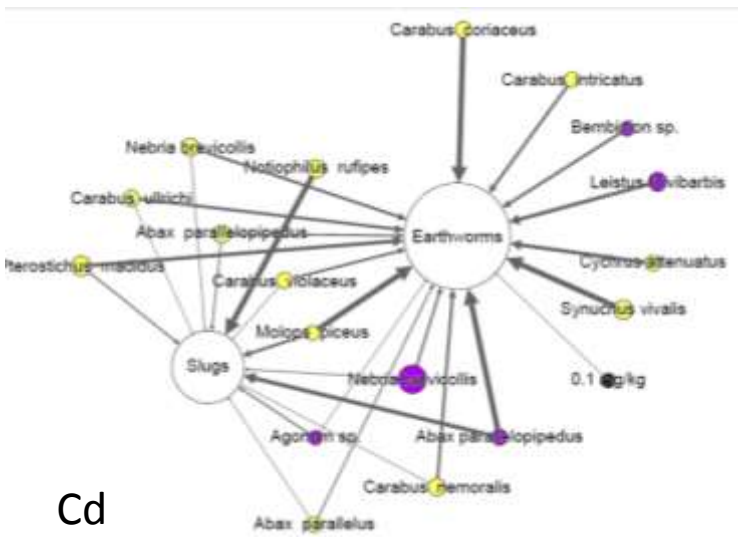
✓ Some evidence for prey choice was recorded

- ✓in early summer samples, with earthworms being taken preferentially in comparison with other prey present in the field.
- ✓In autumn prey was consumed in correlation to its density on the field.

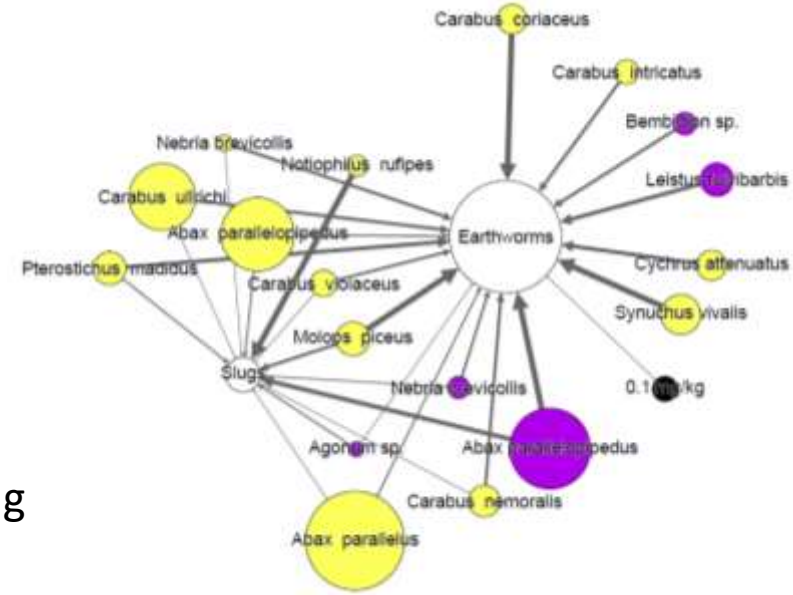
Fig,: Node diagrams of trophic interactions observed between carabid predator species and prey groups. Lucija Šerić Jelaska et al. 2014 *Eur. J. Entomol.* ***111(5): 631–638, 2014***



Pb



Cd



Hg

Beetles caught in spring

Beetles caught in autumn

Prey group

✓HM concentrations in carabids were the lowest ones, except for Hg

✓Concentrations of metal in main prey groups were positively correlated with those in carabids

✓seasonal variations in diet influence metal concentrations along the food chain

Figs.: Node diagrams of observed trophic interactions between prey groups and predator species with measured metal concentrations in the tissue. Size of the nodes reflects mean concentrations of metals in earthworms, slugs and carabids. Arrow thickness represents the percentage of carabid species testing positive for the given trophic interaction.

Šerić Jelaska L, et al (2014) *Molecular ecology* 23, 3755–3766.

