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The rove beetles (Coleoptera Staphylinidae) of three horticultural farms in Lombardy (Northern Italy) (*)

Abstract - Rove beetles (Staphylinidae) were surveyed across three horticultural farms, inserted in a peri-urban contest, in the Po plain in Lombardy (Northern Italy) from April 2003 to March 2005. Their biodiversity was estimated using pitfall traps. A total of 1341 specimens, 45 genera and 76 species were collected during the survey. Most of the species detected have already been recorded as frequent in other European agricultural fields. The rove beetle assemblage displayed the dominance of *Drusilla canaliculata* (Fabricius, 1787), *Atheta aeneicollis* (Sharp, 1869), *Atheta triangulum* (Kraatz, 1856) and *Omalium caesum* Gravenhorst, 1806, contributing to over half of the total number of the specimens detected. Land use seemed to have a significant effect on the number and composition of the species.

Riassunto - *I Coleotteri Stafilinidi di tre aziende orticole lombarde*.
Sono illustrati i risultati di un'indagine condotta dall'aprile 2003 al marzo 2005 volta a stimare la composizione dei Coleotteri Stafilinidi di tre aziende orticole, situate in un contesto periubano della Pianura Padana. Nel corso dell'indagine sono stati raccolti 1341 esemplari, ripartiti in 45 generi e 76 specie. La maggior parte delle specie censite sono risultate spesso legate ad ambienti agrari europei. *Drusilla canaliculata* (Fabricius, 1787), *Atheta aeneicollis* (Sharp, 1869), *Atheta triangulum* (Kraatz, 1856) e *Omalium caesum* Gravenhorst, 1806, da sole, rappresentano più della metà degli esemplari catturati. Dai risultati ottenuti sono emerse alcune indicazioni sull'influenza della tecnica colturale adottata sul numero e sulla composizione delle specie presenti.

Key words: bioindicators, rove beetles, agricultural crops, pitfall traps, land management

INTRODUCTION

The Staphylinidae is one of the largest families of the order Coleoptera, comprising more than 45000 species from all zoogeographical regions of the world (Herman, 2001).

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More than 2300 species are known from Italy (Ciceroni *et al.*, 1995), if Pselaphinae are included (Poggi & Sabella, 2005).

Rove beetles can be considered biological indicators of the environmental status, particularly of the human influence on ecosystems because of their immense diversity, not only in species, but also in potential habitats and feeding habits (Buse & Good, 1993; Bohac, 1999). Many of them are known as generalist predators, feeding on various soil inhabitants such as nematodes, mites, collembola, small immature insect and larvae, etc. (Mank, 1923).

Many live in the soil of all ecosystems both in natural and managed landscapes. A large number of species are associated with temporary habitats (fungi, dung, carrions), as predator but also as saprophagous. Wetlands are also inhabited by large numbers of ripicolous species along fresh waters and sea sides. Several species live in peculiar microhabitats such as nests of mammals, birds and social insects, in tree holes, under barks, on flowers as pollen feeders, and in human habitations.

Although there are many investigations on Carabid beetles as bioindicators (Brandmayr & Pizzolotto, 1994; Holland, 2002; Rainio & Niemela 2003; Purtauf *et al.*, 2005), few are on Staphylinidae. However, according to Bohac (1999), the number of rove beetles is often higher than that of ground beetles in farming areas and their abundance in some biotopes can be 15 times greater than that of ground beetles. Besides, there is a growing literature about non-target effects of chemical pesticides on Staphylinidae in agricultural crops (Krooss & Schaefer, 1998; Gyldenkǽrne *et al.,* 2000), to the point that *Aleochara bilineata* (Gyllenhal) (a beneficial species) has become a favoured test animal for the effects of insecticides, herbicides, and plant-growth regulators (Samsøe-Petersen, 1987; 1993; 1995). The destruction of natural habitat by humans, undoubtedly contributes to the rarity of many poorly-known staphylinid species, mostly if associated to peculiar microhabitats such as tree holes occupied by nests of birds. Clearly, agroecosystems are altered, but different agricultural practices can have different effects on the arthropods living in them.

The present study has the purpose to improve the knowledge on the structure of taxocenosis of the Staphylinidae which, since now, has only been studied in two agroecosistem near Verona (Veneto Region, Northern Italy) (Daccordi & Zanetti, 1987; 1989) and to begin evaluating the function of each species in the perspective of bioindication.

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 conventionally managed. The others (BIO1 and BIO2) are respectively in Torre Boldone (Bergamo province) and in Cernusco sul Naviglio (Milan province) and biologically managed, according to European Community law N. 2092/91.

They are all small farms inserted in a fragmented peri-urban contest, close to towns with highway and bypass nearby; and water supplied by canals. 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. Farm CONV borders with the town and cereal cultivated fields. More characteristic of each farm are listed in Table 1.

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

Sampling

Rove beetles were surveyed from April 2003 through 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 the four cardinal side of each farm, between tunnel in uncultivated strips of land. They were

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	Aromatic plants	Aromatic plants
	Blackberry	Blackberry	Blackberry
	Cherry laurel	Cherry laurel	Cherry laurel
Chemical plant protection	According to official recommendation Weed control	No chemical protection No weed control	No chemical protection No weed control

(*) map datum WGS84.

