Ground Beetle Diversity (Coleoptera: Carabidae) in Winter Oilseed Rape and Winter Wheat Fields in North-Western Croatia

Tanja GOTLIN ČULJAK [1]
Wolfgang BÜCHS [2]
Sabine PRESCHER [2]
Ludger SCHMIDT [2]
Ivan SIVČEV [3]
Ivan JURAN [1(✉)]

Summary

During a two-year period of research on the ground beetle fauna (Coleoptera: Carabidae) in winter oilseed rape and winter wheat agroecosystems in North-Western Croatia, 14072 carabid specimens were collected. A total of 72 species from 31 genera and 6 subfaimilies were identified. The high epigeic activity was recorded for *B. crepitans*, *B. explodens*, *A. similata* and *H. distinguendes*. The endogeic activity was recorded for the species *A. meridianus* and *A. interstitialis* also for *Brachinus* species, *A. familiaris, A. similata*, *A. aenea* and *H. distinguendus*. One species was recorded for the first time in Croatia: *Harpalus akinini* Tschitscherine 1895.

Key words

Coleoptera, Carabidae, Croatia, oilseed rape, winter wheat, new records

[1] University of Zagreb, Faculty of Agriculture, Department of Agricultural Zoology, Svetošimunska 25, 10000 Zagreb, Croatia
✉ e-mail: ijuran@agr.hr
[2] Federal Institute for Cultivated Plants, Institute for Crop and Soil Science, Bundesallee 50, 38116 Braunschweig, Germany
[3] Institute for Plant Protection and Environment, Teodora Drajzera 9, 11000 Belgrade, Serbia

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Introduction

Ground beetles (Carabidae) as the most important members of epigeic fauna and valuable bioindicators can be found in different habitats (e.g. Stork, 1990; Tallosi and Vujčić-Karlo, 2007). Carabid beetles can serve as potential predators of oilseed rape pests (stem mining weevils and pollen beetle larvae when dropping on the soil for pupation). Very few studies concering the ground beetles in oilseed rape exist and current data are unavailable to producers, what is major obstacle in targeted approach to integrated protection of oilseed rape crops. According to literature data there are 32561 carabid species within 1859 genus (Lorenz, 1998). In Europe are present about 2700 carabid species (Wachman et al., 1995 cit. Wiliams et al., 2010) but only ca. 42 species occur commonly in oilseed rape fields. Depending of country, season (spring, autumn) and production management of oilseed rape (conventional, integrated and organic) their compostion and dominance can be differed. Ground beetles, as a family, are well studied over the Europe with good knowledge about their biology and ecology (Lovei and Sunderland, 1996; Rainio and Niemelä, 2003; Honek et al., 2003; Tallosi and Vujčić-Karlo, 2007). In Croatia faunistic investigations in woodland ecosystems were carried by Durbešić (1982), Vujčić-Karlo (1999), Šerić-Jelaska et al. (2004), Vujčić-Karlo and Durbešić (2004), Šerić-Jelaska et al. (2011), Vujčić-Karlo et al. (2013), Brigić et al. (2014) and Postić (2015). Faunistic investigations of ground beetles in agroecosystems in Croatia were carried by Kovačević and Balarin (1960) and Balarin (1974) in legumes, Sekulić et al. (1973), Sekulić (1977), Štrbac (1981) and Popović and Štrbac (2010) in wheat, Bažok et al. (2007) and Kos et al. (2011) in maize, Štrbac et al. (1979), Štrbac (1985) and Bažok et al. (2015) in sugar beet, Stančić et al. (2010) in traditional gradens of Hrvatsko Zagorje, Gotlin Čuljak et al. (2011), Büchs et al. (2012), Büchs et al. (2013) and Juran et al. (2013) in oilseed rape. Within master degree thesis (Petrak, 2013; Hrsan, 2014) and literature analisys about ground beetles fauna in Croatia by Novak (1952), Bregović (1985), Lóbl and Smetana (2003) an incomplete list with 578 ground beetle species was made. According to preliminary list (Vujčić-Karlo and Brigić, unpublished) there are about 820 ground beetles species and subspecies. Faunistic researches in Croatian agroecosystems are very scarce so the aim of this research is to determine species composition of ground beetles in winter oilseed rape and winter wheat in location of Šašinovečki Lug. This investigation was conducted within project SEE-ERA.NET Plus Joint Call "Impact of oilseed rape (OSR) production on functional biodiversity of predators and decomposers - development of management strategies for conservation and improvement in Croatia, Germany and Serbia".