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FACULTY OF SCIENCE
Department of Biology

MOLECULAR ECOLOGY
Molecular Ecology (2014) 23, 3758–3766 doi: 10.1111/mec.12866

SPECIAL ISSUE: MOLECULAR DETECTION OF TROPHIC INTERACTIONS

Molecular field analysis of trophic relationships in soil-dwelling invertebrates to identify mercury, lead and cadmium transmission through forest ecosystems

LUCIJA ŠERIĆ JELASKA,*† JASNA JURASOVIĆ,‡ DAVID S. BROWN,† IAN P. VAUGHAN† and WILLIAM O. C. SYMONDSON†
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Eur. J. Entomol. 111(5): 631–638, 2014
doi: 10.14411/eje.2014.079
ISSN 1210-5759 (print), 1802-8829 (online)

Prey detection in carabid beetles (Coleoptera: Carabidae) in woodland ecosystems by PCR analysis of gut contents

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ISSN 0031-5362

original research article

Predation on epigeic, endogeic and anecic earthworms by carabids active in spring and autumn

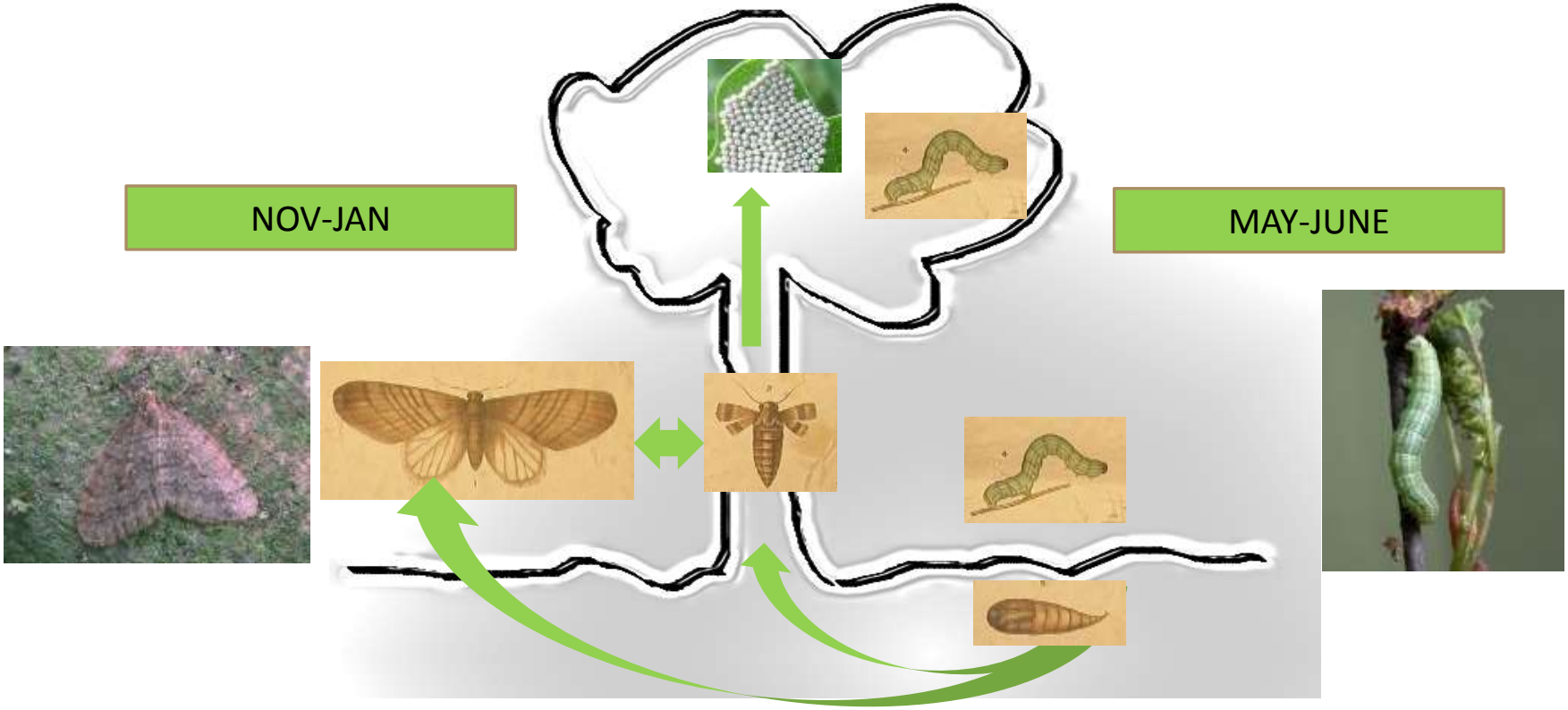
LUCIJA ŠERIĆ JELASKA[1]
WILLIAM O. C. SYMONDSON[2]