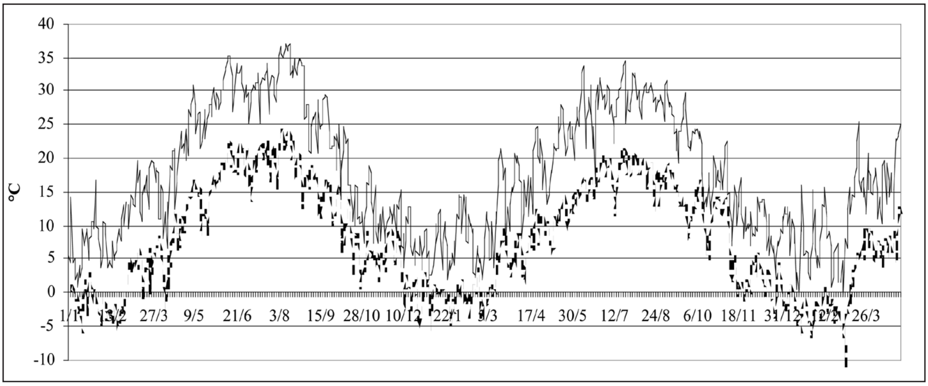

Fig. 1 - Minimum and maximum temperature in the whole period of study. (Data from Stezzano - Bergamo province, provided by Ersaf - Ente Regionale Servizi Agricoltura e Foreste).

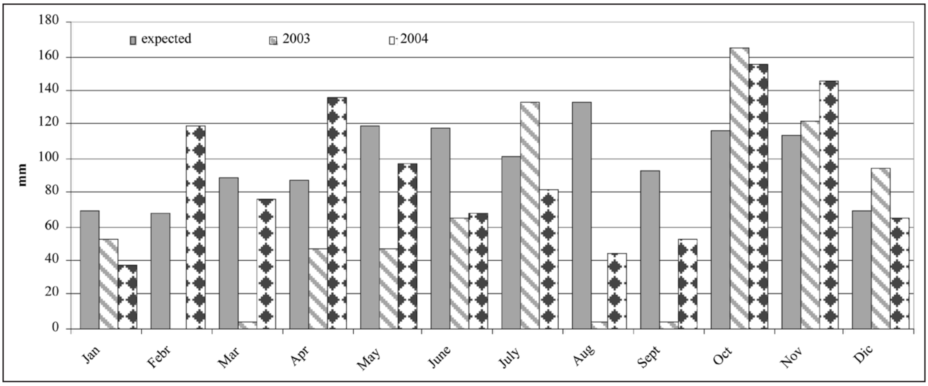

Fig. 2 - Rain effective and expected (data calculated over a 30 year period) in 2003 and 2005 (Data from Stezzano –Bergamo province, provided by Ersaf - Ente Regionale Servizi Agricoltura e Foreste).

examined fortnightly from April through October and monthly from November to March. A total of 324 lot of samples were examined.

Samples were washed through a fine aquarium sieve in the laboratory. Adult Staphylinidae were separated and identified to species level and sorted to trophic groups according to their feeding type and to ecological groups according to their macro and microhabitat preferences.

The systematic nomenclature of Smetana (2004) is adopted. Division in subfamilies is the one of Newton and Thayer (1992). Samples were also compared with the ones in Zanetti’s private collection.

Analysis

To calculate the biodiversity of rove beetles, 4 diversity indexes were used: Margalef (Mg) (Margalef, 1968); Simpson (D and 1-D) (Simpson, 1949); Shannon-Wiener (H') (Shannon & Wiener, 1963); and Sørensen Similarity (s) (used to evaluate differences of the paired farms).

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

A total of 1341 specimens were captured. Among them 1312 were classified and 29 discarded because damaged and no suitable for classification. A total of 45 genera and 76 species were collected during the survey (Table 2-3) distributed in the farms as in Table 4-5-6.

Each species has been grouped in function of its autoecology with particular reference to the habitat (Table 7). This approach is fundamental because the great ecological range of Staphylinidae allows species with low interactions to share the same habitat without competition for food and spaces. Each species was further associated to its feeding group. The result was that 92.68% of the specimen is represented by predators, 5.65% by saprophagous species, 0.76% by probably saprophagous species, 0.76% by parasitoids (*Aleochara*) and 0.15% by algae eater.

The most common staphylinid species (eudominant species) are *Drusilla canaliculata* (Fabricius, 1787), *Omalium caesum* Gravenhorst, 1806, *Atheta aeneicollis* (Sharp, 1869), and *Atheta triangulum* (Kraatz, 1856) (Table 8). They are all predators and they contribute to over half of the total number of the specimens detected (53.74%).

Table 2 - Rove beetles caught in the three farms.