Materials and methods

Ground beetles were sampled in three winter oilseed rape fields of approximately 1 ha each between October 5, 2010 and June 30, 2011 in winter oilseed rape crop (conventional, integrated and organic), then during fallow period from June 30 to October 18, 2011 and lastly in the succeeding crop of winter wheat (conventional, integrated and organic) from November 16, 2011 to June 20, 2012. Fields were located at Šašinovečki Lug, near the city of Zagreb (GPS coordinates 45°5′43′′N, 16°11′47′′E) (Figure 1).

Figure 1. Map of Croatia with the marked point that designates the area of the Šašinovečki Lug, Greater Zagreb, Croatia, as the locality at which the ground beetle species were recorded

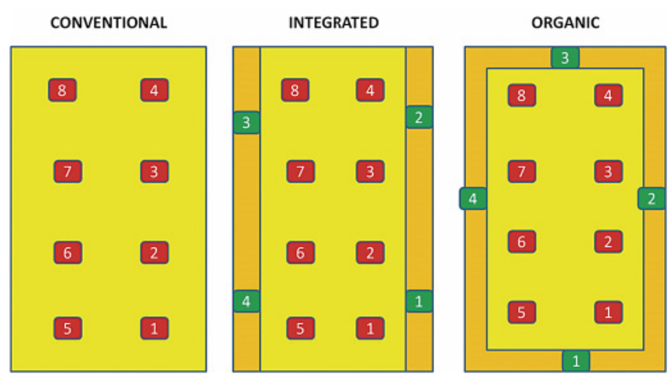

Figure 2. A grid of sampling points on experimental fields at Šašinovečki Lug, Greater Zagreb, Croatia

Within each experimental field a grid of 32 sampling points (Figure 2) on September 29, 2010 were installed. Each sampling point consisted of three trap types (epigaeic pitfall trap, endogeic trap and emergence trap) that were positioned along the central line and border of each field with the first sampling point placed 20 meters within the crop and the distance between sampling points was 50 meters. During fallow period (between harvest of oilseed rape and drillig of winter wheat) two sampling points were installed in each field along the central line with the first sampling point placed 50 meters within the field and a distance of 70 meters was between them, and four sampling points were installed on the border of the each field.

Epigaeic pitfall traps (Figure 3a) were used to measure activity density of epigaeic active predators and other arthropods. Each pitfall trap consisted of a two plastic cups (11 cm diameter and 9 cm depth) filled up with a 5% benzoic acid solution. The outer cup was with holes in the bottom in orded to ensure runoff while

Figure 3. Epigeic pitfall trap (a) and endogeic trap (b) in oilseed rape crop (Juran)

Figure 4. Emergence traps with photoeclectors on top in oilseed rape crop (Juran)

inner cup was without drilled holes in the bottom. The plastic cup was positioned in the soil on a round holder (ring) so that the upper edge was in line with the soil surface.

To record the subterranean activity of soil organism, Storegard W.B. Probe II Traps (endogeic traps) were used (Figure 3b). Endogeic traps resemble the perforated tube and are made of hard and long term perforated plastic 43.18 cm in length, which can easily be insert into soil. At the top of the probe an insect reservoir is located that was filled with 5% benzoic acid solution.

Emergence traps (Figure 4) with photoeclectors on top and with the addition of a pitfall trap inside were used in order to collect beetles that hatched from the covered soil. Due to high temperatures and fast evaporation during summer, ethylene glycol was used in photoeclectors and pitfall traps, instead of 5% solution sodium benzoate.

Pitfall trap sampling in oilseed rape started on October 5, 2010 and continued weekly until November 30, 2010 when the temperature dropped below 5°C. Sampling continued from December 21, 2010 with monthly controls until February 2011. On February 3, 2011 endogeic traps were installed at each sampling point and both types of traps were controlled weekly until harvest. In oilseed rape emergence traps were installed on May 25, 2011 at each sampling point. Traps were controlled weekly until harvest.

