Boll. Zool. agr. Bachic.
Ser. II, 39 (3): 193-209

31 dicembre 2007

D. LUPI, M. COLOMBO, S. FACCHINI

The ground beetles (Coleoptera: Carabidae) of three horticultural farms in Lombardy, Northern Italy (*)

Abstract - Ground beetles (Coleoptera: Carabidae) were surveyed across three horticultural farms, located in a peri-urban area, in the Po plain in Lombardy (Northern Italy) from April 2003 to March 2005. Their biodiversity was estimated using pitfall traps. A total of 29 genera and 39 species were collected. Notes on ants and spiders presence were also furnished. Land use seemed to have a significant effect on the number and composition of the species: catches were lower in the conventional farm and higher in biological farms. Apart from land use, all the species detected have already been recorded as frequent in agricultural fields and are characteristic of lowland agroecosystem in Northern Italy.

Riassunto - *I Coleotteri Carabidi di tre aziende orticole lombarde*

Si riferisce di un'indagine biennale (aprile 2003 - marzo 2005) effettuata sui Coleotteri Carabidi di tre aziende orticole lombarde inserite in un contesto periurbano nella Pianura Padana. La biodiversità di tale famiglia è stata stimata utilizzando trappole a caduta. È stato catturato un totale di 39 specie afferenti a 29 generi. Vengono fornite indicazioni anche dei formicidi e ragni catturati nelle stesse trappole. La gestione aziendale sembra aver avuto un ruolo significativo sul numero e sulla composizione delle specie: le catture erano significativamente più basse nell'azienda convenzionale rispetto a quelle biologiche. Indipendentemente dalla gestione aziendale le specie catturate sono comunque comuni nei campi coltivati e caratteristiche degli agroecosistemi del nord Italia.

Keywords: Carabidae, ground beetle, biodiversity, biological farm, conventional farm.

INTRODUCTION

Carabids play key roles in ecosystem because of their dominant contribution to biodiversity and their influence on most important ecological processes. The family has

---

(*) Work published with a grant from Lombardia Region (Italy) research project "Individuation of exotic arthropods in Lombardy - INARRESTO" financed for research and development plan 2004-2006.

more than 34000 species (34275 in Lorenz, 2005) all over the world. In Italy, there are about 1300 species (Vigna Taglianti, 1993).

It is the family with the greatest number of terrestrial predators.Studies on various cultures have shown that carabids have a significant role in the control of pest even if it is really difficult to predict their effective impact. Many carabids can be considered zoospermophagous as they are able to supplement the diet with seeds or vegetative parts of plants. Many are generalist carnivorous, comprising mollusc or earthworm feeders and insectivorous species. Some species are predominantly granivorous as they eat seed from spontaneous vegetation (Martinková *et al*., 2006). Only few are phytophagous species that are described as harmful to agriculture (Briggs, 1965).

As stated by Holland and Reynolds (2003), ground beetles are often monitored in cultivation experiments for two reasons: the first is that they are the most abundant and diverse group overwintering within cultivated land; the second is that they are the most caught group in pitfall traps, the most frequently used method to evaluate diversity. Besides the “success of the family” is due to the relative simplicity to classify its species and, consequently, to study their biology.

To date, there are two major books on ground beetle agroecology. In 1977, Thiele published his essay on ground beetles ecology. Since Thiele’s book, many were the articles on these arthropods in scientific journals. In 2002, Holland attempted to bring together all data and information on carabids in agroecosystem.

In the 1980s, there was a growing interest in studying the impact of pesticides on these insects. The major part of methods for testing insecticides on ground beetles in Europe was developed by IOBC (Working Group “Pesticides and Beneficial Organisms”). The results show that ground beetles are considered good bioindicators of the quality of the environment. As stated by Holland (2002), “there is evidence that the abundance of Carabidae is declining in the long term since farming started to become more intensive in the 1950s.” High diversity and abundance of ground beetles is considered an index of undisturbed ecosystem (Tuovinen *et al*., 2006; Kromp, 1999). Most studies comparing carabid fauna in conventional and organic systems have found a greater abundance of ground beetle and species richness in organic management (Kromp, 1999; Bommarco 1998; Clark *et al*., 2006). Notwithstanding this, Turin *et al*. (1991) and Turin (2000) (in Holland, 2002) analyzed a 30-year pitfall trapping from all habitats in the Netherlands and concluded that most ground beetles detected in agricultural lands are eurytopic species with high tolerance of disturbance and chemical pollution.

Information on the biology, distribution, and dispersal of Carabidae in agricultural landscape in Italy are referred by Magistretti (1965), Casale *et al*. (1982), Facchini (2001), Brandmayr (1980), Brandmayr and Pizzolotto (1994), and Brandmayr *et al*. (2005).

The present study aimed to describe ground beetles composition in three horticultural farms in Northern Italy and to evaluate the influence of different management practices on ground beetles populations and biodiversity. This work appears on completion of an article on rove beetles (Lupi *et al*., 2006).

MATERIALS AND METHODS

Study area and study sites

Sampling was made in three horticultural farms in Lombardy, Northern Italy. The first one (CONV) is located in Dalmine, Bergamo province and is conventionally managed. The others (BIO1 and BIO2) are respectively in Torre Boldone, Bergamo province and in Cernusco sul Naviglio, Milan province, and are biologically managed, according to European Community Law N. 2092/91.

They are all small farms located in a fragmented peri-urban area, close to towns with highway and bypass nearby and water supplied by canals. Farm CONV borders the town and cereal cultivated fields. Farm BIO1 is surrounded by houses with strips of cultivated lands and a small wood with pine and oak nearby. Farm BIO2 borders on cereal cultivated lands, a riding-school, and a nursery. More characteristics of each farm are listed in Table 1.