	First year		**Second year**		**Total**	
	Samples	**N° of species**	**Samples**	**N° of species**	**Samples**	**N° of species**
BIO1	280	19	462	39	742	44
BIO2	242	23	266	47	508	53
CONV	40	9	51	22	91	25
TOTAL	562		779		1341	
Different species		29		65		76

Table 3 - Species recorded and relative percentage in the whole period of study.

	Total	**Relative %**
Aleocharinae		
Aleochara meshniggi Bernhauer, 1943	2	0.152
Aleoch. sparsa Heer, 1839	1	0.076
Aleoch. spissicornis Erichson, 1839	7	0.534
Aloconota gregaria (Erichson, 1939)	2	0.152
Amarochara forticornis Quedenfeldt, 1882	2	0.152
Anaulacaspis nigra (Gravenhorst, 1802)	2	0.152
Atheta (Atheta) aeneicollis (Sharp, 1869)	108	8.232
Ath. (Atheta) triangulum (Kraatz, 1856)	47	3.582
Ath. (Bessobia) occulta (Erichson, 1837)	1	0.076
Ath. (Dimetrota) atramentaria (Gyllenhal, 1810)	2	0.152
Ath. (Mix. gr. I) *coriaria* (Kraatz, 1856)	2	0.152
Ath. (Mix. gr. I) *crassicornis* (Fabricius, 1792)	1	0.076
Ath. (Mix. gr. I) *oblita* (Erichson, 1839)	17	1.296
Ath. (Mix. gr. II) *trinotrata* (Kraatz, 1856)	3	0.229
Ath. (*Microdota*) *amicula* (Stephens, 1832)	23	1.753
Ath. (*Microdota*) sp.	30	2.287
Ath. (*Mocyta*) *orbata* (Erichson, 1837)	2	0.152
Ath. (*Philhygra*) *palustris* (Kiesenwetter, 1844)	9	0.686
Callicerus obscurus Gravenhorst, 1802	3	0.229
Cordalia obscura (Gravenhorst, 1802)	4	0.305
Dinaraea angustula (Gyllenhal, 1810)	5	0.381
Drusilla canaliculata (Fabricius, 1787)	468	35.671
Falagria caesa Erichson, 1837	3	0.229
F. sulcatula (Gravenhorst, 1806)	4	0.305
Falagria sp.	1	0.076
Falagrioma thoracica (Stephens, 1832)	36	2.744
Nehemitropia lividipennis (Mannerheim, 1831)	3	0.229
Oligota sp.	14	1.067
Oxypoda brevicornis (Stephens, 1832)	3	0.229
Oxyp. carbonaria (Heer, 1841)	1	0.076
Thamiaraea cinnamomea (Gravenhorst, 1802)	2	0.152
Zyras limbatus (Paykull, 1789)	24	1.829
Micropeplinae		
Micropeplus marietti Jacquelin du Val, 1857	1	0.076

(Table 3 continued)

	Total	Relative %
Omaliinae		
Anthobium a. atrocephalum (Gyllenhal, 1827)	1	0.076
Boreaphilus velox (Heer, 1839)	3	0.229
Omalium caesum Gravenhorst, 1806	82	6.250
Om. rivulare (Paykull, 1789)	14	1.067
Paraphloeostiba gayndahensis (MacLeay, 1871)	7	0.534
Oxytelinae		
Anotylus inustus (Gravenhorst, 1806)	11	0.838
Anot. rugosus (Fabricius, 1775)	9	0.686
Anot. sculpturatus (Gravenhorst, 1806)	11	0.838
Anot. tetracarinatus (Block, 1799)	23	1.753
Bledius gallicus (Gravenhorst, 1806)	1	0.076
Carpelimus corticinus (Gravenhorst, 1806)	1	0.076
Oxytelus sculptus Gravenhorst, 1806	2	0.152
Platystethus capito Heer, 1839	1	0.076
Platys. cornutus (Gravenhorst, 1802)	3	0.229
Platys. nitens (Sahlberg, 1832)	4	0.305
Paederinae		
Astenus immaculatus Stephens, 1833	1	0.076
Ast. lyonessius (Joy, 1908)	27	2.058
Paederus fuscipes Curtis, 1826	4	0.305
Paed. littoralis Gravenhorst, 1802	2	0.152
Rugilus orbiculatus (Paykull, 1789)	2	0.152
Scopaeus laevigatus (Gyllenhal, 1827)	1	0.076
Proteininae		
Megarthrus bellevoyei Saulcy, 1862	1	0.076
Proteinus ovalis Stephens, 1834	18	1.372
Staphylininae		
Astrapaeus ulmi (Rossi, 1790)	2	0.152
Gabrius sp.	2	0.152
Gyrohypnus fracticornis (O. Müller, 1776)	1	0.076
Ocypus olens (O. Müller, 1764)	112	8.537
Othius punctulatus (Goeze, 1777)	1	0.076
Phacophallus parumpunctatus (Gyllenhal, 1827)	2	0.152
Philonthus carbonarius (Gravenhorst, 1802)	1	0.076
Phil. tenuicornis Mulsant & Rey, 1853	6	0.457
Platydracus stercorarius (Olivier, 1795)	5	0.381

