

Species Composition of Carabid (Coleoptera: Carabidae) Communities in Apple and Pear Orchards in Hungary

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Species richness and composition of carabid assemblages were investigated on the ground surface of differently treated (abandoned, commercial and IPM) apple and pear orchards in Hungary. Extensive sampling was carried out by pitfall trapping in 13 apple and 3 pear orchards located in ten different regions. 28 230 individuals belonging to 174 species were collected. Additional four species were collected by trunk-traps and 23 species were found during the review of earlier literature. Altogether 201 carabid species representing 40% of the carabid fauna of Hungary were found in our and earlier studies.

The species richness varied between 23 and 76 in the different orchards, the average species richness was 43 species. The common species, occurring with high relative abundance in the individual orchards in decreasing order were: *Pseudoophonus rufipes*, *Harpalus distinguendus*, *Harpalus tardus*, *Anisodactylus binotatus*, *Calathus fuscipes*, *Calathus erratus*, *Amara aenea*, *Harpalus affinis* and *Pterostichus melanarius*.

The species with wide distribution, occurring in more than 75% of the investigated orchards in decreasing order were: *Pseudoophonus rufipes*, *Trechus quadristriatus*, *Harpalus tardus*, *Harpalus distinguendus*, *Pterostichus melanarius*, *Amara aenea*, *Amara familiaris*, *Calathus fuscipes*, *Poecilus cupreus*, *Calathus ambiguus*, *Calathus melanocephalus*, *Pseudoophonus griseus* and *Harpalus serripes*. Species, which are rare in Hungary, and therefore are interesting in respect of faunal research, were: *Amara cursitans*, *Harpalus progrediens*, *Notiophilus pusillus*, *Olisthopus rotundatus*, *Pangus scaritides* and *Parophonus hirsutulus*.

Keywords: Apple, pear, pitfall trap, Coleoptera, Carabidae.

The faunal investigation of apple orchards in Hungary started in 1976 as a part of a comprehensive study "Apple Ecosystem Research". Mészáros et al. (1984) presented a list of many arthropod taxa from five apple orchards while Markó et al. (1995), Bogya et al. (1999) and Balog et al. (2003) published the list of canopy Coleoptera, Araneae and Staphylinidae species occurring in apple and pear orchards in Hungary. Data on carabid faunal composition of apple orchards in Hungary were presented by Mészáros et al. (1984) – 79 species, Markó and Kádár (2003) – 62 species and Kádár et al. (2003) – 53 species and additional data were given on carabids collected by light traps by Kádár and Szél (1989) and Kádár and Lövei (1987, 1992).

In Europe and America several studies gave faunal data on apple orchard inhabiting carabids. Hagley (1974) found 40, Rivard (1974) 64, Pearsall and Walde (1995) 32 species in apple orchards in Canada. Mader (1984), Gilgenberg (1989) and Heyer (1994) collected 23, 43 and 55 species respectively in apple orchards in Germany. Zelenková and Hurka

(1990) found 80 species in four apple orchards in southern part of the Czech Republic, Kasandrova (1970) 65 species from the former Soviet Union (Tambov and Rhyazan regions) while Sciaky and Trematerra (1991) and Paoletti et al. (1995) found 45 and 33 species in Italy.

In the 12 studies in Europe the following species were mentioned as common (in the parentheses the number of papers where the species was mentioned as abundant): *Pseudoophonus rufipes* (12), *Harpalus distinguendus* (5), *Harpalus tardus* (5), *Nebria brevicollis* (5), *Pterostichus melanarius* (5), *Poecilus cupreus* (5), *Harpalus affinis* (4), *Bembidion lampros* (3) (Kasandrova, 1970; Domenichini, 1980; Basedow and Dickler, 1981; Gilgenberg, 1986; Daccordi and Zanetti, 1989; Molinari et al., 1990; Zelenkova and Hurka, 1990; Schirra, 1991; Sciaky and Trematerra, 1991; Heyer, 1994; Paoletti et al., 1996; Minarro and Dapena, 2003).

In the studied orchards in Czech Republic, which is the closest investigated geographical region to Hungary, six species (*Pterostichus melanarius*, *Bembidion lampros*, *Pseudoophonus rufipes*, *Poecilus cupreus*, *Calathus fuscipes*, *Harpalus affinis*) occurred in all four investigated orchards (Zelenkova and Hurka, 1990). The species with highest activity-abundance were *Pseudoophonus rufipes* and *P. versicolor* (Zelenkova and Hurka, 1990).

Materials and Methods

The samples were collected in 13 apple and three pear orchards in 10 localities representing different regions of Hungary (Fig. 1). Among the environments surrounding the orchards were hilly areas, with forests (Bakonygyirót, Hárskút, Vámosmikola and Pókaszepetk), lowland areas with agricultural fields (Györgytló, Kecskemét, Tura, Újfehértó and Szentlőrinc), and a lowland area with flooded forests (Szigetcsép). The exact co-ordinates of the orchards were as follows: Bakonygyirót (Lat. 47° 25' N, Long. 17° 48' E, UTM: YN15) (conventionally treated commercial apple orchard), Hárskút (Lat. 47° 11' N, Long. 17° 49' E, UTM: YN12) (abandoned apple orchard), Kecskemét (Lat. 46° 54' N, Long. 19° 42' E, UTM: CS99) (abandoned apple orchard), Szigetcsép (Lat. 47° 16' N, Long. 18° 59' E, UTM: CT43) (conventionally treated apple and pear orchards), Tura (Lat. 47° 36' N, Long. 19° 36' E, UTM: CT97) (conventionally treated apple and pear orchards), Újfehértó (Lat. 47° 49' N, Long. 21° 30' E, UTM: ET59) (abandoned, 'IPM' and conventionally treated apple orchards), Györgytló (Lat. 48° 12' N, Long. 21° 40' E, UTM: EU43) (conventionally treated apple and pear orchards), Szentlőrinc (Lat. 46° 3' N, Long. 17° 59' E, UTM: YM30) (conventionally treated apple orchard), Pókaszepetk (Lat. 46° 56' N, Long. 16° 58' E, UTM: XM49) (conventionally treated apple orchard), Vámosmikola (Lat. 48° N, Long. 18° 52' E, UTM: CU31) (a conventionally treated apple orchard and its edge).

In the conventionally treated orchards broad-spectrum insecticides: mainly organophosphorus insecticides and some pyrethroids, organochlorine and carbamate compounds were used. In Újfehértó four apple orchards were investigated: an abandoned, a conventionally treated and an orchard where integrated pest management (IPM) was used. The fourth orchard was divided into IPM and conventionally treated plots, but in this study

was regarded as one orchard. In the IPM orchards, the pest management based on “green” insecticides (insect growth regulators, chitin synthesis inhibitors, *Bacillus thuringiensis* etc.) and on some “yellow” insecticides (e.g. phosalone) less harmful to insect natural enemies. The description of the orchards is given in *Table 1*.