Data on temperatures and rain are synthesized in Figures 1 and 2.

Sampling

Ground beetles were surveyed from April 2003 to March 2005. They were sampled using pitfall traps (7 cm diameter, 10 cm deep) covered with a pantile and filled with vinegar to attract the beetles and salt to preserve fermentation. Four traps were set on four cardinal sides of each farm at nearly 15 m from the perimeter of the farm, between tunnels in uncultivated strips of lands. They were examined fortnightly from April to October and monthly from November to March. A total of 324 sample lots were examined.

Samples were washed through a fine aquarium sieve in the laboratory. Arthropods adult specimens were counted, separated, and identified.

Carabids were identified to species level adopting the systematic nomenclature of Lorenz (2005). They were also sorted to trophic groups according to their feeding type.

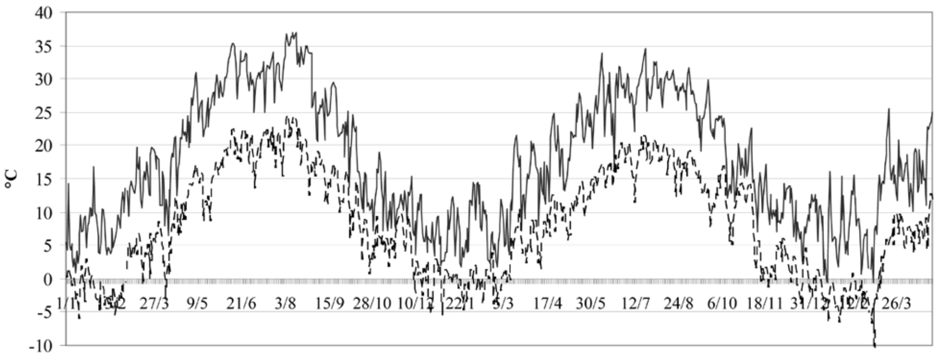

Fig. 1. Minimum and maximum temperature throughout the study period. (Data from Stezzano - Bergamo province, provided by Ersaf Lombardia - Ente Regionale Servizi Agricoltura e Foreste).

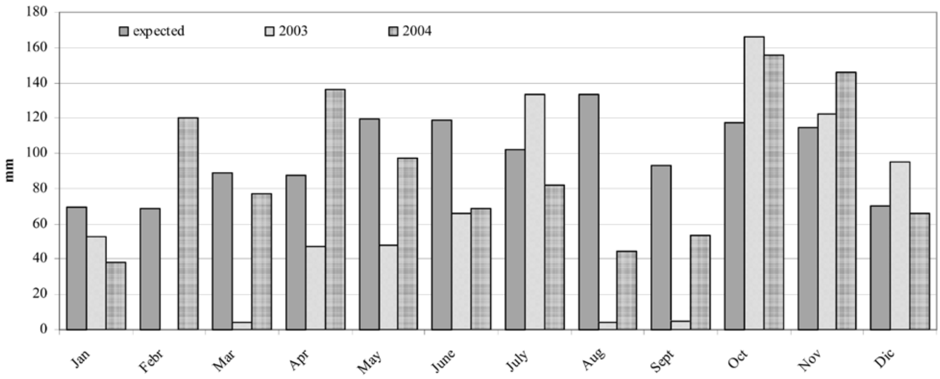

Fig. 2. Effective and expected rainfall (data calculated over 30 years) in 2003 and 2004 (Data from Stezzano -Bergamo province, provided by Ersaf Lombardia - Ente Regionale Servizi Agricoltura e Foreste).

Analysis

To calculate the biodiversity of ground beetles, four diversity indexes were used: Margalef (Mg); Simpson (D); Shannon-Wiener (H'); and Eveness (J').

The dominance rate (DR) was then applied and the species detected were classified in relation to their percentage against the entire range as:

– subrecedent (subrec): less than 1.0%
– rare recedent (rec): 1.0 - 2.0%
– fairly numerous subdominant (subdom): 2.1 - 5.0%
– numerous dominant (dom): 5.1 - 10.0%
– very numerous eudominant (eudom): over 10.0%

RESULTS

Pitfall traps collected a total of 5949 beetles (Table 2). Specimens belonging to three families represented 95% of the whole collection and, in particular, ground beetle was 45.77%. Among the other two representative families, there were rove beetles with 1341 specimens and 76 species (see Lupi *et al*., 2006) and Nitidulidae with 1593 specimens but only three species. Among them, the abundance of *Epuraea ocularis* Fairmaire, a species having tropical origin and recently introduced in Italy (Audisio, 2002), was noticeable.

A total of 2723 ground beetles were collected. Among them, 2676 were classified and 47 discarded because they were damaged and not suitable for classification. A total of 39 species and 29 genera were collected during the survey, among which 25 species were in the farm BIO1, 31 in BIO2, and 18 in conventional (Table 3-5).

Table 1. Main characteristics of the farms.

	BIO1	BIO2	CONV
Location	Torre Boldone	Cernusco sul Naviglio	Dalmine
GPS coordinates(*)	N 45° 39.510’ E 09°36.398’	N 45°32.197’ E 09°20.767’	N 45°42.694’ E 09°42.456
Area Total	6 ha	3.5 ha	3 ha
Area in Tunnel	2 ha	0.5 ha	1 ha
Principal Crops	Aubergine Basil Cauliflower Cucumber Endive Lettuce Marrow Potato Tomato	Aubergine Basil Cauliflower Endive Lettuce Marrow Potato Tomato	Aubergine Basil Cauliflower Cucumber Endive Lettuce Marrow Potatoes Sweet pepper Tomatoes
Woody Trees	Cherry tree Elm Fig tree Hop-hornbeam Oak	Elm Fig-tree Oak Peach Plum Willow	Elm Fig tree London Plane Peach Plum
Shrub	Aromatic plants Blackberry Cherry laurel	Aromatic plants Blackberry Cherry laurel	Aromatic plants Blackberry Cherry laurel
Chemical Plant Protection	No chemical protection No weed control	No chemical protection No weed control	According to official recommendation Weed control

(*) map datum WGS84.