(Table 3 continued)

	Total	Relative %
Quedius ?curtipennis Bernhauer, 1908	3	0.229
Q. levicollis (Brullé, 1832)	28	2.134
Q. meridiocarpathicus Smetana, 1958	20	1.524
Tasgius winkleri (Bernhauer, 1906)	6	0.457
Xantholinus elegans (Olivier, 1795)	7	0.534
X. linearis (Olivier, 1795)	10	0.762
Tachyporinae		
Mycetoporus longulus Mannerheim, 1830	1	0.076
Tachinus corticinus Gravenhorst, 1802	1	0.076
Tach. subterraneus (Linnaeus, 1758)	6	0.457
Tachyporus atriceps Stephens, 1832	1	0.076
Tachyp. hypnorum (Fabricius, 1775)	4	0.305
Tachyp. nitidulus (Fabricius, 1781)	29	2.210
Tachyp. pusillus Gravenhorst, 1806	2	0.152
CLASSIFIED	1312	100
NOT CLASSIFIED (damaged specimens)	29	
TOTAL	1341	

In the present study, *D. canaliculata,* a predator very common and ubiquitous, covered 52.16% of samples in one biological farm (BIO1) and 15.95% of the other biological farm (BIO2) while it was never detected in the conventional one. Maximum number of captures was concentrated in summer (June and July 2003 and late August 2004).

Om. caesum covered 29% of the conventional farm and 4.5% in each biological farm. Maximum captures occurred in May and October in both years. It is a predator common in litter with wide ecological range, present both in woods and anthropic habitats, from the plain to very high altitude (Zanetti, 1987).

Ath. aeneicollis covered 15.35% of the farm BIO2, 4.18% of BIO1, and 3.37% of the conventional. *Ath. triangulum* was detected mostly in the conventional farm covering 14.61% of the catches. In biological farm BIO1, *Ath. triangulum* covered 3.23% and 2.07% in farm BIO2. Maximum captures of *Ath. aeneicollis* and *Ath. triangulum* were in May. *Ath. aeneicollis* and *Ath. triangulum* are saprophilous species widespread from the plains to middle altitude elevations (1000 m). They are both very common predator, but whereas *Ath. triangulum* is found mostly in decaying vegetable matters, *Ath. aeneicollis* is found mostly in fungi (Koch, 1989).

Aleochara meschniggi Bernhauer, 1943, a parasitoid of Diptera detected only once in both biological farms in 2004, is a surprising capture. These are the first records from agriculture habitats in the Po Plain. Most captures of this species in Italy were made in the woods in the Alps at various altitudes up to 2000 m above sea level (Zanetti, unpublished). The species is remarkable owing to the winter phenology of the adults, found often on the snow.

Among the others, *Paraphloeostiba gayndahensis* (MacLeay, 1871) found in both biological farms, is a remarkable species. First detected in Italy in 1987 (Zanetti, 2005), *P. gayndahensis* is native of Australia. The species is now distibuted all over Italy, from sea level to high altitude. Adults are found on decaying vegetable matter, often on fruits.

Due to climatic changes between years (2003 was an exceptional year for high temperatures and low precipitations as stated in Figs. 1 and 2), biodiversity analyses were performed for each year and for the whole period of observation, to see whether the observed relationships where constant over two consecutive years. The result is that all the indexes are quite similar in the two year of observations (Table 9). Margalef index is always higher in biological farms. This index confirm the small number of specimens detected in the conventional one. Simpson (1-D) and Shannon indexes are higher in farm BIO2 as they are affected by the high levels of dominance of *D. canaliculata* in both years in the other biological farm and by the presence of high dominance of *Om. caesum,* which represent the 55% of the specimen captured, in the first year of observation in the conventional farm.

Sørensen index (Table 10), which must be similar to 1 as much as the faunal set is similar, provides values lower than 0.6 in all the farms. It points out a major similarity between the biological farm. The greatest differences emphasized by this index are between the farm BIO2 and the conventional, especially during the first year, in which only *Ath. triangulum*, *Om. caesum*, *Pr. ovalis*, *Tachyp. nitidulus* were common to both. This means that these farms have a different rove beetle composition due to various small niches in which the rove beetles were able to develop.

DISCUSSION

Most of the species detected have already been recorded as frequent in other European agricultural fields (Obrtel, 1968; Daccordi & Zanetti, 1989; Krooss & Schaefer, 1998). Many of them live on decaying matters, as it is really simple to find fruit or vegetable abandoned on the soil in or on which they can develop.

Many of the species detected are good flyers (e.g., species of the genera *Oxytelus*, *Philonthus*, *Atheta*) and consequently, have high potential for recolonization of disturbed habitats. An exception is *D. canaliculata* which, despite very common especially in unforested biotopes, is apparently micropterous (Assing, 2005). Its dispersal capability is apparently great but the dispersal method is unknown.