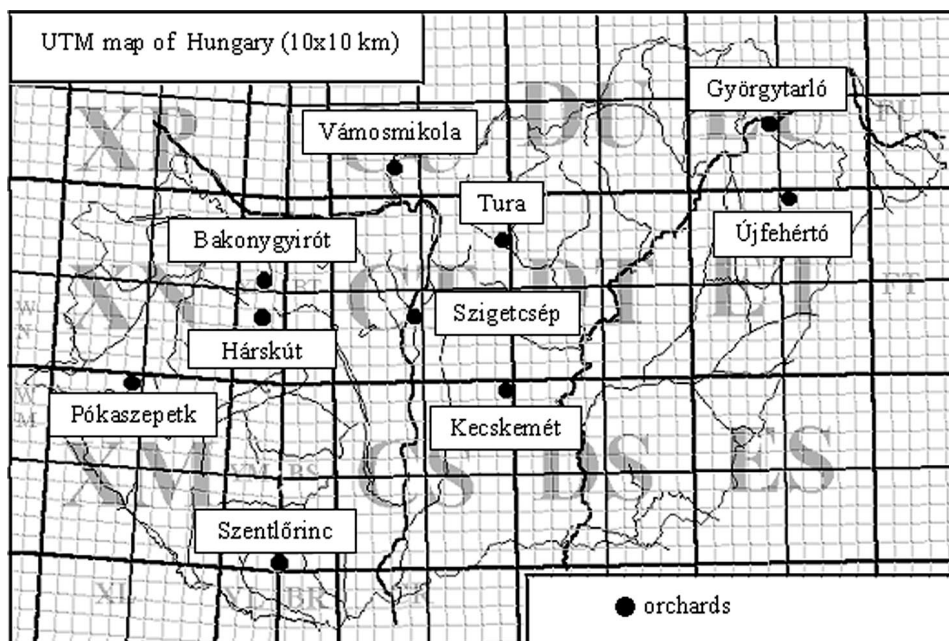


Fig. 1. The UTM map of Hungary with the investigated orchards

Surface active carabids were collected using covered pitfall traps (plastic glasses, 300 cm³ in size and 8 cm in diameter) half filled with 33% ethylene glycol in water. Ten traps were placed in most of the orchards, while six, 32 and eight traps were used in Újfehértó (1999–2001, 2002) and Vámosmikola (1991–2001) respectively (*Table 1*). Where ten traps were used, five were placed into the centre of the orchards and five at about 10–20 m from the edge. The samples were collected from the end of April till end of October, between 1998 and 2003 (*Table 1*).

Additional sampling was carried out using trunk traps in Bakonygyirót, Szentlőrinc, Szigetcsép, Tura, Kecskemét and Györgyarló. The trunk traps (up-turned plastic bottles with cut bottom, 2000 cm³ in size, fasten tightly to trunks of the trees and filled with 33% ethylene glycol) were used for collecting insects moving down on the surface of the trunks. Five to ten traps were placed in the investigated orchards, at the height of 70 cm. The traps were emptied monthly from April till October.

Table 1
The characteristics of the investigated orchards

Locality	Bakonygyűrőt	Kecskemét	Szigetcsép	Tura	Újfehértó	Györgyvárló	Szentlőrinc	Pókaszapetk	Vámosmikola	Háskút
Environment	Woodland in mountains	Agricultural lowland	Flooded forest area	Agricultural lowland	Agricultural lowland	Agricultural lowland	Agricultural lowland	Woodland in mountains	Woodland in mountains	Woodland
Neighbouring habitats	Forest (Robinia pseudoacacia)	Agricultural fields, ruderal	Agricultural fields	Agricultural fields, ruderal, orchards	Apple orchards, agricultural fields	Orchards, agricultural fields	Agricultural fields	Agricultural fields	Oak forests, orchards	Forest (Fagus sylvatica)
Fruit species	apple	apple	apple	apple	apple	apple	apple	apple	apple	apple
Year of planting	1960	1963	1977	1988	1990	1990	1995	2002	1997	1988
Size of plantation	6 ha	20 ha	5.5 ha	4 ha	118 ha	5 ha	0.4, 8 and 7 ha	5 ha+	53 ha	20–25 ha
Cultivars	Jt, Bd, S	Jt, S, St	Jt, Jg, G, S	C, V, P, BG	Jt, Ap, Ep	B, D, V	G, Jt, S	Jt, I, F	Jg, Es	I, E
Planting system	7 × 7 m	5 × 4 m	4.5 × 2.5 m	6 × 4 m	8 × 4 m	7 × 4 m	5 × 2 m	5 × 2 m	1.2 × 3.2 m	4 × 1.6 m
Abandoned		+			+					+
CON	+		+	+	+	+	+	+	+	+
IPM					+					
Treatments /year	10 – 15	–	12–17	12–13	10–12	8–10	15–16**	8–10	10–12	10–14
Years of collection	1998–2001	1998–2000	1998–2001*	1998–2001*	1998–2000	1998–2000	1999–2001	2002	1998–2001	1999–2001
Pitfall traps / plot	10	10	10	10	10	10	3 × 6	Con 8 IPM 24	10	6 × 2
Soil	Sandy	Sandy	Sandy-loam	Sandy-loam	Sandy-loam	Sandy-loam	Sandy	Sandy	Clay	Clay
Weed management	Mw	NM	Mw	Mw	Cu	Cu	NM, Cu	Mw, Cu	Mw	Mw

Apple cultivars: Ap – Asztraháni piros, Bd – Budai domonkos, Cr – Cox Orange Renet, F – Florina, G – Golden Delicious, Gl – Gloszter, E – Éva, Ep – Egri piros, Es – Elstar, I – Idared, Jg – Jonagold, Jt – Jonathan, P – Parker pepin, S – Starking, St – Staymared.

Pear cultivars: B – Bosc kobak, BG – Bella di giugno, C – Clapp kedvelte, D – Diel vajkorte, P – Packham's Triumph, V – Vilmos.

Pest management: CON – Conventional, IPM – Integrated Pest Management.

Weed management: Cu – Cultivated, Mw – Mowed, NM – Non Managed.

* There were not collections in 1999, + IPM plot: 4 ha, Con plot: 1 ha.