Sampling during the fallow period started on 2 July, 2011 and continued monthly until the sowing of winter wheat (20 October, 2011).

In the winter wheat period sampling started on October 23, 2011 and continued monthly until March 1, 2012. In two weeks intervals sampling continued until May 10, 2012 when traps control was finished.

The landscape of the studied area consists of farmland on a costal zone with regulated watercourse of Kašina stream on 125 m altitude above the sea level and represents a narrow strip of recent alluvial sediment along the watercourse. The soil type of the experimental fields is alluvium.

The entomological material is stored at the University of Zagreb, Faculty of Agriculture, Zagreb, Croatia as well as at the Julius Kühn-Institut, Institute for Crop and Soil Science, Braunschweig, Germany.

The determination of ground beetles (Coleoptera: Carabidae) to the species level was taken over by Sabine Prescher, PhD. For difficult species and general verification of determinations of Carabidae a specialized taxonomist four ground beetles, Ludger Schmidt, mag. biol. (Neustadt am Rübenberge) was engaged (e.g. genus *Amara*, *Bembidion*, *Harpalus*). The newest systematics and nomenclature were used (Löbl and Smetana, 2003). The dominance index (D%) was calculates according to formula: $D = (n_i/n) \times 100$ (%), where n is total number of ground beetle individuals in sample and n_i is number of individuals of specific species in sample (Tonhasca, 1993). According to results obtained species were categorized in one of the following categories: eudominant > 10.1%; dominant 5.1–10%, subdominant 2.1–5%, recendent 1.1–2% i subrecendent < 1%.

Results and discussion

A list of sampled and determined ground beetle species during two years growing seasons from oilseed rape and winter wheat fields is shown in Table 1.

A total of 14072 ground beetle specimens belonging to 72 species, 31 genera and 6 subfaimilies were collected and identified. From 72 indetified species, 71 species were already recorded in Croatia (Novak, 1952; Bregović, 1985; Löbl and Smetana, 2003), but their habitats were not recorded in oilseed rape and winter wheat crops. This recored presents much higher biodiversity in oilseed rape fields compared to previously mentioned data (Alfrod et al., 2003; Wiliams et al., 2010). One species is new in ground beetle fauna in Croatia: *Harpalus akinini* Tschitscherine 1895.

Most of the ground beetles individuals were recorded in epigeic pitfall traps in oilseed rape fields (11746). During fallow period 1165 individuals and in winter wheat fields 1681 were recorded. Endogeic activity of ground beetles was several times smaller. In oilseed rape fields 649 individuals were recorded. Fallow period was without ground beetles activity and in winter wheat fields 203 ground beetle individuals were recorded. In emergence traps during fallow period 200 individuals were recorded while in winter wheat fields 786 ground beetle individuals were recorded.

According to dominance index in pitfall traps four eudominant (*B. crepitans* – 28%, *B. explodens* – 14.9%, *A. similata* – 11.6% i *H. distinguendes* – 10.8%), two dominant (*P. cupreus* – 7.9% i *A. dorsalis* – 6.6%) and four subdominant (*B. elegans* – 3.7%, *H. affinis* – 3.2%, *H. rufipes* – 3.2% i *A. aenea* – 2.1%) ground beetle species were recorded.

Table 1. List of the ground beetle species from oilseed rape and winter wheat fields at Šašinovečki Lug, Greater Zagreb, Croatia, recorded between September 2010 and June 2012