Remarkable is the fact that in both biological farms the number of species detected is really higher than in the conventional one. There are also much more species linked to meadows or uncultivated lands which probably represent the bases of rove beetles repopulation in agroecosistem and which are mostly predators. In both BIO1 and BIO2 the presence of *Ocypus olens* (O. Müller, 1764), never detected in CONV, is symptomatic because this species don't tolerate agricultural practices like ploughing (Daccordi & Zanetti, 1989).

Table 4 - BIO1: species recorded, distribution and relative percentage.

	First year	**Second year**	**Total**	**Relative %**
Aleocharinae				
Aleochara meshniggi Bernhauer, 1943	0	1	1	0.135
Amarochara forticornis Quedenfeldt, 1882	0	2	2	0.270
Atheta (Atheta) aeneicollis (Sharp, 1869)	12	19	31	4.178
Ath. (Atheta) triangulum (Kraatz, 1856)	6	18	24	3.235
Ath. (Mix. gr. I) *coriaria*	0	2	2	0.270
Ath. (Mix. gr. I) *crassicornis* (Fabricius, 1792)	0	1	1	0.135
Ath. (Mix. gr. I) *oblita* (Erichson, 1839)	2	5	7	0.943
Ath. (Mix. gr. II) *trinotrata* (Kraatz, 1856)	0	1	1	0.135
Ath. (*Microdota*) sp.	0	15	15	2.022
Callicerus obscurus Gravenhorst, 1802	2	1	3	0.404
Dinaraea angustula (Gyllenhal, 1810)	0	5	5	0.674
Drusilla canaliculata (Fabricius, 1787)	124	263	387	52.156
Falagria sulcatula (Gravenhorst, 1806)	2	0	2	0.270
Falagrioma thoracica (Stephens, 1832)	32	4	36	4.852
Oligota sp.	0	1	1	0.135
Oxypoda brevicornis (Stephens, 1832)	0	2	2	0.270
Micropeplinae				
Micropeplus marietti Jacquelin du Val, 1857	0	1	1	0.135
Omaliinae				
Boreaphilus velox (Heer, 1839)	2	0	2	0.270
Omalium caesum Gravenhorst, 1806	20	14	34	4.582
Om. rivulare (Paykull, 1789)	0	3	3	0.404
Paraphloeostiba gayndahensis (MacLeay, 1871)	2	1	3	0.404
Oxytelinae				
Anotylus inustus (Gravenhorst, 1806)	2	3	5	0.674
Anot. sculpturatus (Gravenhorst, 1806)	0	10	10	1.348
Anot. tetracarinatus (Block, 1799)	0	4	4	0.539
Bledius gallicus (Gravenhorst, 1806)	0	1	1	0.135
Platystethus cornutus (Gravenhorst, 1802)	0	1	1	0.135
Platys. nitens (Sahlberg, 1832)	0	3	3	0.404
Paederinae				
Astenus immaculatus Stephens, 1833	0	1	1	0.135
Ast. lyonessius (Joy, 1908)	8	12	20	2.695
Rugilus orbiculatus (Paykull, 1789)	0	1	1	0.135

(Table 4 continued)

	First year	**Second year**	**Total**	**Relative %**
Proteininae				
Megarthrus bellevoyei Saulcy, 1862	0	1	1	0.135
Proteinus ovalis Stephens, 1834	6	3	9	1.213
Staphylininae				
Ocypus olens (O. Müller, 1764)	40	33	73	9.838
Platydracus stercorarius (Olivier, 1795)	0	1	1	0.135
Quedius ?curtipennis Bernhauer, 1908	2	0	2	0.270
Q. levicollis (Brullé, 1832)	2	0	2	0.270
Q. meridiocarpathicus Smetana, 1958	8	7	15	2.022
Tasgius winkleri (Bernhauer, 1906)	0	2	2	0.270
Xantholinus elegans (Olivier, 1795)	0	1	1	0.135
X. linearis (Olivier, 1795)	4	1	5	0.674
Tachyporinae				
Mycetoporus longulus Mannerheim, 1830	0	1	1	0.135
Tachinus subterraneus (Linnaeus, 1758)	0	1	1	0.135
Tachyporus atriceps Stephens, 1832	0	1	1	0.135
Tachyp. nitidulus (Fabricius, 1781)	4	14	18	2.426
NOT CLASSIFIED (damaged specimens)	0	1	1	0.135
TOTAL	280	462	742	100

However, species richness is the result of many factors, such as environmental diversity, soil cultivation, insecticide and herbicide treatment, differences of microclimatic conditions at the soil level, and influence of the surrounding biotopes. Landscape simplification in the conventional farm must have had a negative impact on the community of rove beetles. These insects in fact depend on a variety of habitats for food resources as well as for refuge and for overwintering sites and, probably, they could have been influenced by an inappropriate or excessive use of agricultural inputs (pesticides, nitrogen, phosphorous, raw organic matter containing undesirable residues such as heavy metals).

Semi natural habitats are important overwintering sites, particularly for potentially beneficial arthropods such as Staphylinidae. Frank and Reichhart (2004) established that the abundance of rove beetles and species richness of overwintering staphylinids continuously increased with age of the wildflower areas as predators may profit from undisturbed developmental conditions in these areas.