** Only in the Conventional and in the IPM orchards.

The commonness of the carabid species in the orchards was approached in three ways: 1) the proportion of individuals of a species in the total catch of the 16 orchards was counted; 2) the sum of the scores was calculated, where the seven most abundant species collected in an orchard were placed in decreasing order, and the dominant species, with highest relative abundance scored 7, the second one 6 etc. The scores from different orchards were summarised by species. The highest possible score, if a species was dominant in all orchards, was (15×7) 105. The presence or absence of the species 3) in the orchards was also investigated. The most widely distributed species (which were found in 16 of the 16 investigated orchards) got 100%; the species, which was collected in 12 orchards, got 75% etc.

The identification of the collected carabids based on the works of Freude (1976) and Hurka (1996).

Results and Discussion

The carabid species collected on the ground surface of the investigated apple and pear orchards are shown in *Tables 2* and *3*. The orchards were grouped by soil composition. The species collected in orchards with sandy and sandy-loam soils are listed in *Table 2*; and the species collected in orchards with clay and clay loam soils are shown in *Table 3*.

In the investigated 13 apple orchards 24 016 individuals belonging to 155 species were found, while in the three pear orchards 3 217 individuals belonging to 87 species. Altogether 28 230 individual belonging to 174 carabid species were collected by pitfall trapping.

The species with higher relative abundance than 5% are shown in *Table 4*. The number of collected specimens and the total species richness are also given. The species richness of the investigated carabid assemblages varied between 23 and 76, the average species richness was 43 species (*Table 4*). As the sampling effort was not too high, the realistic species richness values must be those higher than average.

The indication of the common carabid species, typical in apple and pear orchards based on three methods: on their proportion in the total catch of the investigated orchards; on the scoring of the seven commonest species in the different orchards (total scores) and on their presence in the orchards (distribution).

The most abundant species, with the proportion almost 50% in the total catch, was *Pseudoophonus rufipes* (46%) followed by *Harpalus distinguendus* (11%), *Pterostichus melas* (6%), *Harpalus tardus* (4.3%), *Calathus erratus* (3.6%) and *Calathus fuscipes* (2.3%). More than 70% (73.2) of the carabid specimens collected in apple and pear orchards belonged to this five species. Other species with higher proportion than 1.0% were: *Amara aenea* (1.8%), *Pseudoophonus griseus* (1.7%), *Harpalus serripes* (1.5%), *Amara familiaris* (1.5%), *Calathus ambiguus* (1.3%), *Harpalus affinis* (1.3%), *Pterostichus melanarius* (1.3%). This 13 species gave the 83.6% of the total catch.

The species, which dominated the carabid assemblages in the local orchard habitats (with the total scores), were *Pseudoophonus rufipes* (96), *Harpalus distinguendus* (47),

Table 2
List of carabid species occurring on the soil surface of apple and pear orchards
with sandy and sandy-loam soil and the years of collection

Species	Bakonygyűrűt		Kecskemét		Szigetsép*		Szigetsép*		Tura		Tura		Újfehértó		Újfehértó		Újfehértó	
	CON	apple	AB	apple	CON	apple	CON	pear	CON	apple	CON	pear	AB	apple	CON	apple	IPM	apple
<i>Abax parallelepipedus</i> (Piller and Mitterpacher, 1783)	98, 99, 00																	
<i>Acupalpus luteatus</i> (Duftschmid, 1812)																		02
<i>Acupalpus meridianus</i> (Linnaeus, 1767)								98, 00										
<i>Agonum atratum</i> (Duftschmid, 1812)				00														02
<i>Agonum gracilipes</i> (Duftschmid, 1812)																		02
<i>Agonum lugens</i> (Duftschmid, 1812)								01										
<i>Agonum permolestum</i> Puel, 1938																		
<i>Agonum sexpunctatum</i> (Linnaeus, 1758)	99																	
<i>Agonum viridicupreum</i> (Goeze, 1777)																		
<i>Anara aenea</i> (De Geer, 1774)	98, 99, 00, 01		99, 00		98, 00, 01		98, 00, 01		99, 00				99		01		99, 00, 01	
<i>Anara anthobia</i> A. Villa et J. B. Villa, 1833	01		00		98, 00, 01		98, 00, 01						00, 01				01	
<i>Anara apricaria</i> (Paykull, 1790)				00											99		01	
<i>Anara aulica</i> (Panzet, 1797)	00, 01		98, 99, 00										00					02
<i>Anara bifrons</i> (Gyllenhal, 1810)	98, 99, 00, 01		98, 99, 00		00, 01		00, 01		00				99					
<i>Anara communis</i> (Panzet, 1797)	99														99			
<i>Anara consularis</i> (Duftschmid, 1812)	98		99, 00		01		00		98				00					
<i>Anara convexior</i> Stephens, 1828													00					
<i>Anara cursitans</i> (Zimmermann, 1831)	00, 01																	
<i>Anara eurynota</i> (Panzet, 1797)	00, 01																	
<i>Anara familiaris</i> (Duftschmid, 1812)	98, 99, 00, 01		99, 00		98, 00, 01		98, 00, 01		99, 00				00, 01				00, 01	
<i>Anara fulva</i> (O. F. Müller, 1776)	98, 99, 00, 01				00													02
<i>Anara gebleri</i> Dejean, 1831	99, 01																	
<i>Anara ingenua</i> (Duftschmid, 1812)			00				00		99						99			
<i>Anara lucida</i> (Duftschmid, 1812)																		02
<i>Anara majuscula</i> Chaudoir, 1850	98																	
<i>Anara municipalis</i> (Duftschmid, 1812)	00																	
<i>Anara plebeja</i> (Gyllenhal, 1810)	00																	
<i>Anara saphyrea</i> Dejean, 1828																		
<i>Anara similata</i> (Gyllenhal, 1810)	99, 00				98, 01		98, 00, 01						00, 01		00		00, 01	02

Table 2 (cont.)