All the species detected have a wide geographic distribution: to remember, among the species with Palaearctic chorotype, *Anchomenus dorsalis* (Pontoppidan, 1763) and *Amara aenea* (Degeer, 1774) widely distributed all over Italy; among the Asiatic-European chorotype, *Harpalus affinis* (Schrank, 1781) and *Poecilus cupreus* (L., 1758); and among the Europeo-Mediterranean chorotype, *Calathus fuscipes* (Goeze, 1777) and *Brachinus sclopeta* (Fabricius, 1792).

Most species detected have been recorded as frequent in agricultural fields by other authors and they are all characteristic of lowland agroecosystem in the north of Italy (Facchini, 2001). They have different feeding regimes being predators (mollusc feeders or insectivorous), granivorous, or polyphagous (predominantly predators or granivorous, phytozoophagous, and opportunistic feeders, according to prey and food availability)

Table 2. Coleoptera families detected in pitfall traps

Families	First year	Second year	Total
Anobidae	1	0	1
Anthicidae	26	10	36
Carabidae	780	1943	2723
Chrysomelidae	30	6	36
Coccinellidae	10	20	30
Cucujdae	1	1	2
Curculionidae	16	77	93
Dermestidae	2	1	3
Driopidae	4	0	4
Elateridae	16	8	24
Lucanidae	2	1	3
Nitidulidae	1234	359	1593
Pselaphidae	0	3	3
Scarabeidae	0	1	1
Scydmaenidae	0	4	4
Staphylinidae	562	779	1341
Tenebrionidae	1	0	1
Other Coleoptera	31	20	51
Total	2716	3233	5949

(Table 6). For example *Pseudoophonus rufipes* (Degeer 1774), *Calathus fuscipes* (Goeze, 1777) and *Anchomenus dorsalis* (Pontoppidan, 1763) are common predators in arable fields in Europe (Jensen *et al*., 1989). *Harpalus* spp. and *Amara* spp. are predominantly granivorous, characterized by unstable habitat either arable or anthropic. Among them, *H. distinguendus* is considered a nitrophilic species. *A. anthobia* is a species common in anthropic areas, mainly in towns in the north of Italy. *A. aenea* is a species common in unstable habitat mostly recorded from better-drained, open situations but on most soil types including deep peat. This species seems to be attracted by Cruciferae. *Anisodactylus binotatus* (Fabricius, 1787), *A. signatus*, and *P. griseus* are also predominantly granivorous, typical of arable fields, but associated to microclimatic conditions with high humidity.

All the species detected were smaller than 2 cm. The only exception is *Carabus germari fiorii* (Born, 1901), which can reach 3.8 mm, of which only few specimens were detected in BIO2 and CONV. This means that all habitats used in this study were disturbed. According to Blake *et al*. (1994), more disturbed habitats have a carabid fauna of smaller average body size.

The ground beetle assemblage displayed the dominance of *P. rufipes*, *H. affinis*, *C. fuscipes* (Goeze, 1777), *Abax continuus* (Baudi, 1876), and *B. sclopeta* (Table 7). They

Table 3. BIO1: Ground beetles species recorded, distribution and relative percentage

Species	**First year**	**Second year**	**Total**	**Relative %**
Abax continuus Baudi, 1876	23	28	51	6.44
Amara aenea (Degeer, 1774)	0	7	7	0.88
Anchomenus dorsalis (Pontoppidan, 1763)	6	24	30	3.79
Bembidion quadrimaculatum (L., 1761)	2	0	2	0.25
Brachinus explodens Duftschmid, 1812	0	1	1	0.13
Brachinus ganglbaueri Apfelbeck,1904	2	0	2	0.25
Brachinus sclopeta (Fabricius,1792)	6	27	33	4.17
Calathus fuscipes (Goeze, 1777)	10	33	43	5.43
Chlaeniellus nitidulus (Schrank, 1781)	0	1	1	0.13
Clivina fossor (L., 1758)	6	0	6	0.76
Diachromus germanus (L., 1758)	3	1	4	0.50
Harpalus affinis (Schrank, 1781)	0	12	12	1.51
*Harpalus anxius (*Duftschmid,1812)	0	1	1	0.13
Harpalus dimidiatus (Rossi, 1790)	0	14	14	1.77
Harpalus flavicornis Dejean, 1829	0	1	1	0.13
Metallina properans (Stephens, 1828)	0	4	4	0.50
Microlestes fissuralis (Reitter, 1900)	0	1	1	0.13
Microlestes minutulus (Goeze, 1777)	0	2	2	0.25
Microlestes sp	0	1	1	0.13
Ophonus azureus (Fabricius, 1775)	0	5	5	0.63
Parophonus maculicornis (Duftschmid, 1812)	0	2	2	0.25
Poecilus cupreus (L., 1758)	47	0	47	5.93
Pseudoophonus rufipes (Degeer, 1774)	215	284	499	63.00
Pterostichus (Feronidius) melas ssp. italicus (Dejean, 1828)	6	0	6	0.76
Stenolophus teutonus (Schrank, 1781)	0	1	1	0.13
Trechus quadristriatus (Schrank, 1781)	2	2	4	0.50
NOT CLASSIFIED (damaged specimens)	10	2	12	1.52
TOTAL	338	454	792	100

contributed to nearly 80% of the total number of the specimens detected. In BIO1 and BIO2, however, the major number of subrecedent species is noticeable because the reduction of less abundant or rare species is always associated to pollution.

