The Ground Beetle Fauna (Coleoptera) of Apple Orchard in Croatia

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Summary

The ground beetle fauna was studied in IPM apple orchard in northwest part of Croatia (Krapina). Carabids were sampled by pitfall trapping in the year of 2015 from July 1st until October 15th. A total of 183 individuals belonging to 17 species and 9 genera were collected. The most abundant species, with the proportion of almost 55% in the total catch, was *Pterostichus melas melas* Creutzer, 1799 followed by *Carabus coriaceus coriaceus* Linné, 1758 (18.03%) and *Calathus fuscipes graecus* Dejean, 1831 (4.92%). This three species account for about 80% of the total catch. The apple orchard ground beetle community can be characterized as having relatively low diversity, dominated by nonspecific (eurytopic) species of open habitats which are highly tolerant to anthropogenic influence. Presented results confirm that carabid population dynamics is strongly influenced by climatic conditions (air and soil temperatures).

Key words

Carabidae; pitfall trap; diversity; IPM

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Introduction

The ground beetles (fam. Carabidae), one of the most important family of ground dwelling insects, may be considered as environmental bio indicators because they react sensitively to anthropogenic changes in habitat quality (Lövei and Sunderland, 1996; Kromp, 1999). In agricultural production they are mostly beneficial species, predators of a wide range of agricultural pests. Agricultural production through the management of pests (e.g. usage of broad spectrum insecticides), diseases and weeds (e.g. disturbance of soil) has a considerable influence on the abundance and diversity of the epigeic fauna and carabids as well (Miñarro and Dapena, 2003; Miñarro et al., 2008; Funayama, 2011; Vonlanthen et al., 2015).

The composition and richness of Croatian ground beetle fauna was explored among different ecosystems (e.g. forests, grasslands and meadows, swamps and water lands) (Kovačević and Balarin, 1960; Durbešić, 1967, 1982 and 1987; Durbešić et al., 2000 and 2006; Vujčić-Karlo, 1999; Brigić et al., 2003, 2012 and 2014) and agro ecosystems (e.g. alfalfa and red clover, winter wheat and barley, maize, sugar beet and vegetable gardens) (Kovačević and Balarin, 1960, Sekulić et al., 1973; Bažok et al., 2007, Kos et al., 2010, 2011 and 2013, Stančić, et al., 2010). Although the carabids were investigated in production systems in Croatia, there is a lack of investigation of these species in any type of orchards in Croatia. Investigations of ground beetle fauna from apple orchards from Hungary and Italy have showed that the species richness varied from 33 to 45 species (Kutasi et al., 2004; Paoletti et al., 1995).

Objective of this study was to: (1) establish species composition and abundance of most dominant species of ground beetles in IPM apple orchard, (2) observe possible influences of weather conditions on activity of adult ground beetles.

Material and methods

The ground beetle fauna was studied in IPM apple orchard (N 46° 9′ 47″, E 15° 52′ 52″) in northwest part of Croatia (Krapina), at an altitude of 282 m. The orchard was planted in the year of 2004 and is surrounded by agricultural fields (e.g. arable lands and grasslands). Six apple cultivars (Braeburn, Idared, Golden Delicious, Granny Smith and Jonagold) are grown in planting system of 1 x 3 m on the plantation area of 3600 m^2. The soil in the apple orchard is characterized as typical pseudogley. The apples are treated in the accordance with integrated pest management 10 to 15 times per year. During the investigation period in the year of 2015, insecticide treatments were not applied in order to exclude their impact on orchard entomofauna. Weeds in the orchard are managed by mulching treatments between rows several times in the season and only one mulching treatment during the ground beetles study (on 22nd August) was performed.

Surface active carabids were sampled using covered pitfall traps (polythene pots: 10 cm wide and 20 cm deep) half filled with salted water. Three traps were placed in a triangle chosen randomly into the center of the orchard at about 10 m from the edge. The samples were collected in the year 2015 from July 1st until October 15th on a weekly basis (from week 28 to week 42). The identification of the collected carabids was based on the work of Freude et al. (2006). Catalogue of Palaearctic Coleoptera (Löbl and Smetana, 2003) was used for systematic classification of species. Weather conditions data on the weekly air temperatures, weekly soil temperatures and total weekly rainfalls for the studied area were provided by the Croatian Meteorological and Hydrological Service.

The dominance value of carabids presented in percentage shares of a particular species in community was calculated according to Tischler (1949) as follows: eudominants (10-100%), dominants (5-10%), subdominants (2-5%), recedent (1-2%) and subrecedent (<1%). The data about ecological characteristics of the species were taken from Thiele (1977), Lindroth (1992) and Wachmann et al. (1995) and the classification was done according to feeding habits, habitat and reproduction period. The number of collected carabids per week and weather conditions (mean weekly air temperatures, mean weekly soil temperatures and total weekly rainfall) in the period of collection (from week 28 to week 42 of the year 2015) was compared in order to see possible influences on abundance of most dominant species.