Species	Bakonygyöri*			Szigetcsép*			Tura		Tura	Újfehértó		Újfehértó		Újfehértó	
	1998-2001	1998-2000	1998-2001	1998-2001	1998-2001	1998-2001	1998-2000	1998-2000	1998-2000	1999-2000	1999-2001	1999-2001	1999-2001	1999-2001	2002
	CON	AB	CON	CON	pear	apple	CON	apple	CON	AB	CON	apple	CON	IPM	IPM, CON
<i>Amara tibialis</i> (Paykull, 1798)															
<i>Amara tricuspidata</i> Dejean, 1831	00, 01	98			01										
<i>Anchomenus dorsalis</i> (Pontoppidan, 1763)	98, 00		00, 01	98, 00, 01					99, 00					99	02
<i>Anisodactylus binotatus</i> (Fabricius, 1787)			98, 01	98, 00, 01			98, 99, 00		98, 99, 00	00, 01		01		00	02
<i>Anisodactylus signatus</i> (Panzar, 1797)	99, 00			00, 01			99, 00					00, 01		01	02
<i>Asaphidion flavipes</i> (Linnaeus, 1761)	99											99			
<i>Badister bullatus</i> (Scrank, 1798)			98, 00, 01		00				99, 00	00					
<i>Badister lacertosus</i> Sturm, 1815							98		99						
<i>Badister meridionalis</i> Puel, 1925			01						98						
<i>Bembidion femoratum</i> (Sturm, 1825)	98, 99, 00														
<i>Bembidion gilvipes</i> (Sturm, 1825)					00										
<i>Bembidion lampros</i> (Herbst, 1784)	98, 99, 01														
<i>Bembidion lunulatum</i> (Fourcroy, 1785)					98										
<i>Bembidion octomaculatum</i> (Goeze, 1777)			00										01		
<i>Bembidion properans</i> (Stephens, 1828)	98, 00		00	98, 00, 01			99							99, 00	02
<i>Bembidion quadrimaculatum</i> (Linnaeus, 1761)	98, 99, 00, 01		00	00			00						00		
<i>Bembidion varium</i> (Olivier, 1795)															
<i>Brachinus crepitans</i> (Linnaeus, 1758)					98										02
<i>Brachinus explodens</i> Duftschmid, 1812	99	98, 99	98, 01	98, 00, 01										01	
<i>Brachinus ganglbaueri</i> Apfelbeck, 1904				98, 00			00								
<i>Bradycellus caucasicus</i> Chaudoar, 1846							98								
<i>Bradycellus eskii</i> Laczó, 1912	01	00			00										
<i>Brosicus cephalotes</i> (Linnaeus, 1758)													01		02
<i>Calathus ambiguus</i> (Paykull, 1790)	98, 99, 00, 01	98, 99, 00	00, 01	00, 01			99		99, 00	00		99, 00, 01		01	02
<i>Calathus cinctus</i> Motschulsky, 1850	98, 99, 01	98, 99, 00													
<i>Calathus erratus</i> (Sahlberg, 1827)	98, 99, 00, 01	98, 00										99, 00, 01			02
<i>Calathus fuscipes</i> (Goeze, 1777)	98, 00, 01	98, 99, 00	00, 01	98, 00, 01			00		98, 99, 00	99, 00, 01					02
<i>Calathus melanocephalus</i> (Linnaeus, 1758)	98, 00	98, 99, 00		98, 00, 01			00		00	99, 00, 01		01		99	02
<i>Calosoma inquisitor</i> (Linnaeus, 1758)													00		02
<i>Calosoma sycophanta</i> (Linnaeus, 1758)															
<i>Carabus cancellatus</i> Illiger, 1798	99														
<i>Carabus convexus</i> Fabricius, 1775		99, 00													

Table 2 (cont.)

Species	Bakonygyirő		Kecskemét		Szigetcsép*		Szigetcsép*		Tura		Tura		Újfehértó		Újfehértó		Újfehértó	
	CON	AB	CON	AB	CON	apple	CON	pear	CON	apple	CON	pear	CON	apple	CON	apple	CON	apple
<i>Harpalus smaragdinus</i> (Duftschmid, 1812)	98, 99, 00	98, 99	01	01	01						99, 01		99, 01	01	01	01	02	02
<i>Harpalus subcylindricus</i> Dejean, 1829	00, 01		01		01								01		01	01	02	02
<i>Harpalus tardus</i> (Panzer, 1797)	98, 99, 00, 01	98, 99, 00	98, 00, 01	00, 01	00, 01	98, 99, 00			98, 99, 00		00, 01		00, 01	99, 00, 01			02	02
<i>Leistus ferrugineus</i> (Linnaeus, 1758)	00	98, 99, 00	01	00, 01	00, 01						01							
<i>Leistus rufomarginatus</i> (Duftschmid, 1812)																		
<i>Licinus casideus</i> (Fabricius, 1792)		98, 99, 00																
<i>Licinus depressus</i> (Paykull, 1790)	01	98, 99, 00									00, 01							
<i>Masoreus wetterhalli</i> (Gyllenhal, 1813)	01																	
<i>Microlestes maurus</i> (Sturm, 1827)																		
<i>Microlestes minutulus</i> (Goeze, 1777)	00		00														02	02
<i>Nebria brevicollis</i> (Fabricius, 1792)	98, 99, 00, 01																	
<i>Notiophilus palustris</i> (Duftschmid, 1812)	00																	
<i>Notiophilus rufipes</i> Curtis, 1829	98, 99, 00	00			98													
<i>Notiophilus pusillus</i> Waterhouse, 1833																		
<i>Oodes helopoides</i> (Fabricius, 1792)			01															
<i>Ophonus azureus</i> (Fabricius, 1775)	98	98, 99																
<i>Ophonus melletti</i> (Heer, 1837)		99											01					
<i>Ophonus nitidulus</i> Stephens, 1828	01																	
<i>Ophonus puncticeps</i> (Stephens, 1828)		98, 99, 00											01					
<i>Ophonus puncticollis</i> (Paykull, 1798)		99																
<i>Ophonus rufibarbis</i> (Fabricius, 1792)		98, 99																
<i>Ophonus schaubergerianus</i> Puel, 1937		98																
<i>Panagaeus bipustulatus</i> (Fabricius, 1775)	98	98, 99											00, 01					
<i>Pangaeus scaritides</i> (Sturm, 1825)		98																
<i>Paratychus bistriatus</i> (Duftschmid, 1812)																		
<i>Parophonus hirsutulus</i> (Dejean, 1829)		98, 99						00										
<i>Parophonus complanatus</i> (Dejean, 1829)	98, 99, 01	98, 99, 00	98, 00, 01		98, 00, 01													
<i>Parophonus maculicornis</i> (Duftschmid, 1812)	98																	
<i>Platyderus rufus</i> (Duftschmid, 1812)	01	98, 99, 00							99, 00		99, 00, 01		99, 00, 01					
<i>Poecilus cupreus</i> (Linnaeus, 1758)	98, 99, 00, 01		01		98, 00, 01				99		99, 00		99, 00, 01		99, 00	99, 00, 01	02	02
<i>Poecilus lepidus</i> (Leske, 1785)	98, 99, 00												99, 00, 01		99, 00, 01			
<i>Poecilus punctulatus</i> (Schaller, 1783)		98, 99																

Table 2 (cont.)