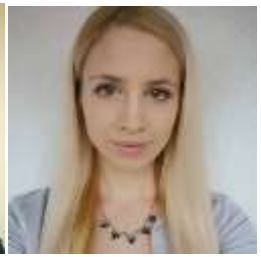
Abstract

Background and purpose: Generalist predatory carabid beetles can

Ecosystem services - predation on early defoliator in deciduous forest

Operophtera brumata winter moth – early defoliator in deciduous forest



Predation on early defoliator in deciduous forest

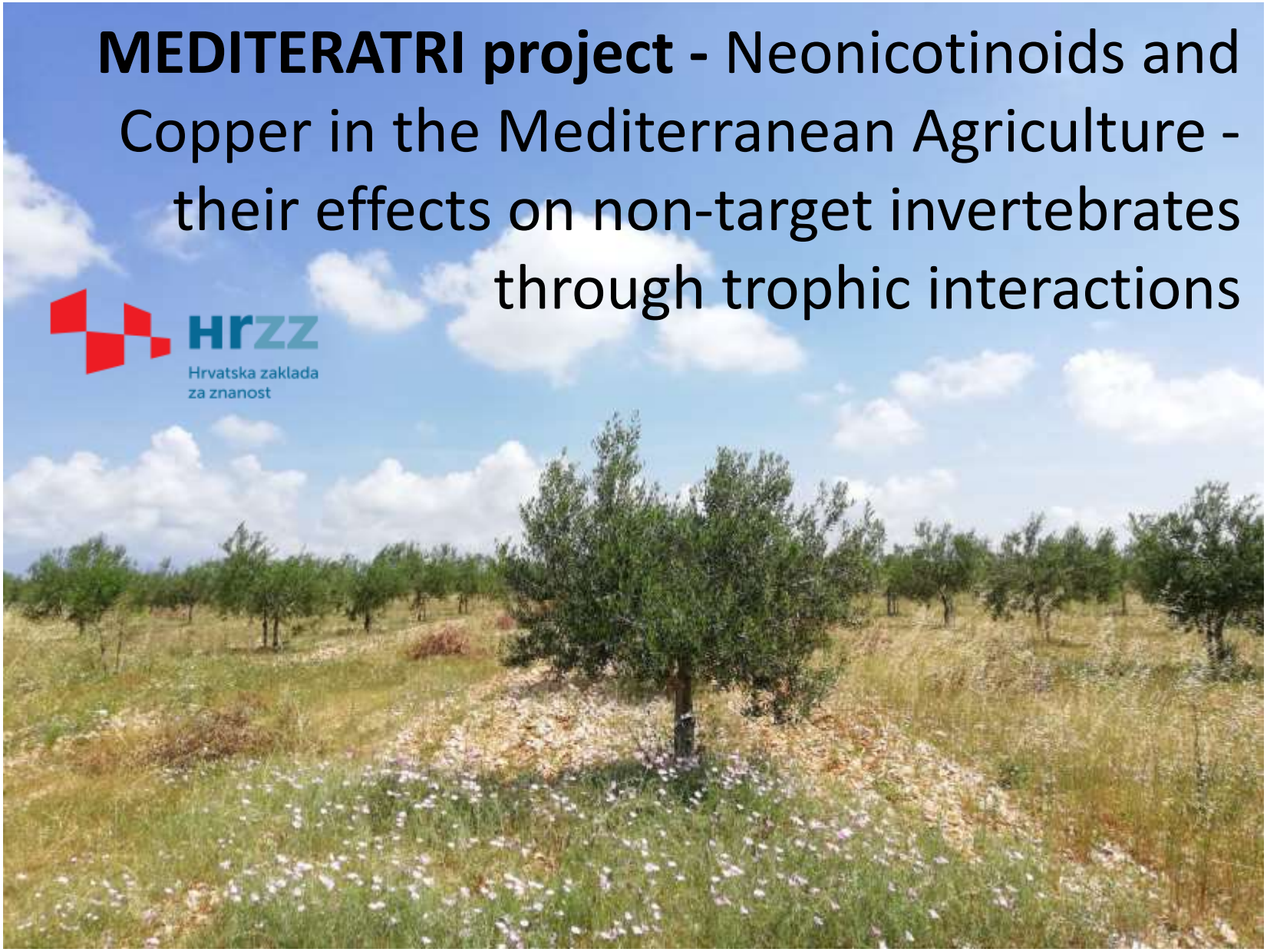
Iva Šutevski and Klara Krmpotić,
Graduate students
University of Zagreb

- Natural enemies of winter moth in its native range,
  - on the ground:
    - I. when free feeding caterpillars balloon down from the canopy
    - II. during pupation
- Predatory arthropods: might provide background-level control. But: first have to be identified




MEDITERATRI project - Neonicotinoids and Copper in the Mediterranean Agriculture - their effects on non-target invertebrates through trophic interactions

HrZZ
Hrvatska zaklada za znanost



https://feeds.croatia.hr/

Project study aims

→to build the food web by analyzing trophic interactions from field-collected invertebrates

→ to see a role of predatory arthropods in biocontrol depending on management type

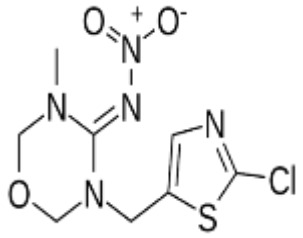
→ to propose the actions that may promote predator sustainability in the field