To calculate the diversity of the carabid assemblages, Simpson (λ) and Shannon-Wiener indices (H') were used. Evenness was estimated using Pielou's evenness. Analyses were carried out using the MATLAB program (2015).

Results

A total of 183 individuals belonging to 17 species and 9 genera were collected (Table 1). The highest number of species comes from the genus *Harpalus* Latreille, 1802 (4 species) and *Ophonus* Dejean, 1821 (4 species). The most abundant species, with the proportion of almost 55% in the total catch, was *Pterostichus melas melas* Creutzer, 1799 followed by *Carabus coriaceus coriaceus* Linné, 1758 (18.03%) and *Calathus fuscipes graecus* Dejean, 1831 (4.92%). This three species account for about 80% of the total catch. The species *P. melas melas* and *C. coriaceus coriaceus* belong to the group of eudominant species while *C. fuscipes graecus* was classified as dominant species. Four species are characterized as subdominant, seven as recedent and tree as subrecedent.

The species, which dominated the carabid assemblage in the apple orchard habitat (with the total captures), were *P. melas melas* (100), *C. coriaceus coriaceus* (33), *C. fuscipes graecus* (9), *Harpalus dimidiatus* P. Rossi, 1790 (7) and *Harpalus atratus* Latreille, 1804 (6) (Table 1).

Analysis of feeding habits showed that predator and phytophagous species were represented with six species while five species were omnivorous (Table 1).

Analysis of habitat preferences showed that about 50% of species inhabits arable land while almost 25% of species inhabit perennial plantations. Species that inhabit forests or are equally represented in the forests and perennial plantations cover less than 20% of species (Table 1).

The majority of species were autumn breeders (9 species), 5 species were spring breeders and one species breeds in both seasons (Table 1).

In IPM apple orchard three culminations of ground beetles population have been observed. The first population maximum

Table 1. List of ground beetles, feeding habits, habitat, reproduction period, total number of specimens and dominance value of species in IPM apple orchard in northwest Croatia (Krapina)

Species	Diet	Habitat	Reproduction period	N	DV (%)
Carabus coriaceus coriaceus Linné, 1758	OM	open, anthropogenically altered areas like gardens and parks, or near set-aside arable areas	A with spring activity	33	18.03
Trechus quadristriatus Schrank, 1781	P	open and dry habitats including agricultural land but also in urban or built up areas; parks, gardens	A	1	0.55
Chlaenius decipiens L. Dufour, 1820	PHY	cultivated field	-	2	1.09
Anisodactylus binotatus Fabricius, 1787	OM	meadows, ruderal habitats, gardens, parks, vineyards, forest edges; unshaded habitats	S	3	1.64
Harpalus atratus Latreille, 1804	PHY	forested areas, agricultural land	S	6	3.28
Harpalus dimidiatus P. Rossi, 1790	OM	ruderal habitats, gardens, parks, vineyards	S	7	3.83
Harpalus rubripes Duftschmid, 1812	OM	dry or gravelly ground with sparse vegetation such as postindustrial sites, dry sandy grass areas and grasslands	S	3	1.64
Harpalus rufipes De Geer, 1774	OM	under stones and logs in open, dry situations, especially arable fields	A	2	1.09
Ophonus azureus Fabricius, 1775	PHY	meadows, fields, steppe, pastures, unshaded habitats	A	4	2.19
Ophonus gammeli Schauberger, 1932	PHY	Shaded habitats, forest edges	A	1	0.55
Ophonus parallelus Dejean, 1829	PHY	unshaded habitats, vineyards, fields, steppe	A	2	1.09
Ophonus sabulicola Panzer, 1796	PHY	unshaded habitats, steppe, fields, vineyards	A	4	2.19
Microlestes minutulus Goeze, 1777	P	indifferent to shade, steppe, meadows, forests	S	2	1.09
Pterostichus transversalis Duftschmid, 1812	P	forest, forest edges	-	3	1.64
Pterostichus melas melas Creutzer, 1799	P	pastures, open forests, forest edges, forests, agricultural land, meadows	A	100	54.64
Calathus fuscipes graecus Dejean, 1831	P	dry open ground, including gardens and arable land	A/S	9	4.92
Calathus melanocephalus melanocephalus Linné, 1758	P	sandy soil, arable land, meadows and pastures, open habitats	A	1	0.55

Diet: P - predator, OM - omnivorous, PHY - phytophagous; Reproduction period: A - autumn breeder, S - spring breeder, - no data; N - total number of specimens; DV - dominance value

occurred in the week 34 (middle of August), second occurred four weeks later in the middle of September (week 38). The third population maximum occurred in the week 41 (beginning of October). All these culminations of population occurred after decrease in air and soil temperatures (followed by population abundance decline) (Figure 1).

The diversity of fauna was relatively low: Simpson (1-λ') diversity index 0.6616, Shannon-Wiener index (H') 1.676 and Pielou's evenness 0.5917.