Subfamily	Tribe	Genus	Species
Nebriinae	Nebriini	Leistus	*Leistus (Leistus) ferrugineus* (Linné, 1758)
		Nebria	*Nebria (Nebria) brevicollis* (Fabricius, 1792)
Carabinae	Carabini	Calosoma	*Calosoma (Calosoma) inquisitor inquisitor* (Linné, 1758)
		Carabus	*Carabus (Tachypus) cancellatus* Illiger, 1798
			Carabus (Procrustes) coriaceus Linné, 1758
			Carabus (Megodontus) violaceus violaceus Linné, 1758
Brachininae	Brachinini	Brachinus	*Brachinus (Brachinus) crepitans* Linné, 1758
			Brachinus (Brachinus) elegans Chaudoir, 1842
			Brachinus (Brachynidius) explodens Duftschmid, 1812
			Brachinus (Brachinus) psophia Audinet – Serville, 1821
Scaritinae	Clivinini	Clivina	*Clivina (Clivina) fossor fossor* (Linné, 1758)
Trechinae	Bembiidini	Asaphidion	*Asaphidion flavipes* (Linné, 1761)
		Bembidion	*Bembidion (Philochthus) biguttatum* (Fabricius, 1779)
			Bembidion (Peryphanes) dalmatinum dalmatinum Dejean, 1931
			Bembidion (Philochhtus) guttula guttula (Fabricius, 1792)
			Bembidion (Philochthus) lunulatum (Geoffroy, 1785)
			Bembidion (Metallina) properans (Stephens, 1828)
			Bembidion (Bembidion) quadrimaculatum quadrimaculatum Linné, 1761
		Tachys	*Tachys (Paratachys) caspius* Kolenati, 1845
			Tachys(Paratachys) micros (Fischer von Waldheim, 1828)
	Patrobini	Patrobus	*Patrobus atrorufus* (Ström, 1768)
	Trechini	Trechus	*Trechus (Trechus) quadristriatus* (Schrank, 1781)
Harpalinae	Dryptini	Drypta	*Drypta (Drypta) dentata* (Rossi, 1790)
	Harpalini	Diachromus	*Diachromus germanus* (Linné, 1758)
		Anisodactylus	*Anisodactylus (Anisodactylus) binotatus* (Fabricius, 1787)
			Anisodactylus (Pseudoanisodactylus) signatus Panzer, 1796
		Harpalus	*Harpalus (Harpalus) akinini* Tschitscherine 1895*
			Harpalus (Harpalus) anxius (Duftschmid, 1812)
			Harpalus (Harpalus) affinis (Schrank, 1781)
			Harpalus (Harpalus) dimidiatus (Rossi, 1790)
			Harpalus (Harpalus) distiguendus distinguendus (Duftschmid, 1812)
			Harpalus (Harpalus) latus (Linné, 1758)
			Harpalus (Harpalus) luteicornis (Duftschmid, 1812)
			Harpalus (Harpalus) rubripes (Duftschmid, 1812)
			Harpalus (Pseudoophonus) rufipes (DeGeer, 1774)
			Harpalus(Harpalus) serripes serripes (Quensel, 1806)
			Harpalus (Harpalus) sulphuripes sulphuripes Germar, 1824
			Harpalus (Harpalus) taciturnus Dejean, 1829
			Harpalus (Harpalus) pumilus Sturm, 1818
			Harpalus (Pseudoophonus) calceatus Duftschmid, 1812
		Ophonus	*Ophonus (Ophonus) ardosiacus* (Lutshnik, 1922)
			Ophonus (Hesperophonus) azureus (Fabricius, 1775)
			Ophonus (Metophonus) meletti Heer, 1837
			Ophonus (Ophonus) sabulicola Panzer, 1796
			Ophonus (Hesperophonus) similis Dejean, 1829
		Parophonus	*Parophonus (Parophonus) maculicornis* (Duftschmidt, 1812)
		Acupalpus	*Acupalpus (Acupalpus) exiguus* Dejean, 1829
			Acupalpus (Ancylostria) interstitialis Reitter, 1884
			Acupalpus (Acupalpus) meridianus Linné, 1761
		Stenolophus	*Stenolophus (Stenolophus) teutonus* (Schrank, 1781)
	Lebiini	Demetrias	*Demetrias (Demetrias) atricapillus* Linné, 1761
		Microlestes	*Microlestes maurus maurus* Sturm, 1827
		Lebia	*Lebia (Lamprias) chlorocephala* Hoffmann, 1803
	Licinini	Badister	*Badister (Badister) bullatus* Schrank, 1798
	Platynini	Agonum	*Agonum (Agonum) viridicupreum viridicupreum* Goeze, 1777
		Anchomenus	*Anchomenus (Anchomenus) dorsalis* (Pontoppidan, 1763)
	Pterostichini	Abax	*Abax (Abax) parallelepipedus parallelepipedus* Piller & Mitterpacher, 1783
	Pterostichini	Pterostichus	*Pterostichus (Feronidius) melas melas* (Creutzer, 1799)
			Pterostichus (Morphnosoma) melanarius melanarius (Illiger, 1798)
			Pterostichus (Argutor) vernalis Panzer, 1796
	Sphodrini	Dolichus	*Dolichus halensis* Schaller, 1783
		Laemostenus	*Laemostenus (Laemostenus) complanatus* (Dejean, 1828)
	Zabrini	Amara	*Amara (Amara) aenea* (DeGeer, 1774)
			Amara (Amara) communis (Panzer, 1797)
			Amara (Amara) convexior Stephens, 1828
			Amara (Amara) curta Dejean, 1828
			Amara (Amara) familiaris (Duftschmid, 1812)
			Amara litorea C.G. Thomson, 1857
			Amara (Amara) lucida Duftschmid, 1812
			Amara (Amara) ovata Fabricius, 1792
			Amara (Amara) similata (Gyllenhal, 1810)