Biodiversity and community	• Potential prey and predator diversity • Genetic barcoding
Functional diversity	• Detection of trophic interaction between predators and prey using metabarcoding • Building food webs in agroecosystems • Prey preferences models
Population and individual levels	• Body burden with pesticides in situ • Oxidative stress and fitness to pesticides application in vitro • FA using GMM

Barbara Anđelić
PhD student
University of Zagreb

Neonicotinoids and Copper (Cu) in Mediterranean agriculture

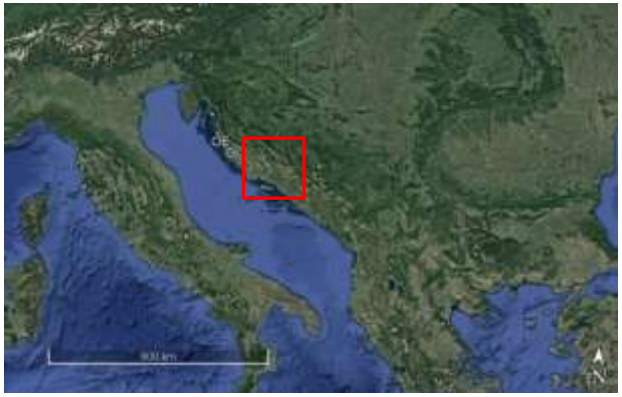
Neonicotinoids – synthetic, harmful for pollinators
Copper- traditionally used and allowed to use in ecological agrosystems



Thiamethoxam chemical structure

Aims :

1. Quantification of pesticide accumulation in IPM and EBPM
2. Impact of used pesticides on shape asymmetry in carabid beetles
3. Carabid beetles, important predator group especially in EPM systems, function in stress environments



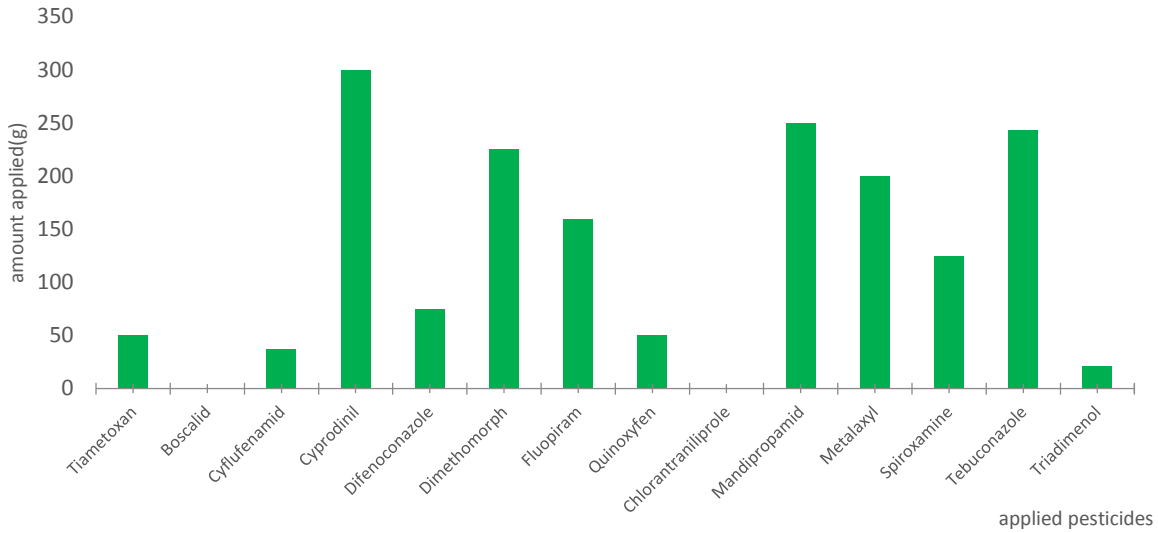


Fig: Amount (in grams) of pesticides applied in integrated managed vineyard (VI) in Baštica, Zadar County, Croatia.