Discussion

The species composition of ground beetle fauna in IPM apple orchard (Krapina) can be characterized as the basic dominant agricultural carabid fauna which is rather uniform across Europe (Thiele, 1977). These are mostly widespread species and many of them have high tolerance to disturbances and chemical pollution (Thiele, 1977; Luff, 2002). Usually, no more than 10 to 40 species are active in a habitat in the same season (Lövei and

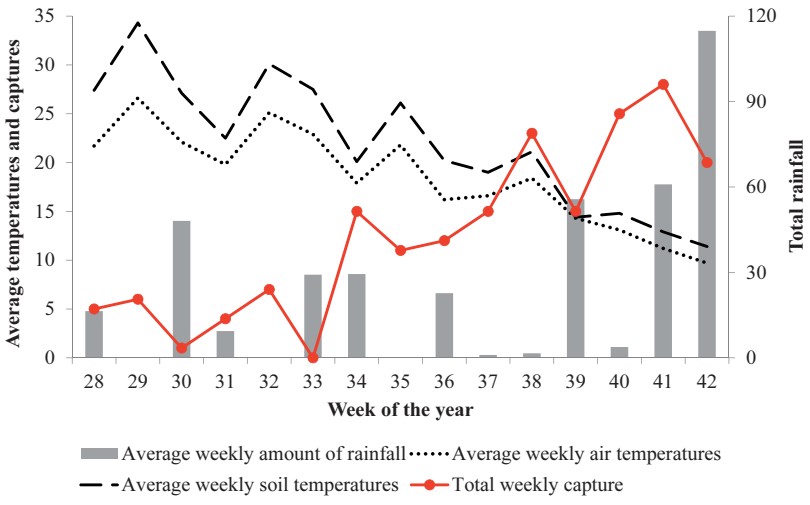

Figure 1. The relationship between the number of collected carabid beetles per week and weather conditions (mean weekly air temperatures, mean weekly soil temperatures and total weekly rainfall) from week 28 to week 42 in the year of 2015 in IPM apple orchard

Sunderland, 1996) and the results of our investigation are in accordance with the above mentioned data (17 species identified). Kutasi et al. (2004), similarly to our list, reported species from genera *Harpalus*, *Pterostichus* and *Calathus* as a common species of carabids in apple orchards from Hungary. In addition, results of this investigation point that the species from the *Ophonus* genera are also common species in IPM apple orchard (Krapina). Lövei and Sunderland (1996) report that habitat and microhabitat distribution of species can be influenced by several factors like weather conditions (e.g. temperature and humidity extremes), food conditions, presence and distribution of competitors (e.g. spiders), life history and season. For example, exclusively spermophagous *Ophonus* spp. are present in open habitats where seed of family *Apiaceae* are available, whereas polyphagous *Harpalus* spp. aggregate in crops. In perennial crop like apple orchard, the species from the family *Apiaceae* (e.g. wild carrot (*Daucus carota* L.)) are regularly occurring (Pajač Živković et al., 2012) so the presence of *Ophonus* species was expected.

Furthermore, in Hungarian research (Kutasi et al., 2004) among the list of the most abundant species were *P. melas melas* and *C. fuscipes* which were also present as the most abundant species in our research. While in research of Kutasi el al. (2004) the predominant species was *H. rufipes*, which was in our study classified as recedent, the most dominant species from Croatian apple orchard was *P. melas melas*. Results of our investigation have shown high dominance of species *C. coriaceus coriaceus* (18.03%), which is found to be common in orchards with characteristically different soil composition and extra- and intra-orchard vegetation (Kutasi et al., 2004). According to Kutasi et al. (2012) this species can be found mainly in agricultural fields with low disturbance levels (perennial crops, low insecticide input) and close to woodlands and even in orchards where broad spectrum insecticides were applied. Analysis of feeding habits indicates that this is a relatively stable agroecosystem in which the predators, omnivores and phytophagous are equally present.

Miñarro and Dapena (2003) found that groundcover management in apple orchards may affect the activity density of epigeic predators which may contribute to the natural control of pests. Although Miñarro et al. (2008) have observed that mulching treatments reduced carabid abundance, in our study the negative effect of this treatment on of carabid fauna was not observed. The possible explanation could be that only one mulching treatment was performed throughout the study period.

Thiele (1977) reported that temperature and humidity extremes influences density of carabids. This thesis was supported by our research where high temperatures and increased moisture along with high amount of precipitation reduced number of ground beetles (Figure 1). Climatic variation may have been a factor in the current study that influences carabid abundance recorded in IPM apple orchard (Krapina). Presented results confirm that carabid population dynamics is strongly influenced by climatic conditions (air and soil temperatures) but additional research is strongly advisable. According to these information carabids seems to prefer humid areas and periods with lower air and soil temperatures.

Conclusion

Presence of caught ground beetle fauna seems to be expected for the agricultural area of fruit production where the survey was conducted. Presented results confirm that carabid population dynamics is strongly influenced by climatic conditions (air and soil temperatures). According to this information further investigations of impact of agricultural measures applied after temperature decrease in the environment should be researched closely. Since the carabid fauna has not been researched in Croatian apple orchards until now, this work presents new insights into the Croatian ground beetles fauna.

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