Species	Bakonygyöri*		Kecskemét		Szigetcsép*		Tura		Tura		Újfehértó		Újfehértó		Újfehértó	
	1998–2001	CON	1998–2000	AB	1998–2001	CON	1998–2001	apple	1998–2000	CON	1998–2000	apple	1999–2001	CON	1999–2001	apple
<i>Poecilus versicolor</i> Fischer, 1824																
<i>Poecilus versicolor</i> (Sturm, 1824)																
<i>Pseudophonus calceatus</i> (Duftschmid, 1812)																
<i>Pseudophonus griseus</i> (Panzer, 1797)	00			00	00	00, 01			00							
<i>Pseudophonus rufipes</i> (De Geer, 1774)	98, 99, 00, 01		99, 00	00	00	00, 01			00				99, 00, 01		00, 01	
<i>Pseudophonus anthracinus</i> (Illiger, 1798)	98, 99, 00, 01		98, 99, 00	00	98, 00, 01	98, 00, 01			98, 99, 00				99, 00, 01		99, 00, 01	
<i>Pterostichus macer</i> (Marsham, 1802)																
<i>Pterostichus macer</i> (Marsham, 1802)																
<i>Pterostichus melanarius</i> (Illiger, 1789)	98, 99, 00, 01		99	00, 01	00, 01				98, 99, 00				99			
<i>Pterostichus niger</i> (Schaller, 1783)				00	00				98, 99				01		99	
<i>Pterostichus oblongopunctatus</i> (Fabricius, 1787)																
<i>Pterostichus strenuus</i> (Panzer, 1797)	00								99, 00				00, 01		99	
<i>Pterostichus vernalis</i> (Panzer, 1796)																
<i>Pterostichus vernalis</i> (Panzer, 1796)																
<i>Stenolophus mixtus</i> (Herbst, 1784)																
<i>Stenolophus mixtus</i> (Herbst, 1784)																
<i>Stomis pumicatus</i> (Panzer, 1796)																
<i>Syntomus foveatus</i> (Fourcroy, 1785)	98, 99, 00		00													
<i>Syntomus obscuroguttatus</i> (Duftschmid, 1812)																
<i>Syntomus pallipes</i> (Dejean, 1825)	98, 99		98, 99, 00	98, 99	98, 99, 00	98, 99, 00			99, 00							
<i>Synuchus vivalis</i> (Illiger, 1798)																
<i>Trechus quadristriatus</i> (Schrank, 1781)	98, 99, 00, 01			00, 01	98, 00	98, 00			99, 00				99, 00		99, 00, 01	
<i>Zabrus spinipes</i> (Fabricius, 1798)																
<i>Zabrus tenebrioides</i> (Goeze, 1777)	98, 99, 00, 01		98, 99, 00	98					99, 00							

Explanation: AB – Abandoned, CON – Conventional, IPM – Integrated Pest Management.

* No collections in 1999.

Table 3
List of carabid species occurring on the soil surface of apple and pear orchards
with clay and clay loam soils and the years of collection

Species	Gyöngyártarló 1998–2001		Gyöngyártarló 1998–2001		Szentlőrinc 1998–2001		Pókaszepetk 2001–2002		Vámosmikola 1999–2001		Vámosmikola 1999–2001		Hárskút 2002–2003	
	CON	apple	CON	pear	CON	apple	CON	apple	ED	apple	CON	apple	AB	apple
<i>Abax carinatus</i> (Duftschmid, 1812)					00									
<i>Abax parallelepipedus</i> (Piller and Mitterpacher, 1783)					01				99, 00		99		03	
<i>Abax parallelus</i> (Duftschmid, 1812)							01, 02		99		99, 00, 01		02, 03	
<i>Acupalpus meridianus</i> (Linnaeus, 1767)					98, 99									
<i>Amara aenea</i> (De Geer, 1774)	98				99		01, 02		99		99, 00			
<i>Amara anthobia</i> A. Villa et J. B. Villa, 1833					98		02				99			
<i>Amara apricaria</i> (Paykull, 1790)											99			
<i>Amara aulica</i> (Panzer, 1797)							01, 02		99		01			
<i>Amara bifrons</i> (Gyllenhal, 1810)	98													
<i>Amara consularis</i> (Duftschmid, 1812)	00								99, 00		99			
<i>Amara convexior</i> Stephens, 1828	00, 01		98, 00								99, 00		03	
<i>Amara equestris</i> (Duftschmid, 1812)													02, 03	
<i>Amara eurynota</i> (Panzer, 1797)											01		03	
<i>Amara familiaris</i> (Duftschmid, 1812)					98, 99, 01		01, 02		00		99			
<i>Amara lucida</i> (Duftschmid, 1812)							01							
<i>Amara lunicollis</i> Schiodte, 1837													03	
<i>Amara ovata</i> (Fabricius, 1792)	98										99			
<i>Amara sabulosa</i> (Audinet – Serville, 1821)					00									
<i>Amara saphyrea</i> Dejean, 1828											99, 00			
<i>Amara similata</i> (Gyllenhal, 1810)	98		98, 99		98, 01		02				99, 00			
<i>Anchomenus dorsalis</i> (Pontoppidan, 1763)	98, 99		98, 99		99				99		99			
<i>Anisodactylus binotatus</i> (Fabricius, 1787)	98, 99, 00, 01		98, 99, 01											
<i>Anisodactylus signatus</i> (Panzer, 1797)					99, 00, 01		01, 02							
<i>Aptinus bombarda</i> (Illiger, 1800)													03	
<i>Asaphidion flavipes</i> (Linnaeus, 1761)	98				99									
<i>Badister bullatus</i> (Scrank, 1798)	01		98		00, 01									
<i>Badister meridionalis</i> Puel, 1925					99									

Table 3 (cont.)