As stated by Holland and Reinolds (2003) cultivation may affect survival directly causing physical disruption, and indirectly by modifying the habitat and food availability. The practice of weeding near the cultivated strip in the conventional farm could have directly influenced the presence of some species living on soil surface and on vegetation. The same practice could have had an indirect effect on the presence of some predators

Table 5 - BIO2: species recorded, distribution and relative percentage.

	First year	**Second year**	**Total**	**Relative %**
Aleocharinae				
Aleochara meshniggi Bernhauer, 1943	0	1	1	0.197
Aleoch. sparsa Heer, 1839	0	1	1	0.197
Aleoch. spissicornis Erichson, 1839	0	7	7	1.378
Anaulacaspis nigra (Gravenhorst, 1802)	0	2	2	0.394
Atheta (Atheta) aeneicollis (Sharp, 1869)	56	18	74	14.567
Ath. (Atheta) triangulum (Kraatz, 1856)	10	0	10	1.969
Ath. (Bessobia) occulta (Erichson, 1837)	0	1	1	0.197
Ath. (Mix gr. I) *oblita* (Erichson, 1839)	2	8	10	1.969
Ath. (Mix gr. II) *trinotrata* (Kraatz, 1856)	0	2	2	0.394
Ath. (*Microdota*) *amicula* (Stephens, 1832)	12	11	23	4.528
Ath. (*Microdota*) sp.	0	13	13	2.559
Ath. (*Mocyta*) *orbata* (Erichson, 1837)	0	1	1	0.197
Ath. (*Philhygra*) *palustris* (Kiesenwetter, 1844)	0	9	9	1.772
Cordalia obscura (Gravenhorst, 1802)	0	4	4	0.787
Drusilla canaliculata (Fabricius, 1787)	48	33	81	15.945
Falagria caesa Erichson, 1837	2	1	3	0.591
Falagria sp.	0	1	1	0.197
Nehemitropia lividipennis (Mannerheim, 1831)	0	3	3	0.591
Oligota sp.	0	10	10	1.969
Oxypoda carbonaria (Heer, 1841)	0	1	1	0.197
Thamiaraea cinnamomea (Gravenhorst, 1802)	0	2	2	0.394
Zyras limbatus (Paykull, 1789)	24	0	24	4.724
Omaliinae				
Anthobium a. atrocephalum (Gyllenhal, 1827)	0	1	1	0.197
Boreaphilus velox (Heer, 1839)	0	1	1	0.197
Omalium caesum Gravenhorst, 1806	8	14	22	4.331
Om. rivulare (Paykull, 1789)	8	2	10	1.969
Paraphloeostiba gayndahensis (MacLeay, 1871)	2	2	4	0.787
Oxytelinae				
Anotylus inustus (Gravenhorst, 1806)	0	1	1	0.197
Anot. rugosus (Fabricius, 1775)	0	5	5	0.984
Anot. sculpturatus (Gravenhorst, 1806)	0	1	1	0.197
Anot. tetracarinatus (Block, 1799)	2	17	19	3.740
Oxytelus sculptus Gravenhorst, 1806	0	2	2	0.394

(Table 5 continued)

	First year	Second year	Total	Relative %
Paederinae				
Astenus lyonessius (Joy, 1908)	4	3	7	1.378
Paederus fuscipes Curtis, 1826	4	0	4	0.787
Paed. littoralis Gravenhorst, 1802	2	0	2	0.394
Rugilus orbiculatus (Paykull, 1789)	0	1	1	0.197
Proteininae				
Proteinus ovalis Stephens, 1834	4	1	5	0.984
Staphylininae				
Astrapaeus ulmi (Rossi, 1790)	2	0	2	0.394
Gyrohypnus fracticornis (O. Müller, 1776)	0	1	1	0.197
Ocypus olens (O. Müller, 1764)	6	33	39	7.677
Othius punctulatus (Goeze, 1777)	0	1	1	0.197
Phacophallus parumpunctatus (Gyllenhal, 1827)	0	2	2	0.394
Philonthus tenuicornis Mulsant & Rey, 1853	0	6	6	1.181
Platydracus stercorarius (Olivier, 1795)	4	0	4	0.787
Quedius ?curtipennis Bernhauer, 1908	0	1	1	0.197
Q. levicollis (Brullé, 1832)	18	8	26	5.118
Tasgius winkleri (Bernhauer, 1906)	0	4	4	0.787
Xantholinus elegans (Olivier, 1795)	0	5	5	0.984
X. linearis (Olivier, 1795)	4	1	5	0.984
Tachyporinae				
Tachinus corticinus Gravenhorst, 1802	0	1	1	0.197
Tach. subterraneus (Linnaeus, 1758)	0	5	5	0.984
Tachyporus hypnorum (Fabricius, 1775)	2	1	3	0.591
Tachyp. nitidulus (Fabricius, 1781)	6	1	7	1.378
Tachyp. pusillus Gravenhorst, 1806	0	2	2	0.394
NOT CLASSIFIED (damaged specimens)	12	14	26	5.118
TOTAL	242	266	508	100

because of the reduction of preys which lives on weeds. Therefore, the more stable and lasting the presence of vegetation, the more elevated is the number of specimens.