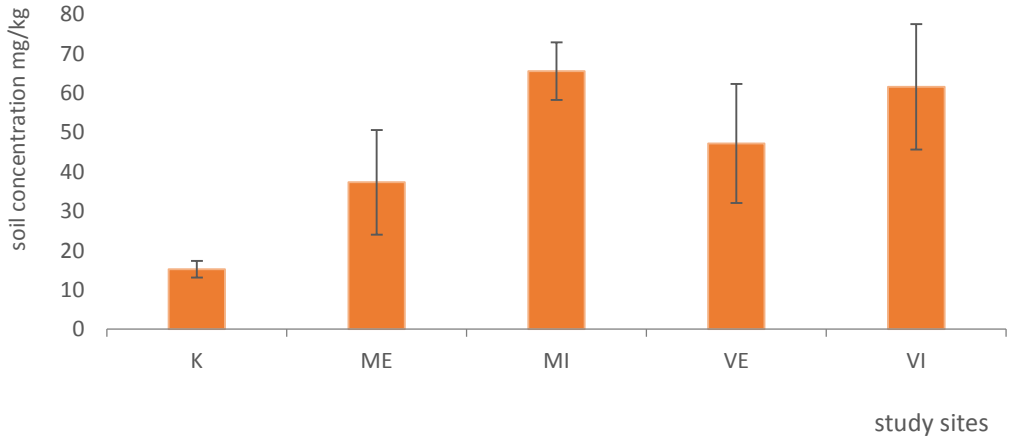


Fig: Soil concentrations of copper for all study sites, K represents control site, ME ecological olive orchard, MI integrated olive orchard, VE ecological vineyard and VI integrated one.

K – control site
ME – EPM olive grooves
MI – IPM olive grooves
VE – EPM vineyards
VI – IPM vineyards