Species	Györgyártó 1998–2001		Györgyártó 1998–2001		Szentlőrinc 1998–2001		Pókaszepetk 2001–2002		Vámosmikola 1999–2001		Hárskút 2002–2003	
	CON	apple	CON	pear	CON	apple	CON	apple	ED	CON	AB	apple
<i>Bembidion dalmatinum</i> Dejean, 1831						00						
<i>Bembidion guttula</i> (Fabricius, 1792)	01											
<i>Bembidion lampros</i> (Herbst, 1784)												
<i>Bembidion properans</i> (Stephens, 1828)			99				01			99	02	
<i>Brachinus crepitans</i> (Linnaeus, 1758)					99					99	03	
<i>Brachinus expulans</i> Duftschmid, 1812	98		98		99, 01		01, 02		99, 00	99	03	
<i>Brachinus ganglbaueri</i> Apfelbeck, 1904	98		98, 99		00		02					
<i>Calathus ambigua</i> (Paykull, 1790)							01			99, 01		
<i>Calathus cinctus</i> Motschulsky, 1850	99											
<i>Calathus fuscipes</i> (Goeze, 1777)					99, 00, 01		01, 02		99, 00	99, 00, 01	02, 03	
<i>Calathus melanocephalus</i> (Linnaeus, 1758)	98						01		99, 00	01	03	
<i>Calosoma sycophanta</i> (Linnaeus, 1758)	00											
<i>Carabus cancellatus</i> Illiger 1798											03	
<i>Carabus convexus</i> Fabricius 1775											03	
<i>Carabus coriaceus</i> Linnaeus, 1758					98, 00, 01				99, 00	99, 00, 01	02, 03	
<i>Carabus germari</i> Sturm, 1815											02, 03	
<i>Carabus glabratus</i> Paykull 1790											03	
<i>Carabus granulatus</i> Linnaeus, 1758	99											
<i>Carabus hortensis</i> Linnaeus, 1758											03	
<i>Carabus nemoralis</i> Müller, 1764									99, 00	99, 00, 01	03	
<i>Carabus scheidleri</i> Panzer, 1799											02, 03	
<i>Carabus ulrichi</i> Germar, 1824					00				99, 00	99, 00, 01		
<i>Carabus violaceus</i> Linnaeus, 1758										99		
<i>Cicindela germanica</i> Linnaeus, 1758					99, 00		01, 02					
<i>Clivina collaris</i> (Herbst, 1784)						01						
<i>Cychrus attenuatus</i> (Fabricius, 1792)											02	
<i>Dolichus halensis</i> (Schaller, 1783)										00		
<i>Harpalus affinis</i> (Schrank, 1781)	98		00		00, 01		01, 02			99, 00, 01		

Table 3 (cont.)

Species	Gyöngytarló 1998–2001		Gyöngytarló 1998–2001		Szentlőrinc 1998–2001		Pókaszepetk 2001–2002		Vámosmikola 1999–2001		Vámosmikola 1999–2001		Hárskút 2002–2003	
	CON	apple	CON	pear	CON	apple	CON	apple	ED	apple	CON	apple	AB	apple
<i>Harpalus anxius</i> (Duftschmid, 1812)												99		
<i>Harpalus atratus</i> Latreille, 1804						00	01		99			99		
<i>Harpalus dimidiatus</i> (Rossi, 1790)							01, 02							
<i>Harpalus distinguendus</i> (Duftschmid, 1812)	98				99, 00, 01		01, 02		99		99, 00, 01			
<i>Harpalus flavicornis</i> Dejean, 1829											99			
<i>Harpalus honestus</i> (Duftschmid, 1812)					99, 01								03	
<i>Harpalus latus</i> (Linnaeus, 1758)	98, 99, 00, 01		98, 01											
<i>Harpalus luteicornis</i> (Duftschmid, 1812)			98											
<i>Harpalus pumilus</i> Sturm, 1818			98						99		99			
<i>Harpalus roubali</i> Schaubberger, 1928			98				02		99		99, 00			
<i>Harpalus rubripes</i> (Duftschmid, 1812)							02		99, 00		99, 01		02, 03	
<i>Harpalus serripes</i> (Quensel, 1806)	98		98								99			
<i>Harpalus smaragdinus</i> (Duftschmid, 1812)							01							
<i>Harpalus subcylindricus</i> Dejean, 1829											00			
<i>Harpalus tardus</i> (Panzer, 1797)					98, 99, 00, 01	98, 99, 00, 01	01, 02		99, 00		99, 00, 01			
<i>Leistus ferrugineus</i> (Linnaeus, 1758)	98, 99, 00, 01		98, 99, 00, 01		99, 00		01, 02						02, 03	
<i>Leistus rufomarginatus</i> (Duftschmid, 1812)							01				99, 01			
<i>Licinus depressus</i> (Paykull, 1790)														
<i>Microlestes maurus</i> (Sturm, 1827)					98, 00, 01		01						02	
<i>Microlestes minutulus</i> (Goeze, 1777)														
<i>Molops piceus</i> (Panzer, 1793)							01							
<i>Nebria brevicollis</i> (Fabricius, 1792)					00, 01		01, 02		99, 00		99, 00, 01		03	
<i>Notiophilus palustris</i> (Duftschmid, 1812)					01									
<i>Notiophilus rufipes</i> Curtis, 1829					99								03	
<i>Olisthopus rotundatus</i> (Paykull, 1790)														
<i>Ophonus azureus</i> (Fabricius, 1775)					00		01				99			
<i>Ophonus diffinis</i> (Dejean, 1829)							01							
<i>Ophonus gammeli</i> (Schaubberger, 1932)							01						02, 03	

Table 3 (cont.)

Species	Györgyártó 1998–2001		Györgyártó 1998–2001		Szentlőrinc 1998–2001		Pókaszepetk 2001–2002		Vámosmikola 1999–2001		Vámosmikola 1999–2001		Hárskút 2002–2003	
	CON	apple	CON	pear	CON	apple	CON	apple	ED	apple	CON	apple	AB	apple
<i>Ophonus mellei</i> (Heer, 1837)									00					
<i>Ophonus puncticeps</i> (Stephens, 1828)							01		99, 00		01			
<i>Ophonus puncticollis</i> (Paykull, 1798)									99					
<i>Ophonus rufibarbis</i> (Fabricius, 1792)	98, 99, 01		98, 01						99					
<i>Ophonus rupicola</i> (Sturm, 1818)									99					
<i>Paratichus bistriatus</i> (Duftschmid, 1812)					98									
<i>Paraphonus maculicornis</i> (Duftschmid, 1812)											99			
<i>Platyderus rufus</i> (Duftschmid, 1812)	98, 99		00								99			
<i>Poecilus cupreus</i> (Linnaeus, 1758)	98		98		98, 00, 01		01, 02							
<i>Poecilus versicolor</i> (Sturm, 1824)													02, 03	
<i>Pseudoophonus griseus</i> (Panzer, 1797)							01				99, 00, 01			
<i>Pseudoophonus rufipes</i> (De Geer, 1774)	98, 99, 00, 01		98, 00, 01		98, 99, 00, 01		01, 02		99, 00		99, 00, 01		02, 03	
<i>Pterostichus incommodus</i> Schaum, 1858									99, 00		99, 01			
<i>Pterostichus macer</i> (Marsham, 1802)							02							
<i>Pterostichus melanarius</i> (Illiger, 1789)	98		98		98, 99, 00, 01		01, 02		00		99		02, 03	
<i>Pterostichus melas</i> (Creutzer, 1799)					98, 99, 00, 01		01, 02		99, 00		99, 01		02, 03	
<i>Pterostichus niger</i> (Schaller, 1783)	98, 99				00				99					
<i>Pterostichus ovoideus</i> (Sturm, 1824)							01, 02		99				03	
<i>Pterostichus strenuus</i> (Panzer, 1797)	98								00					
<i>Stomis punicatus</i> (Panzer, 1796)					99, 00						99			
<i>Syntomus obscuriguttatus</i> (Duftschmid, 1812)	98, 01		98, 99, 01		00									
<i>Synuchus vivalis</i> (Illiger, 1798)	00, 01		00						99				02, 03	
<i>Trechus austriacus</i> Dejean, 1831					98									
<i>Trechus quadristriatus</i> (Schrank, 1781)	98, 99		98, 01		98, 99, 00, 01		01, 02				99		03	
<i>Zabrus tenebrioides</i> (Goeze, 1777)							01, 02		99					