Table 6 - CONV: species recorded, distribution and relative percentage.

	First year	**Second year**	**Total**	**Relative %**
Aleocharinae				
Aloconota gregaria (Erichson, 1939)	0	2	2	2.197
Atheta (Atheta) aeneicollis (Sharp, 1869)	0	3	3	3.297
Ath. (Atheta) triangulum (Kraatz, 1856)	2	11	13	14.286
Ath. (Dimetrota) atramentaria (Gyllenhal, 1810)	2	0	2	2.198
Ath. (*Microdota*) sp.	0	2	2	2.198
Ath. (*Mocyta*) *orbata* (Erichson, 1837)	0	1	1	1.099
Falagria sulcatula (Gravenhorst, 1806)	2	0	2	2.197
Oligota sp.	0	3	3	3.297
Oxypoda brevicornis (Stephens, 1832)	0	1	1	1.099
Omaliinae				
Omalium caesum Gravenhorst, 1806	22	4	26	28.570
Om. rivulare (Paykull, 1789)	0	1	1	1.099
Oxytelinae				
Anotylus inustus (Gravenhorst, 1806)	0	5	5	5.495
Anot. rugosus (Fabricius, 1775)	4	0	4	4.396
Carpelimus corticinus (Gravenhorst, 1806)	0	1	1	1.099
Platystethus capito Heer, 1839	0	1	1	1.099
Platys. cornutus (Gravenhorst, 1802)	0	2	2	2.197
Platys. nitens (Sahlberg, 1832)	0	1	1	1.099
Paederinae				
Scopaeus laevigatus (Gyllenhal, 1827)	0	1	1	1.099
Proteininae				
Proteinus ovalis Stephens, 1834	2	2	4	4.396
Staphylininae				
Gabrius sp.	2	0	2	2.198
Philonthus carbonarius (Gravenhorst, 1802)	0	1	1	1.099
Quedius meridiocarpathicus Smetana, 1958	2	3	5	5.495
Xantholinus elegans (Olivier, 1795)	0	1	1	1.099
Tachyporinae				
Tachyporus hypnorum (Fabricius, 1775)	0	1	1	1.099
Tachyp. nitidulus (Fabricius, 1781)	2	2	4	4.396
NOT CLASSIFIED (damaged specimens)	0	2	2	2.197
TOTAL	40	51	91	100

Table 7 - Main characteristics of the species detected.

	Feeding group	**Dimension (mm)**	**Diffusion**	**Micro and macro habitat**
Aleocharinae				
Aleochara meshniggi Bernhauer, 1943	parasitoid (Diptera)	5-7	rare	wood and open areas, usually on mountain
Aleoch. sparsa Heer, 1839	parasitoid (Diptera)	2-5	common	nests of birds, also phytodetritus, on trees
Aleoch. spissicornis Erichson, 1839	parasitoid (Diptera)	2-3.5	not common	phytodetritus in dry places, thermophilic
Aloconota gregaria (Erichson, 1939)	predator	2.7-3.8	common	phytodetritus in meadows often on banks
Amarochara forticornis Quedenfeldt, 1882	predator	3.5-4	not common	phytodetritus, nests, on trees
Anaulacaspis nigra (Gravenhorst, 1802)	predator	1.7-2.1	not common	phytodetritus in meadows
Atheta (Atheta) aeneicollis (Sharp, 1869)	predator	3.5-3.8	very common	decaying matters
Ath. (Atheta) triangulum (Kraatz, 1856)	predator	3.4-3.7	common	decaying matters
Ath. (Bessobia) occulta (Erichson, 1837)	predator	2.5-3.5	not common	decaying matters
Ath. (Dimetrota) atramentaria (Gyllenhal, 1810)	predator	2.8-3.3	very common	decaying matters
Ath. (Mix gr. I) *coriaria* (Kraatz, 1856)	predator	2.3-2.8	very common	decaying matters
Ath. (Mix gr. I) *crassicornis* (Fabricius, 1792)	predator	2.8-3.4	very common	decaying matters
Ath. (Mix gr. I) *oblita* (Erichson, 1839)	predator	2-2.4	very common	decaying matters
Ath. (Mix gr. II) *trinotrata* (Kraatz, 1856)	predator	2.8-3.5	very common	decaying matters
Ath. (*Microdota*) *amicula* (Stephens, 1832)	predator	1.7-1.9	very common	decaying matters
Atheta (*Mocyta*) *orbata* (Erichson, 1837)	predator	2-3	common	phytodetritus in meadows

(Table 7. Continued)