Copper accumulation

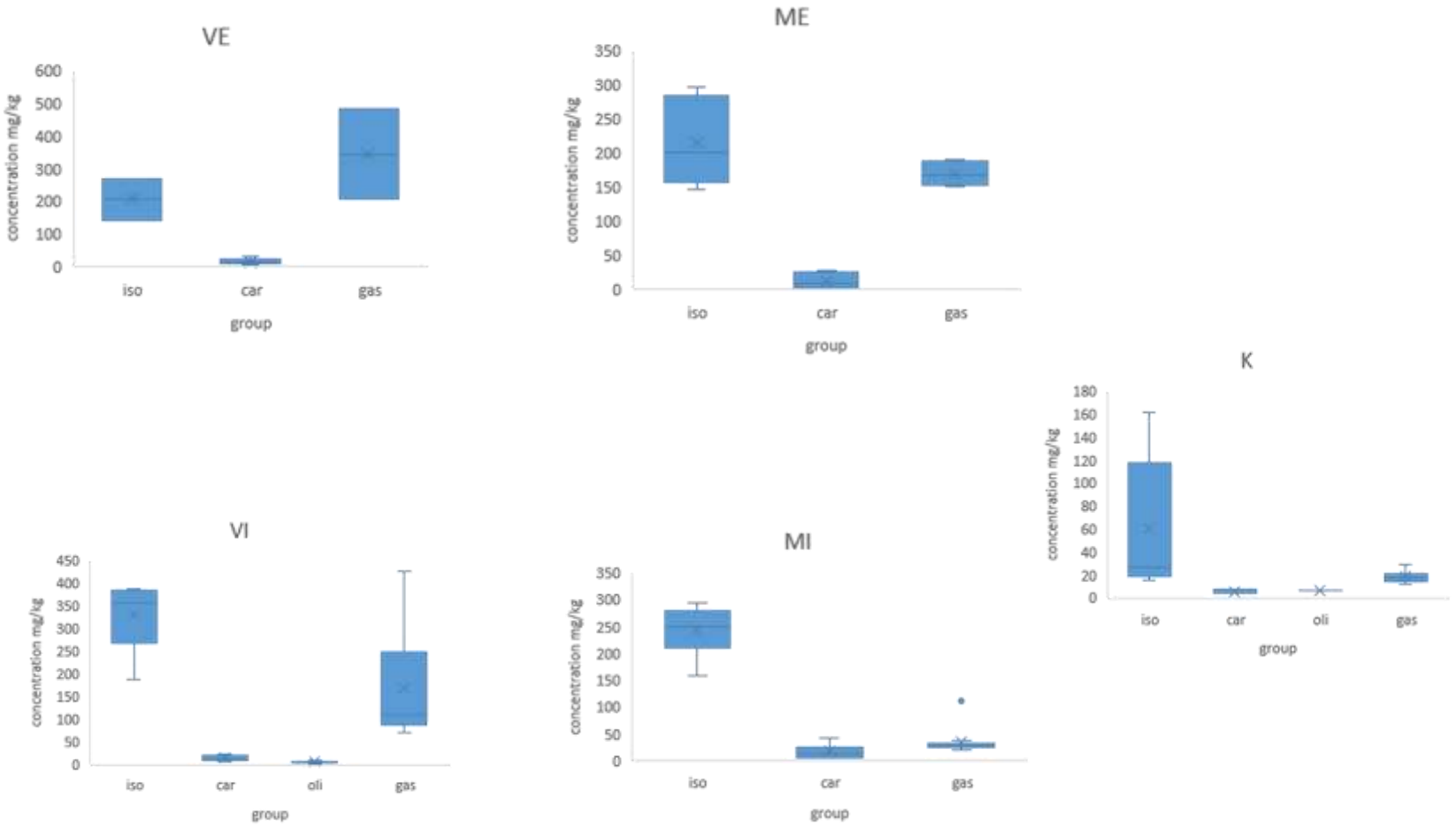
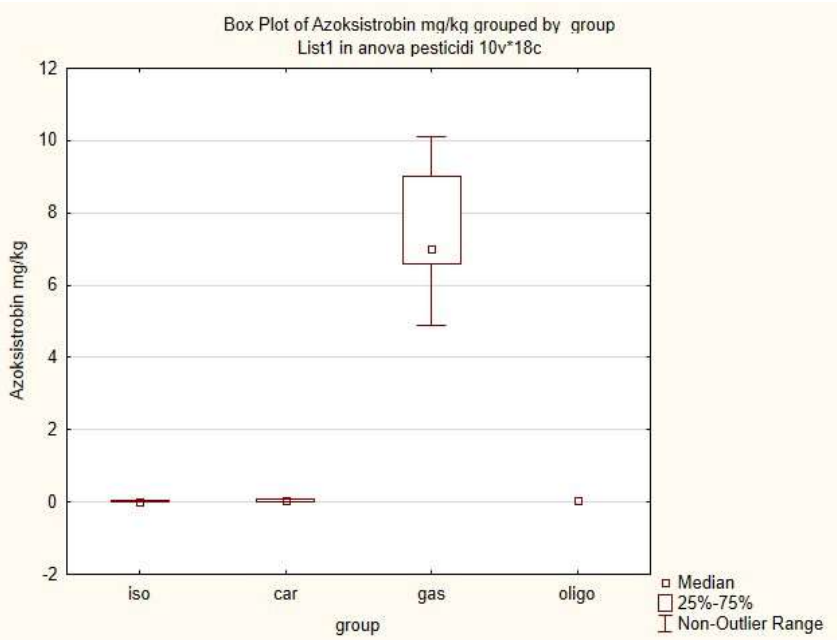
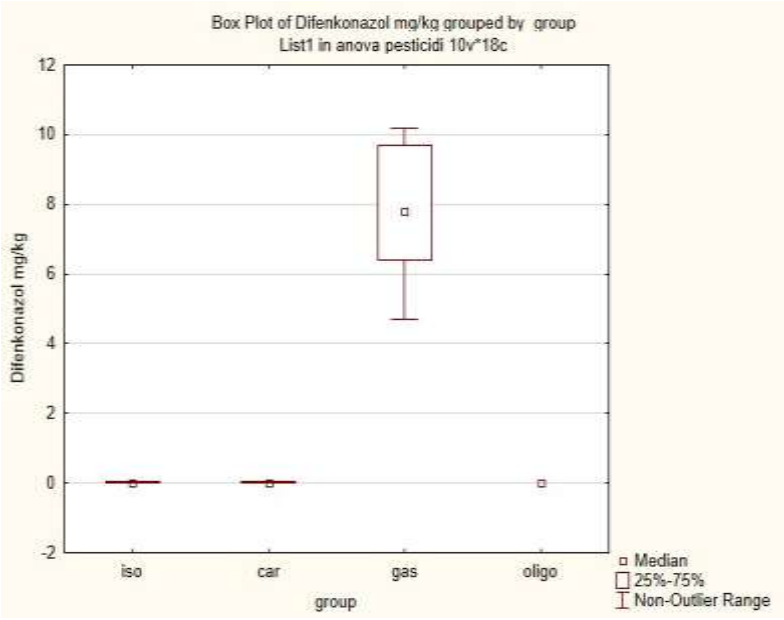
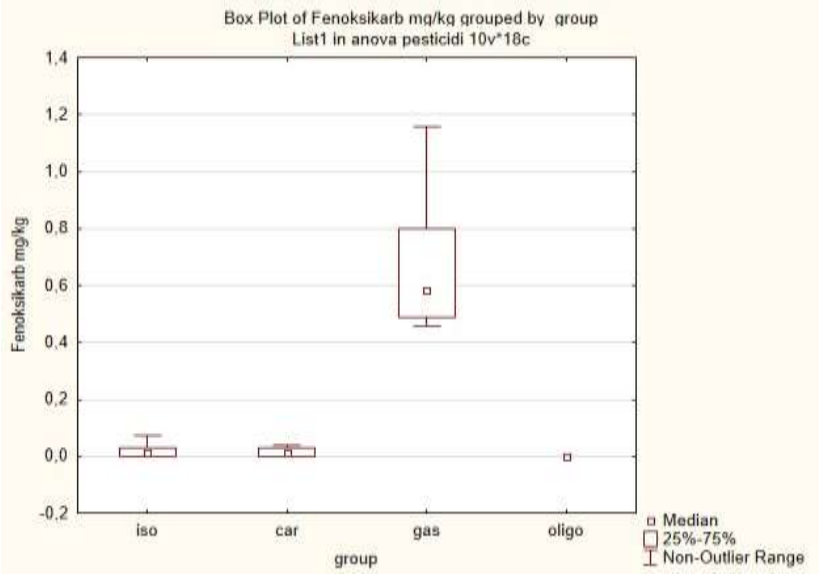


Fig.: Different accumulation levels between groups of invertebrates for each study site. Star represents the statistically significant difference between the groups.