Explication: AB – Abandoned, CON – Conventional, ED – Edge, IPM – Integrated Pest Management

Table 4

Relative abundance (%) and the total scores of the most abundant carabid species; the total catch and the species richness in the investigated apple and pear orchards in Hungary.
Relative abundance lower than 5% were marked with +

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total score
<i>Pseudoophonus rufipes</i>	6.6	30	83	68	24	9	12	9.5	38	67	22	14	25	59	54	11	96
<i>Harpalus distinguendus</i>	11	+	+	5	5.8	+	77	+	40	18	+	+	+	+	+	+	47
<i>Harpalus tardus</i>	6.4	+	+	+	+	9.6	+	6.8	+	+	44	25	9	+	21	+	46
<i>Anisodactylus binotatus</i>	+	+	+	+	27	5	+	+	+	+	5	10.7	+	+	+	+	20
<i>Calathus fuscipes</i>	+	11	+	+	+	+	+	5.3	+	+	+	+	+	+	+	8.3	19
<i>Calathus erratus</i>	30	+	+	+	+	+	+	20	+	+	+	+	+	+	+	+	18
<i>Amara aenea</i>	10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	17
<i>Harpalus affinis</i>	+	+	+	+	+	+	+	+	5.5	+	+	+	+	6.8	+	+	17
<i>Pterostichus melanarius</i>	+	+	+	+	+	23	+	+	+	+	+	+	+	+	+	6.5	16
<i>Pterostichus melas</i>	+	+	+	+	+	+	+	+	+	+	+	+	47	+	+	43.6	14
<i>Brachinus explorens</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	5	+	+	13
<i>Harpalus serripes</i>	+	15	+	+	+	+	+	+	+	+	+	+	+	+	+	+	11
<i>Pseudoophonus griseus</i>	5	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	10
<i>Nebria brevicollis</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	11	+	+	9
<i>Amara familiaris</i>	9.3	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	9
<i>Trechus quadristriatus</i>	+	+	+	+	+	20	+	+	+	+	+	+	+	+	+	+	8
<i>Calathus melanocephalus</i>	+	+	+	+	+	+	+	12	+	+	+	+	+	+	+	+	7
<i>Amara anthobia</i>	+	+	+	+	+	+	+	8.4	+	+	+	+	+	+	+	+	7
<i>Anchomenus dorsalis</i>	+	+	+	+	+	+	+	+	+	+	+	6.4	+	+	+	+	6
<i>Carabus scheldleri</i>	+	+	+	+	+	+	+	+	+	+	+	8.6	+	+	+	10	5
<i>Harpalus latus</i>	+	7	+	+	+	+	+	+	+	+	+	+	+	+	+	+	4
<i>Amara aulica</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	4
<i>Harpalus rubripes</i>	+	+	+	+	+	+	+	+	+	+	+	5.4	+	+	+	5.4	4
<i>Ophonus rufibarbis</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	3
Specimens	2832	2405	1820	2906	411	218	879	484	858	7941	288	93	1423	1407	1761	2171	-
Species	76	53	43	71	39	36	27	46	31	47	32	23	42	41	50	37	-

Keys to the codes: 1: Bakonygyűrűt, 2: Kecskemét, abandoned, 3: Szigetcsép, apple, 4: Szigetcsép, pear, 5: Tura, apple, 6: Tura, pear, 7: Újfehértó, conventional, 8: Újfehértó, abandoned, 9: Újfehértó, IPM, 10: Újfehértó, 2002, 11: Györgyvári, apple, 12: Györgyvári, pear, 13: Szentlőrinc, 14: Pókaszeptek, 15: Vámosmikola, 16: Hárskút, abandoned.

Harpalus tardus (46), *Anisodactylus binotatus* (20), *Calathus fuscipes* (19), *Calathus erratus* (18), *Amara aenea* (17), *Harpalus affinis* (17) and *Pterostichus melanarius* (16).

Pseudoophonus rufipes was found in all investigated orchards (100%). *Trechus quadristriatus* were found in the 94% of the investigated orchards. *Harpalus tardus*, *Harpalus distinguendus* and *Pterostichus melanarius* occurred in 87.5%, while *Amara aenea*, *Amara familiaris*, *Calathus fuscipes* and *Poecilus cupreus* in 81% of the investigated orchards. *Calathus ambiguus*, *Calathus melanocephalus*, *Pseudoophonus griseus* and *Harpalus serripes* were also widely distributed (75%).

The frequency-abundance relationship of orchard inhabiting carabids is given in Fig 2. The curve shows that the widely distributed species usually were the most abundant, and the species occurring only in one or two orchards were rarely common.

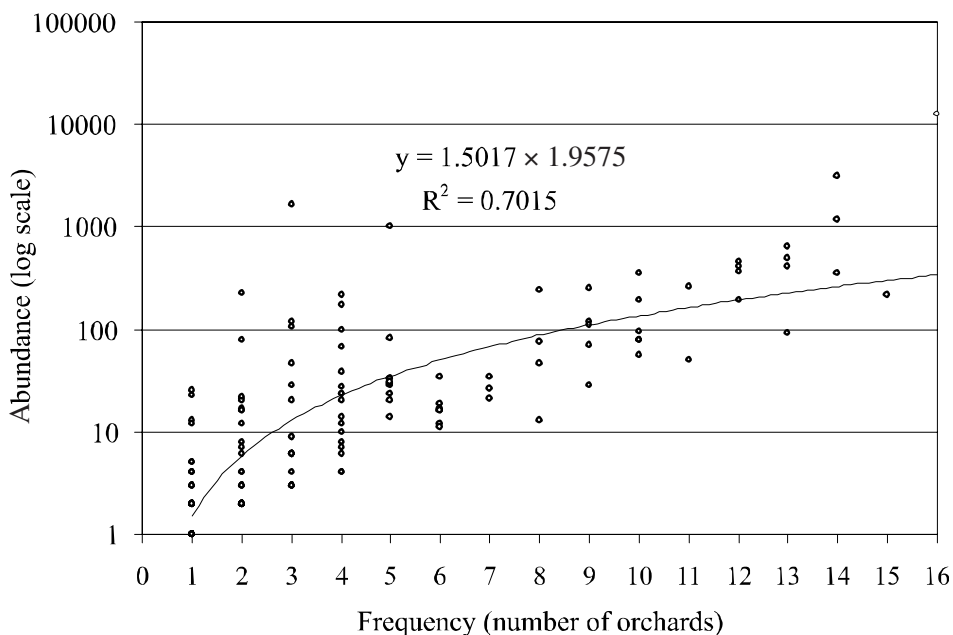


Fig. 2. Relationship between the frequency of occurrence and the total abundance of orchard inhabiting carabid species in Hungary