In BIO1 and BIO2, *P. rufipes* (Degeer, 1774) was the most representative species representing 63.00% and 36.21%, respectively. In CONV, the most represented species was *Harpalus affinis* (40.90%), while *P. rufipes* was the second abundant species (22.69%). Among other species, *Calathus fuscipes* (5.43% in BIO1; 20.46% in BIO2) and *Diachromus germanus* (0.50% in BIO1; 2.23% in CONV) have to be mentioned (Tables 2- 4).

Table 4. BIO2: Ground beetles species recorded, distribution and relative percentage.

Species	**First year**	**Second year**	**Total**	**Relative %**
Abax continuus Baudi, 1876	4	17	19	1.24
Amara aenea (Degeer, 1774)	0	55	55	3.60
Anchomenus dorsalis (Pontoppidan, 1763)	20	25	45	2.94
Anisodactylus binotatus (Fabricius, 1787)	0	7	7	0.46
Anisodactylus signatus (Panzer, 1797)	0	13	13	0.85
Bembidion quadrimaculatum (L., 1761)	0	2	2	0.13
Brachinus crepitans (L., 1758)	0	1	1	0.06
Brachinus explodens Duftschmid, 1812	2	46	48	3.14
Brachinus ganglbaueri Apfelbeck,1904	0	6	6	0.39
Brachinus sclopeta (Fabricius,1792)	0	100	100	6.54
Calathus fuscipes (Goeze, 1777)	20	293	313	20.46
Calathus melanocephalus (L., 1758)	2	3	5	0.33
Calathus rubripes Dejean, 1831	0	1	1	0.06
Calathus sp.	0	2	2	0.13
Carabus germari fiorii Born, 1901	6	1	7	0.46
Chlaeniellus nitidulus (Schrank, 1781)	0	1	1	0.06
Harpalus affinis (Schrank, 1781)	0	169	169	11.05
Harpalus anxius (Duftschmid,1812)	0	2	2	0.13
Harpalus dimidiatus (Rossi, 1790)	0	1	1	0.06
Harpalus distinguendus (Duftschmid, 1812)	0	4	4	0.26
Harpalus honestus (Duftschmid, 1812)	2	1	3	0.20
Harpalus rufipalpis Sturm, 1818	0	1	1	0.06
Harpalus tardus (Panzer, 1796)	0	2	2	0.13
Lebia humeralis Dejean, 1825	0	1	1	0.06
Metallina properans (Stephens, 1828)	0	12	12	0.78
Ophonus azureus (Fabricius, 1775)	0	1	1	0.06
Parophonus maculicornis (Duftschmid, 1812)	2	1	3	0.20
Phonias strenuus (Panzer, 1796)	0	2	2	0.13
Poecilus cupreus (L., 1758)	2	82	84	5.50
Pseudoophonus griseus (Panzer, 1797)	2	48	50	3.27
Pseudoophonus rufipes (Degeer, 1774)	138	416	554	36.21
Stenolophus teutonus (Schrank, 1781)	6	10	16	1.05
NOT CLASSIFIED (damaged specimens)	0	0	0	0
TOTAL	206	1326	1530	100

The highest number of specimens was in farm BIO1 and the lowest was in the conventional one (Table 3-5). This was much more noticeable in 2004 than in the previous year. The record heat wave that affected many parts of Europe in summer of 2003, exceptional both for temperatures and precipitations (Beniston and

Table 5. CONV: Ground beetles species recorded, distribution and relative percentage.

Species	First year	Second year	Total	Relative %
Abax continuus Baudi, 1876	8	3	11	2.74
Amara aenea (Degeer, 1774)	0	15	15	3.74
Amara familiaris (Duftschmid, 1812)	0	1	1	0.25
Amara similata (Gyllenhal, 1810)	0	20	20	4.99
Anchomenus dorsalis (Pontoppidan, 1763)	0	4	4	1.00
Bembidion quadrimaculatum (L., 1761)	10	2	12	2.99
Brachinus sclopeta (Fabricius,1792)	0	6	6	1.50
Carabus germari fiorii Born, 1901	0	1	1	0.25
Chlaeniellus nitidulus (Schrank, 1781)	4	2	6	1.50
Clivina fossor (L., 1758)	0	1	1	0.25
Diachromus germanus (L., 1758)	0	9	9	2.23
Harpalus affinis (Schrank, 1781)	108	56	164	40.90
*Harpalus anxius (*Duftschmid,1812)	2	0	2	0.50
Harpalus distinguendus (Duftschmid, 1812)	16	0	16	3.99
Metallina properans (Stephens, 1828)	4	2	6	1.50
Pseudoophonus griseus (Panzer, 1797)	2	2	4	1.00
Pseudoophonus rufipes (Degeer, 1774)	74	17	91	22.69
Stenolophus teutonus (Schrank, 1781)	0	13	13	3.24
NOT CLASSIFIED (damaged specimens)	10	9	19	4.74
TOTAL	238	163	401	100

Diaz, 2004; Sparnocchia *et al*., 2006) (Fig.1 and 2), could have affected the catches.

Because of climatic changes between years, biodiversity analyses were performed for each year and throughout the observation period to determine whether the observed relationships were constant over two consecutive years. The result is that all the indexes were quite similar in the two-year observation (Table 8) and all values were typical of disturbed habitats.