Olive orchard with intagrated pest management- pesticide accumulation







Figs.: Box plots for different pesticides present in the tissue samples of all invertebrate groups analyzed from IPM olive orchard

Vineyard with integrated pest management- pesticide accumulation

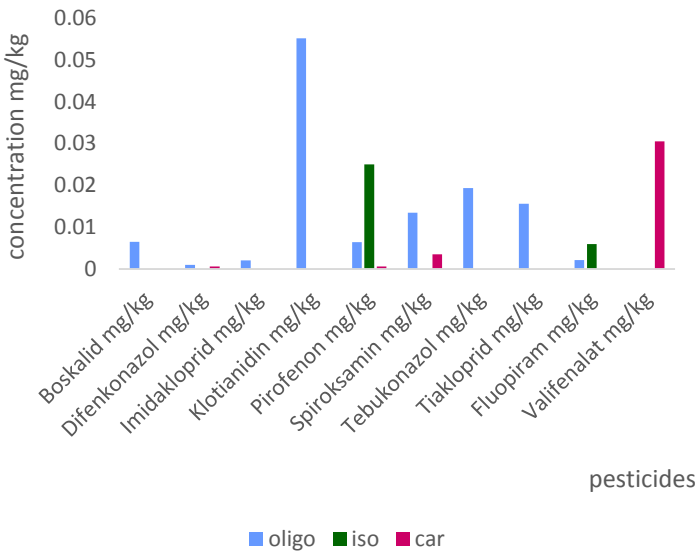


Fig: Concentration of all pesticides detected in tissue samples collected in IPM vineyard.

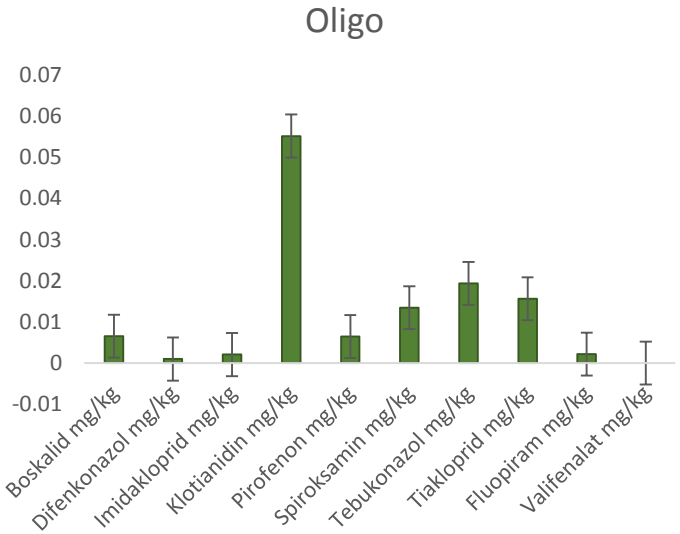


Fig: Concentration of all pesticides detected in tissue samples of earthworms collected in IPM vineyard.

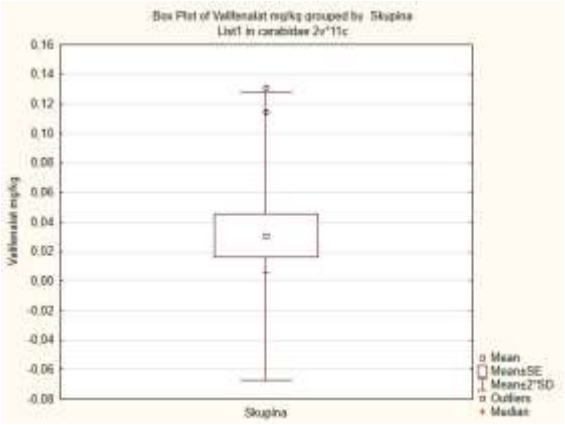


Fig: Concentration of valifenalate detected in tissue samples of Carabid beetles collected in IPM vineyard.