It can be concluded that three species *Pseudoophonus rufipes*, *Harpalus tardus* and *Harpalus distinguendus* were among the commonest species in the orchards in respect of all three approaches. Four additional species were dominant in some of the orchards *Calathus erratus* (Bakonygyirót and in the abandoned orchard in Újfehértó), *Anisodactylus binotatus* (apple orchard, Tura), *Pterostichus melanarius* (pear orchard, Tura) and *Pterostichus melas* (Szentlőrinc, Hárskút).

Kádár et al. (2003), similarly to our results, reported *Harpalus distinguendus*, *Anisodactylus binotatus* and *Harpalus tardus* as common species in apple orchards in Újfehértó.

Mészáros et al. (1984) did not give quantitative data, but *Pseudoophonus rufipes*, *Harpalus tardus* and *Anisodactylus signatus* occurred in all five orchards investigated and *Amara similata*, *A. familiaris* and *H. distinguendus* were found in four orchards. However, in orchards with characteristically different soil composition and extra- and intra-orchard vegetation some other species were also found to be common: *Anchomenus dorsalis*, *Brachinus expulso*, *Bembidion lampros*, *Carabus violaceus*, *Carabus coriaceus* were abundant in an abandoned orchard near an oak forest in Nagykovácsi (Fazekas et al., 1992) and *Harpalus froelichii*, *Harpalus flavescens*, *Calathus ambiguus* and *Harpalus hirtipes* in the sandy orchard habitats of Kecskemét (Markó and Kádár, 2003). *Anisodactylus signatus* was found as a common species in Újfehértó (Fazekas et al., 1997) and *Asaphidion flavipes* in Mátészalka (Kádár et al., 2003). From these species *Harpalus flavescens* is typical and in some localities common in the sandy lowlands between the rivers Danube and Tisza, but its incidence in the other parts of Hungary is very sporadic (Szél, 1996).

The trunk-traps collected four species, which were not encountered by us in pitfall traps: *Dromius spilotus* (Illiger, 1789) (in Bakonygyirót), *Demetrias atricapillus* (Linnaeus, 1758) (in Szentlőrinc) and *Dromius linearis* (Olivier, 1795) and *Harpalus tenebrosus* (Dejean, 1829) (in Kecskemét).

Mészáros et al. (1984) presented in addition 13 carabid species from apple orchards in Hungary: *Calosoma auropunctatum* (Herbst, 1784), *Carabus scabriusculus* Olivier, 1795, *Carabus hortensis* Linnaeus, 1758, *Drypta dentata* (Rossi, 1790), *Dyschirius globosus* (Herbst, 1784), *Poecilus striatopunctatus* (Duftschmid, 1812), *Abax ovalis* (Duftschmid, 1812), *Laemostenus terricola* (Herbst, 1783), *Agonum duftschmidi* Schmidt, 1994, *Platynus krynickii* (Sperk, 1835), *Harpalus neglectus* Audinet – Serville, 1821, *Harpalus servus* (Duftschmid, 1812) and *Panagaeus crux major* (Linnaeus, 1758). Markó and Kádár (2003) collected additional nine species from Central Hungary: *Cicindela hibrida* Linnaeus 1758, *Harpalus flavescens* (Piller et Mitterpacher, 1783), *Harpalus hirtipes* (Panzer, 1797), *Harpalus melancholicus* (Dejean, 1829), *Harpalus pygmaeus* Dejean, 1829, *Harpalus zabroides* Dejean, 1829. Kádár et al. (2003) reported two additional species, not found by us: *Bembidion biguttatum* (Fabricius, 1779) and *Diachromus germanus* (Linnaeus, 1758) from soil samples and pitfall traps. Zilahy-Sebess (1955) and Markó et al. (1995) published data on *Coleoptera* species collected from the canopy of apple orchards. Two carabid species were found only by them: *Lebia humerealis* Dejean, 1825 and *Microlestes fissuralis* (Reitter, 1900).

Altogether, as a result of our and the reviewed investigations, we can conclude, that 201 carabid species, representing 40% of the carabid fauna of Hungary, were found in apple and pear orchards. Kádár and Lövei (1987, 1992) and Kádár and Szél (1989) collected additional species by light trapping. These photoactive species are attracted to the light traps from longer distance and therefore they cannot be regarded as elements of the orchard carabid fauna (Basedow and Dickler 1981, Yahiro and Yano, 1997).

Some of the 174 carabid species collected are known as rare or only local in Hungary. The species which are very rare and has been found only in a few places in Hungary were: *Amara cursitans* (Zimmermann, 1831), *Harpalus progrediens* Schaubberger, 1922, *Notiophilus pusillus* Waterhouse, 1833, *Olisthopus rotundatus* (Paykull, 1790), *Pangus scaritides*

(Sturm, 1825), *Parophonus hirsutulus* (Dejean, 1829). Other rare or sporatically occurring species were: *Agonum gracilipes* (Duftschmid, 1812), *Amara equestris* (Duftschmid, 1812), *Amara sabulosa* (Serville, 1821), *Bembidion gilvipes* (Sturm, 1825), *Carabus marginalis decorus* Seidlitz, 1891, *Harpalus dimidiatus* (Rossi, 1790), *Harpalus modestus* Dejean, 1829, *Masoreus wetterhallii* (Gyllenhal, 1813), *Ophonus gammeli* (Schauberger, 1932), *Pterostichus incommodus* Schaum, 1858, *Pterostichus macer* (Marsham, 1802) and *Trechus austriacus* Dejean, 1831.

The common species in apple orchards in Hungary were the same as those found in the field crops and which can be characterised as “disturbance-tolerant” species (Lindroth, 1986). However, depending on the neighbouring habitats some specimens of species associated with marsh-forests (e.g. *Bembidion gilvipes*), riversides (*Agonum gracilipes*, *Chlaenius tristis*) dry sandy grasslands (*Masoreus wetterhallii*, *Pangus scaritides*), alkaline deserts (*Pterostichus macer*), limestone hills (*Harpalus dimidiatus*), forests (*Abax parallelepipedus*), and even a troglodytic species (*Trechus austriacus*) were also found.

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