Margalef index is always higher in biological farms. This index confirms the small number of specimens detected in the conventional one. Indices such as Shannon's (D) and Simpson's (H') are affected by high levels of dominance of the commonest species, especially in biological farms.

Many Formicidae and Arachnidae were also found in pitfall traps.

The number of ants was strictly dependent on the proximity of a nest. Table 9 lists the species detected in three farms.

They were all common species except for *Hypoponera eduardi* (Forel 1894), a hypogeous micro-arthropod predator which is quite rare in Italy, and for *Paratrechina* sp., a genus not present yet in Italy, with exotic origins (Rigato F. personal communication).

A total of 917 Arachnida belonging to the order of Araneae were captured (Table 10). The major part of the specimens belonged to Linyphiidae, Lycosidae, and Gnaphosidae.

Table 6. Feeding regime of adult Carabidae detected

Species	Feeding Group
A. continuus	polyphagous predator (Brandmayr *et al.*, 2005).
Am. aenea	predomin. granivorous (in Holland, 2002; Martinkova *et al.*, 2006); polyphagous (Brandmayr *et al.*, 2005).
Am. familiaris	predomin. granivorous (in Holland, 2002; Martinkova *et al.* 2006); polyphagous (Brandmayr *et al.*, 2005).
Am. similata	predomin. granivorous (in Holland, 2002; Martinkova *et al.* 2006); polyphagous (Brandmayr *et al.*, 2005).
Anch. dorsalis	generalist carnivorous (Brandmayr *et al.*, 2005).
Ani. binotatus	predomin. granivorous (Martinkova *et al.,*2006).
Ani. signatus	predomin. granivorous (Martinkova *et al.,*2006).
B. quadrimaculatum	generalist insectivorous (in Holland, 2002).
Brach. crepitans	zoophagous (Celano and Hansen; 1998).
Brach. explodens	zoophagous (Celano and Hansen; 1998).
Brach. ganglbaueri	zoophagous (Celano and Hansen; 1998).
Brach. sclopeta	zoophagous (Celano and Hansen; 1998).
C. fuscipes ssp. *latus*	generalist insectivorous (in Holland, 2002).
C. melanocephalus	generalist insectivorous (in Holland, 2002).
C. rubripes	generalist insectivorous (in Holland, 2002).
Car. germari fiorii	polyphagous predator - mollusc feeder (in Holland, 2002; Brandmayr *et al.*, 2005).
Chlae. nitidulus	no information detected. Presumably polyphagous predator.
Cliv. fossor	polyphagous predator (in Holland, 2002).
D. germanus	phytozoophagous (Celano and Hansen, 1998).
H. affinis	predomin. granivorous (in Holland, 2002; Martinkova *et al.*, 2006); zoospermophagous (Brandmayr et al., 2005).
H. anxius	predomin. granivorous (in Holland, 2002; Martinkova *et al.*, 2006), zoospermophagous (Brandmayr *et al.*, 2005).
H. dimidiatus	predomin. granivorous (in Holland, 2002; Martinkova *et al.*, 2006); zoospermophagous (Brandmayr *et al.*, 2005).
H. distinguendus	predomin. granivorous (in Holland, 2002; Martinkova *et al.*, 2006); zoospermophagous (Brandmayr *et al.*, 2005).
H. honestus	predomin. granivorous (in Holland, 2002; Martinkova *et al.*, 2006); polyphagous (Brandmayr *et al.*, 2005).
H. rufipalpis	predomin. granivorous (in Holland, 2002; Martinkova *et al.*, 2006); polyphagous (Brandmayr *et al.*, 2005).
H. tardus	predomin. granivorous (in Holland, 2002; Martinkova *et al.*, 2006); zoospermophagous (Brandmayr *et al.*, 2005).
L. humeralis	predator polyphagous? (Brandmayr *et al.*, 2005).
M. properans	predator polyphagous? (Brandmayr *et al.*, 2005).

(Table 6 continued)

Micr. fissuralis	no information detected. Congeneric species zoophagous (Celano and Hansen, 1998).
Micr. minutulus	insectivorous (Kiss *et al.*, 1998).
O. azureus	predomin. granivorous (Martinkova *et al*., 2006); granivorous (Brandmayr *et al.*, 2005).
P. maculicornis	phytozoofagous (Celano and Hansen, 1998).
Pho. strenuus	predator polyphagous (Celano and Hansen, 1998).
Poe. cupreus	opportunistic feeder - depending on the season (in Holland, 2002).
Pseudo. griseus	predomin. granivorous (Martinkova *et al.*, 2006).
Pseudo. griseus	predomin. granivorous (Martinkova *et al.*, 2006).
Pseudo. rufipes	opportunistic feeder - depending on the season (in Holland, 2002); predomin. granivorous (Martinkova *et al.*, 2006); polyphagous (Brandmayr *et al*., 2005).
Pter. (Feronidius) melas ssp. italicus	predator polyphagous (Molinari *et al*., 1989).
S. teutonus	predomin. granivorous (Martinkova *et al.*, 2006).
T. quadristriatus	generalist insectivorous (in Holland, 2002).

Among these families, wolf spiders Lycosidae have short-distance dispersal, and their influence is strictly related to the habitat in which they were detected. On the other hand, Linyphiidae have long-distance dispersal (ballooning dispersal) because they can be transported in air currents. Ballooning in spiders is effective in habitat recolonization.

The dominant species was *Trochosa ruricola* (De Geer, 1778). In BIO2, the presence of *Zodarium gallicum* (Simon, 1873) (Zodaridae) and *Dysdera crocota* C.L.Koch, 1839 (Dysderidae) was indicative of the abundance of phytosaprophagous species related to the organic fertilization adopted.