Diversity of spiders

- 2807 indviduals (pitfal traps)
- 23 families (pitfal traps)
- 91 species (pitfal traps)

Food web analyses

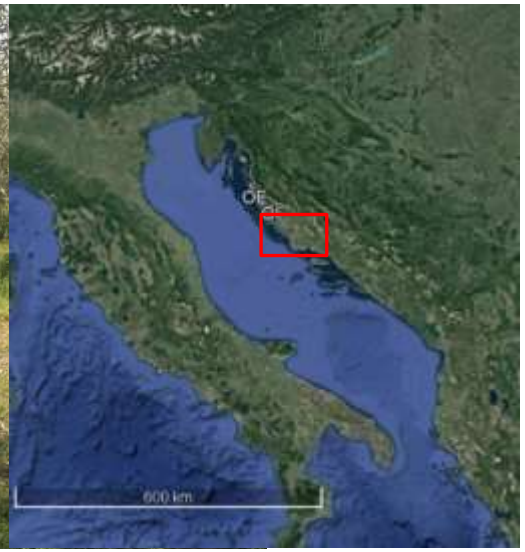
- 13 families (MGCA)
- Lycosidae, Pisauridae,Thomisidae, Gnaphosidae…

Diversity of carabids

- 4828 indviduals (pitfal traps)
- 22 genera (pitfal traps)
- 54 species (pitfal traps)

Food web analyses

- 9 species (MGCA)
- *Poecilus, Pterostichus, Carabus, Anchomenus*…


ÖE
600 km

Biodiversity and community

- predator and potential prey abundance
- genetic barcoding

- For ID
- For metabarcoding analyses of gut content

NCBI and BOLD databases

Potential prey – 2018 samples

- Isopoda 50 individuals
- Oligochaeta 43 ind
- Collembola 31 ind
- Formicidae 32 ind
- Hemiptera 46 ind
- Diptera 20 ind

Sequenced	Discarded	Species ID (>98%
96	13	43 (45%)

Predators (intraguild predation) – 2018 samples

- Spiders 50 ind
- Neuroptera 10 ind
- Centipedes 9 ind
- Staphylinidae

	BOLD identification
22_MED_B_Plate1_B7_LCO1490	Armadillidium vulgare (100%)
B5_MED_B_Plate1_A3_LCO1490	Arthropoda Insecta - Diptera - Delia platura (100%
B8_MED_B_Plate1_A6_LCO1490	Arthropoda Insecta - Diptera - Hydrellia griseola (99.83%)
B10_MED_B_Plate1_A8_LCO1490	Arthropoda - Insecta - Diptera - Dolichopodidae - 98.6%
B11_MED_B_Plate1_A9_LCO1490	Arthropoda Insecta - Diptera - Corynoptera perpusilla (99.82%)
B14_MED_B_Plate1_A11_LCO1490	Arthropoda Insecta - Lepidoptera - Nomophila noctuella (100%)
B15_MED_B_Plate1_A12_LCO1490	Arthropoda Insecta - Hymenoptera - Athalia rosae (99.66%)
B16_MED_B_Plate1_B1_LCO1490	Arthropoda Insecta - Lepidoptera - Endothenia oblongana (100%)
B18_MED_B_Plate1_B3_LCO1490	Annelida - Clitellata - Haplotaxida - Lumbricidae - Octodrilus complanatus 88.54%
B20_MED_B_Plate1_B5_LCO1490	Arthropoda - Malacostraca - Isopoda - Armadillidiidae - Armadillidium nasatum 84.15%
B21_MED_B_Plate1_B6_LCO1490	Arthropoda Insecta - Coleoptera - Lignyodes enucleator (98.18%)
B33_MED_B_Plate1_C3_LCO1490	Annelida - Clitellata - Haplotaxida - Lumbricidae - Octodrilus taxon1
B46_MED_B_Plate1_D4_LCO1490	Annelida - Clitellata - Haplotaxida - Lumbricidae - Octodrilus taxon2

Perspectives…

Present fauna (potential prey species) are not well known, filed screening of fauna, taxonomic ID and genetic barcoding in combination with HTS can provide as with lot of information overcoming the lack of data.

By analyzing trophic interactions we could reveal the extent of benefits that certain organisms can provide in biocontrol and maintaining healthy and sustainable agroecosystem

(i) which carabid and spider species have the potential to contribute to biological control?
(ii) are carabid and spider species potential contributions to biological control depend on environmental factors such as management type or the crop type?

we also hypothesize that cropping practices can modulate pest consumption by carabid and spider species through notably the availability of alternative resources.





Tomislav Kos, Mišel Jelić, Barbara Anđelić, Vedran Bahun, William Symondson and his research group, Domagoj Gajski

Hvala!
Diolch!
Thank you!

http://17ecm.biom.hr/category/news3/

"Learning about carabid habits and habitats – a continuous process in a continuously changing environment"