Species marked with the symbol * is new to the carabid fauna of Croatia.

The xerothermophile *Brachinus* species are in generale highly remarkable and four species cover app. 46% of all ground beetles recorded in pitfall traps. However, *Brachinus* species (bombardier beetles) are not only interesting because of their chemical defense mechanism, but from the ecological point of view because they live as ectoparasites on pupae of the genus *Amara* (Saska and Honek, 2004; 2008). If we look at the *Brachinus/Amara* – ratio (parasitoid/host – ratio) on the basis of our pitfall trap samples, we recognize that the abundance of *Brachynus* species are much higher than of potential *Amara* host. This means that there have to be other potential hosts (some *Anchomenus* pupae). The question is, whether *Brachinus* species as intraguild-predators can be counted among the beneficials.

Endogeic activity for species of *Acupalpus* genus (*A. merdianus, A. interstitialis*) with dominance index of 43.2% was recorded. High endogeic activities show species from genus *Brachinus*, *A. familiaris, A. similata*, *A. aenea* and *H. distinguendus*.

T. quadristriatus (D=44.7%) and *A. interstitialis* (D=13.7%) that are eudominant in winter wheat were recorded in emergence traps.

In terms of the species composition, the genus *Harpalus* with 14 species was the most diverse, followed by *Amara* with nine species. Similar results were obtained in investigations within the same project (SEE-ERA.NET Plus Joint Call) in Serbia (Stari Žednik locality) where 70 species in oilseed rape fields were recorded. Genus *Harpalus* was present with 17 species and genus *Amara* with six species (Sivčev et al., 2014). A survey of literature, reports and unpublished data demonstrates that *Amara similata* is the only species here with an extraordinarily high abundance in oilseed rape fields (Warner et al. 2000; Büchs et al., 2006; Felsmann and Büchs, 2006). It is also the most abundant carabid species in European oilseed rape fields (Büchs et al., 2006; 2007a). According to the further analysis of literature and databases, amongst the other dominant species, *Amara aenea* and *Poecilus cupreus* have a dominance level >5% each in European oilseed rape crops (Büchs et al., 2007a). Büchs et al. (2006; 2007b) also reported that *Poecilus cupreus* plays a major role in European oilseed rape fields as predator of key insect pests – first instar larvae of brassica pod midge *Dasineura brassicae* (Winnertz, 1853) and pollen beetle larvae *Brassicogethes aeneus* (Fabricius, 1775).

Conclusions

Ground beetles are widespread and abundant insect family and majority of carabid species found in oilseed rape fields are known to be predators of economically important oilseed rape pests. Large number of carabid species within this research was recorded, with one new species in Croatia entomofauna, presenting potential in insecticides reduction input that coincides with integrated agricultural production. This can improve ecosystem conservation and sustainable development that is in accordance to joint agricultural policy of European Union. This research presents quality base for knowledge transfer to producers and rich source for further investigations of natural enemies within agroecosystems.

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