Among the species of spiders detected, three were new for Lombardy: *Meioneta gulosa* (L. Koch, 1869) (Linyphiidae); *Tallusia experta* (O.P. Cambridge, 1871) (Linyphiidae); and *Zelotes tenuis* (L. Koch 1866) (*Z. circumspectus*) (Gnaphosidae).

DISCUSSION

The results obtained from this two-year study are a photograph of three different horticultural farms in Lombardy. It is difficult to evaluate if differences in composition and abundance are determined by the cultivation system adopted. Both biological and conventional agroecosystems are composed by a juxtaposition of temporary crops separated by different kinds of small uncultivated habitats which, in biological market gardens are all distributed all over the farm, and in conventional are only outside the farm. In the conventional farm, insecticide and weeding may have affected carabid density and richness and may have altered community composition. It is evident that in

Table 7. Distribution of the species in dominant rate categories.

	BIO1	BIO2	CONV
Eudominant	*Pseudo. rufipes.*	*C. fuscipes; H. affinis;* *Pseudo. rufipes.*	*H. affinis;* *Pseudo. rufipes.*
Dominant	*A. continuus;* *C. fuscipes;* *Poe. cupreus.*	*B. sclopeta;* *Poe. cupreus*	
Subdominant	*Anch. dorsalis;* *Brac. sclopeta.*	*Am. aenea; A .dorsalis;* *Brac. explodens;* *Pseudo. griseus.*	*Ab. continuus;* *Am. aenea;* *Am. familiaris;* *B. quadrimaculatum;* *D. germanus;* *H. distinguendus;* *S. teutonus.*
Recedent	*H. affinis;* *H. dimidiatus.*	*A. continuus;* *S. teutonus.*	*A. dorsalis;* *Brac. sclopeta;* *Chlae. nitidulus;* *M. properans;* *Pseudo. griseus.*
Subrecedent	*Am. aenea;* *B. quadrimaculatum;* *Brach. explodens;* *Brach. sclopeta;* *Brach. ganglbaueri;* *Chlae. nitidulus;* *Cliv. fossor;* *D. germanus;* *H. anxius;* *H. flavicornis;* *M. properans;* *Micr. fissuralis;* *Micr. minutulus;* *O. azureus;* *P. maculicornis;* *Pter. melas;* *S. teutonus;* *T. quadristriatus.*	*Ani. binotatus;* *Ani. signatus;* *B. quadrimaculatum;* *Brach. crepitans;* *Brach. ganglbaueri;* *C. melanocephalus;* *C. rubripes;* *Car. germari fiorii;* *Chlae. nitidulus;* *H. anxius;* *H dimidiatus;* *H distinguendus;* *H. honestus;* *H. rufipalpis ;* *H. tardus;* *L. humeralis;* *M. properans;* *O. azureus;* *P. maculicornis;* *Pho. strenuus.*	*Am. familiaris;* *Car. germari fiorii;* *Cli. fossor;* *H. affinis.*

biological farms, however, there is a higher agroecosystem complexity which maintains undisturbed vegetative refuge habitats such as grasslands, hedgerows, field margins, and grassy strips within the fields, which provide alternative foods, such as preys or grains and overwintering sites. On the other hand, organic farms are more often characterized by a higher disturbance of soil because the physical practices, used to contrast some weeds, can act against pre-imaginal and imaginal ground beetle stages.

Table 8. Biodiversity indexes.

		Margalef	Simpson	Shannon	Eveness
		Mg	**D**	**H'**	**J'**
First year	BIO1	1.90	0.46	1.28	0.51
	BIO2	1.89	0.47	1.27	0.53
	CONV	1.47	0.34	1.39	0.63
Second year	BIO1	3.27	0.41	2.10	0.50
	BIO2	4.10	0.20	2.14	0.62
	CONV	2.99	0.18	2.10	0.76
Total	BIO1	3.75	0.42	1.54	0.47
	BIO2	5.18	0.20	2.10	0.57
	CONV	4.17	0.23	1.86	0.64

Table 9. Formicidae in pitfall traps.

Subfamily	Species	Farm		
		BIO1	**BIO2**	**CONV**
Formicinae	*Formica (Serviformica) cunicularia* Latreille, 1798	x	x	x
	Lasius emarginatus (Olivier, 1791)		x	
	Lasius fuliginosus (Latreille, 1798)		x	
	Lasius niger (Linnaeus, 1758)	x	x	x
	Paratrechina sp	x		
Myrmicinae	*Temnothorax unifasciatus* (Latreille, 1798)	x	x	
	Myrmica rubra (Linnaeus, 1758)	x	x	
	Myrmica sabuleti Meinert, 1860	x	x	
	Myrmica specioides Bondroit, 1918	x	x	
	Solenopsis fugax (Latreille, 1798)		x	
	Temnothorax nylanderi (Förster, 1850)	x		
	Tetramorium caespitum (Linnaeus, 1758)		x	x
Ponerinae	*Hypoponera eduardi* (Forel, 1894)	x	x	
	Ponera coarctata (Latreille, 1802)			x

Low differences among farms emerged from the diversity indexes in the same year. They might be due to a real similarity or to a periodic recolonization of the habitats. Thus, ground beetles are strictly linked to the heterogeneity of the surrounding area which can act as a source of diversity for farmland carabids (Hance *et al.*, 1990; Asteraki *et al.*, 1995), especially for species that use multiple habitats during their lifetime, offering refuges and corridors for beetles dispersing between and across fields.

Table 10. Araneae in pitfall traps.

Family	Species	Farm		
		BIO1	BIO2	CONV
Agelenidae	Undetermined Agelenidae	1	0	0
Araneidae	Undetermined Araneidae	0	0	1
Clubionidae	*Clubiona brevipes* Blackwall, 1841	0	0	1
Dysderydae	*Dysdera crocata* C.L. Koch, 1838	0	12	0
	Dysdera erythrina (Walckenaer, 1802)	0	1	0
	Other undetermined Dysderydae	3	1	1
Gnaphosidae	*Drassyllus pumilus* (C.L. Koch, 1839)	0	4	0
	Micaria pulicaria (Sundevall 1831)	9	17	1
	Micaria sp.	7	0	0
	Zelotes exiguus (Müller & Schenkel , 1895)	4	0	0
	Zelotes hermani (Chyzer, 1897)	1	0	0
	Zelotes tenuis (L. Koch, 1866)	9	6	0
	Zelotes sp.	2	0	0
	Other undetermined Gnaphosidae	5	13	0
Hahniidae	*Hahnia helveola* Simon, 1875	2	0	0
Linyphiidae	*Bathyphantes parvulus* (Westring, 1851)	1	0	0
	Centromerus sylvaticus (Blackwall, 1841)	0	1	0
	Ceratinella brevis (Wider, 1834)	0	1	0
	Diplocephalus alpinus (O. P.-Cambridge, 1872)	1	0	0
	Diplostyla concolor (Wider, 1834)	17	1	0
	Eperigone trilobata (Emerton, 1882)	1	0	0
	Erigone autumnalis Emerton, 1882	1	1	0
	Erigone dentipalpis (Wider, 1834)	2	4	4
	Erigone vagans (Audouin, 1826)	0	1	1
	Frontinellina frutetorum (C.L. Koch,1834)	0	0	1
	Lepthyphantes flavipes (Blackwall, 1854)	11	0	1
	Lepthyphantes pallidus (O. P.-Cambridge, 1871)	3	6	0
	Lepthyphantes sp.	1	4	0
	Meioneta gulosa (C.L. Koch, 1869)	0	0	1
	Meioneta mollis (O. P.-Cambridge, 1871)	1	1	0
	Meioneta rurestris (C.L.Koch, 1836)	7	6	2
	Micrargus subaequalis (Westring, 1851)	2	0	0
	Nematogmus sanguinolentus (Walckenaer, 1842)	3	2	0
	Oedothorax apicatus (Blackwall, 1850)	0	0	24
	Oedothorax retusus (Westring ,1851)	0	0	7
	Porrhomma pygmaeus (Blackwall, 1834)	0	0	1

(Table 10 continued)

	Tallusia experta (O. P.-Cambridge, 1871)	1	0	0
	Other undetermined Linyphiidae	1	2	2
Liocranidae	*Apostenus fuscus* Westring, 1851	0	0	1
	Phrurolithus festivus (C.L. Koch, 1835)	31	7	1
	Phrurolithus minimus C.L. Koch, 1839	4	2	0
	Phrurolithus sp.	9	0	3
Lycosidae	*Alopecosa* sp	0	1	1
	Arctosa leopardus (Sundevall, 1833)	1	1	51
	Hogna radiata (Latreille, 1817)	0	4	0
	Pardosa agrestis (Westring, 1851)	6	2	0
	Pardosa hortensis (Thorell, 1872)	1	13	0
	Pardosa monticola (Clerck, 1758)	0	1	0
	Pardosa proxima (C.L. Koch, 1847)	5	14	4
	Pardosa sp	1	4	2
	Pirata latitans (Blackwall, 1841)	1	0	0
	Trochosa ruricola (De Geer, 1778)	139	174	51
	Xerolycosa nemoralis (Westring, 1861)	0	4	0
	Other undetermined Lycosidae	1	2	5
Oxyopidae	*Oxyopes lineatus* Latreille, 1806	0	0	1
	Philodromus sp.	0	0	1
Philodromidae	*Tibellus oblongus* (Walckenaer, 1802)	4	0	0
Salticidae	*Euophrys frontalis* (Walckenaer, 1802)	2	1	0
	Euophrys sp.	0	1	0
	Heliophanus sp.	0	0	3
	Heliophanus cupreus (Walckenaer,1802)	0	1	0

AKNOWLEDGMENT

The authors are very grateful to Dr. Fabrizio Rigato and Dr. Carlo Pesarini (Museo Civico di Storia Naturale di Milano), respectively, for Formicidae and Araneae classification. Also, gratitude is extended to Dr. Luca Casagrande (Ersaf - Ente Regionale Servizi Agricoltura e Foreste) for the meteorological data.

REFERENCES

Asteraki, E.J., Hanks, C.B., Clements, R.O., 1995 - The influence of different types of grassland field margin on carabid beetle (Coleoptera: Carabidae) communities. - Agric. Ecosyst. Environ. 54: 195-202.

AUDISIO P., 2002. - Nitidulidae. In: MASON F., CERRETTI P., TAGLIAPIETRA A., SPEIGHT M.C.D., ZAPPAROLI M. (eds.).- Invertebrati di una foresta della Pianura Padana, Bosco della Fontana, Primo contributo. - Conservazione Habitat Invertebrati 1. G. Arcari ed., Verona: 82-86.

BENISTON M., DIAZ H. F., 2004 - The 2003 heat wave as an example of summers in a greenhouse climate? Observations and climate model simulations for Basel, Switzerland. - Global Planet. Change, 44: 73-81.

BLAKE S., FOSTER G.N., EYRE M.D., LUFF M.L., 1994 - Effects of habitat type and grassland management practices on the body size distribution of carabid beetles. - Pedobiologia 38: 502-512.

BOMMARCO R., 1998 - Reproduction and energy reserves of a predatory carabid beetle relative to agroecosystem complexity. - Ecol. Appl., 8: 846-853.

BRANDMAYR P., 1980 - Entomocenosi come indicatori delle modificazioni antropiche del paesaggio e pianificazione del territorio: esempi basati sullo studio di popolamenti a Coleotteri Carabidi. - Atti XII Congr. Naz. Ital. Entomol., Roma: 263-283.

BRANDMAYR P., PIZZOLOTTO R., 1994 - I Coleotteri Carabidi come indicatori delle condizioni dell'ambiente ai fini della conservazione. - Atti XVII Cong. Naz. It. Entom., Udine: 439-444

BRANDMAYR P., ZETTO T., PIZZOLOTTO R., 2005 - I Coleotteri Carabidi per la valutazione ambientale e la conservazione della biodiversità. Manuale operativo 34 - APAT, Agenzia per la protezione dell'ambiente e per i servizi tecnici, Roma: 240 pp.

BRIGGS J.B., 1965 - Biology of some ground beetles (Col. Carabidae) injurious to strawberries. - Comm. Agric. Bur.: 79-93.

CASALE A., STURANI M., VIGNA TAGLIANTI A., 1982 - Fauna d'Italia. Coleoptera Carabidae I. Vol XVIII.- Calderini, Bologna: 499 pp.

CELANO V., HANSEN H.D., 1998 - La carabidofauna e l'aracnofauna di una bonifica della laguna di Venezia. - Boll. Mus. Civ. St. Nat. Venezia, 49 (1998) 1999: 55-97.

CLARK S., SZLWECZ K., CAVICELLI M., PURRINGTON F., 2006 - Ground beetle (Coleoptera: Carabidae) Assemblages in Organic, No-Till, and Chisel-till Cropping system in Maryland. - Environ Entom: 304-312.

FACCHINI S., 2001 - I Coleotteri Carabidi negli agroecosistemi della Pianura Padana. - Ann. Mus. Civ. St. Nat. Ferrara, 4: 65-104.

HANCE T., GREGUARIE-WIBO C., LEBRUN P., 1990 - The consequence of crop types and surrounding habitats on activity and species composition. - Pedobiologia, 34: 337-346.

HOLLAND J.M., 2002 - The agroecology of Carabid beetles. - Andover, Hampshire UK: 1-356.

HOLLAND J.M., REYNOLDS C.J.M., 2003 - The impact of soil cultivation on arthropod (Coleoptera and Araneae) emergence on arable land. - Pedobiologia, 47: 181-192.

JENSEN T.S., DYRING L., KRISTENSEN B., NIELSEN B.O., RASMUSSEN E.R., 1989 - Spring dispersal and summer habitat distribution of *Agonum dorsale* (Coleoptera, Carabidae). - Pedobiologia, 33: 155-165.

KISS J., KADAR F., TOTH F., BARTH R., HATVANI A., 1998 - Predatory arthropods sampled in pitfall traps in winter wheat in northern Hungary. - Bull. OILB/SROP, 21 (8): 81-90.

KROMP, B., 1999 - Carabid beetles in sustainable agriculture: a review on pest control efficacy, cultivation impact and enhancement in agriculture - Ecosyst. and Environ, 74: 187-228.

LORENZ W., 2005 - Systematic list of extant ground beetles of the world. Insecta Coleoptera "Geadephaga": Trachypachidae and Carabidae incl. Paussinae, Cicindelinae, Rhysodinae. Second edition. - Lorenz, Tutzing (Germany): 530 pp.

LUPI D., COLOMBO M., ZANETTI A., 2006 - The rove beetles (Coleoptera Staphylinidae) of three horticultural farms in Lombardy (Northern Italy). - Boll. zool Agr. e Bachic, ser II, 38 (2): 143-165.

MAGISTRETTI M., 1965 - Fauna d'Italia. Coleoptera, Cicindelidae, Carabidae. Vol VIII. - Calderini, Bologna: 512 pp.

MARTINKOVÁ Z., SASKA P., HONEK A., 2006 - Consumption of fresh and buried seed by ground beetles (Coleoptera: Carabidae). - Eur. J. Entomol., 103: 361-364.

MOLINARI F., CRAVEDI P., SPADA G., 1989 - Studi sulle popolazioni di coleotteri carabidi in pescheti dell'Italia settentrionale. - Frustula Entomologica, 12: 15-33.

SPARNOCCHIA S., SCHIANO M. E., PICCO P., BOZZANO R., CAPPELLETTI A., 2006 - The anomalous warming of summer 2003 in the surface layer of the Central Ligurian Sea (Western Mediterranean). - Ann. Geophys., 24: 443-452.

THIELE H.U., 1977 - Carabid beetles in their environment. - Springer -, Berlin Heidelberg: 369 pp.

TUOVINEN T., KIKAS A., TOLONEN T., KIVIJÄRVI P, 2006 - Organic Mulches vs. black plastic in organic strawberry: does it make a difference for ground beetles (Col., Carabidae). - J. Appl. Entomol., 130 (9-10): 495-503.

VIGNA TAGLIANTI A., 1993 - Coleoptera Archostemata, Adephaga I (Carabidae). In: MINELLI A., RUFFO S., LA POSTA S. (eds.) Checklist delle specie della fauna italiana, 44. - Calderini, Bologna: 51 pp.

PROF. MARIO COLOMBO, DR. DANIELA LUPI - Istituto di Entomologia agraria, Università degli Studi di Milano, Via Celoria 2, I-20133 Milano (Italy). E-mail: mario.colombo@unimi.it daniela.lupi@unimi.it

DR. SERGIO FACCHINI - Via Prati, 12, I-29100 Piacenza (Italy). E-mail: sfacchini@virgilio.it
All authors contributed equally to the paper.

Accepted 20 July 2007