	Feeding group	Dimension (mm)	Diffusion	Micro and macro habitat
Ath. (*Philhygra*) *palustris* (Kiesenwetter, 1844)	predator	2-2.9	common	phytodetritus in meadows, often on banks
Callicerus obscurus Gravenhorst, 1802	predator	2.5-3	common	phytodetritus in meadows
Cordalia obscura (Gravenhorst, 1802)	predator	2-2.8	very common	decaying matters
Dinaraea angustula (Gyllenhal, 1810)	predator	3-3.7	common	under barks and phytodetritus in meadows
Drusilla canaliculata (Fabricius, 1787)	predator	4-4.8	very common	phytodetritus in meadows and woods, ubiquitous
Falagria caesa Erichson, 1837	predator	2.4-2.8	common	phytodetritus in meadows
Falagria sulcatula (Gravenhorst, 1806)	predator	2-2.5	common	phytodetritus in meadows
Falagrioma thoracica (Stephens, 1832)	predator	2.5-2.9	common	phytodetritus in meadows
Nehemitropia lividipennis (Mannerheim, 1831)	predator	3-3.5	very common	decaying matters
Oligota sp.	predator	/	/	/
Oxypoda brevicornis (Stephens, 1832)	predator	2.5-3.2	common	phytodetritus in meadows and woods
Oxyp. carbonaria (Heer, 1841)	predator	1.8-2.2	common	decaying matters
Thamiaraea cinnamomea (Gravenhorst, 1802)	predator	4-5	not common	on trees on decaying sap
Zyras limbatus (Paykull, 1789)	predator (ants)	4.5-5.5	common	in nests of ants (*Lasius*), on trees
Micropeplinae				
Micropeplus marietti Jacquelin du Val, 1857	saprophagous (?)	2.2-2.5	common	phytodetritus in meadows
Omaliinae				
Anthobium a. atrocephalum (Gyllenhal, 1827)	predator	3-3.5	common	phytodetritus in woods, rarely in meadows
Boreaphilus velox (Heer, 1839)	predator	2-3	not common	phytodetritus in wood and open areas, ubiquitous
Omalium caesum Gravenhorst, 1806	predator	2.5-3.5	common	phytodetritus in meadows and woods

(Table 7. Continued)

	Feeding group	**Dimension (mm)**	**Diffusion**	**Micro and macro habitat**
Omalium. rivulare (Paykull, 1789)	predator	3.5-4	common	decaying matters
Paraphloeostiba gayndahensis (MacLeay, 1871)	predator (?)	1.5-2.5	common	decaying matters
Oxytelinae				
Anotylus inustus (Gravenhorst, 1806)	saprophagous	3-4	very common	decaying matters
Anot. rugosus (Fabricius, 1775)	saprophagous	4.5-5.5	common	phytodetritus in meadows and wetlands
Anot. sculpturatus (Gravenhorst, 1806)	saprophagous	3-4	very common	decaying matters
Anot. tetracarinatus (Block, 1799)	saprophagous	1.7-2.2	very common	decaying matters
Bledius gallicus (Gravenhorst, 1806)	algae eater	4-4.5	common	muddy banks, ripicolous species
Carpelimus corticinus (Gravenhorst, 1806)	algae eater (?)	1.9-2.3	very common	muddy banks
Oxytelus sculptus Gravenhorst, 1806	saprophagous	3.5-4	common	decaying matters
Platystethus capito Heer, 1839	saprophagous (?)	2.5-3	not common	muddy banks
Platys. cornutus (Gravenhorst, 1802)	saprophagous (?)	2.5-4.5	common	muddy banks, ripicolous species
Platys. nitens (Sahlberg, 1832)	saprophagous (?)	1.8-2.5	very common	muddy banks, ripicolous species
Paederinae				
Astenus immaculatus Stephens, 1833	predator	3.5-4	common	phytodetritus in meadows and wetlands
Ast. lyonessius (Joy, 1908)	predator	3-3.5	common	phytodetritus in meadows
Paederus fuscipes Curtis, 1826	predator	6.5-7	common	phytodetritus in meadows
Paed. littoralis Gravenhorst, 1802	predator	7.5-8.5	common	phytodetritus in meadows
Rugilus orbiculatus (Paykull, 1789)	predator	4-4.5	common	phytodetritus in meadows
Scopaeus laevigatus (Gyllenhal, 1827)	predator	3.5	common	phytodetritus in meadows

(Table 7. Continued)

	Feeding group	Dimension (mm)	Diffusion	Micro and macro habitat
Proteininae				
Megarthrus bellevoyei Saulcy, 1862	saprophagous (?)	2.5-2.8	common	decaying matters
Proteinus ovalis Stephens, 1834	saprophagous	1.8-2.2	very common	decaying matters
Staphylininae				
Astrapaeus ulmi (Rossi, 1790)	predator	10-15	not common	phytodetritus in dry places, thermophilic
Gabrius sp.	predator	/	/	/
Gyrohypnus fracticornis (O. Müller, 1776)	predator	7-8	very common	decaying matters
Ocypus olens (O. Müller, 1764)	predator	22-32	very common	meadows and anthropogenic places
Othius punctulatus (Goeze, 1777)	predator	10-14	common	phytodetritus in meadows and woods
Phacophallus parumpunctatus (Gyllenhal, 1827)	predator	5-7	common	decaying matters
Philonthus carbonarius (Gravenhorst, 1802)	predator	6-8	very common	meadows and anthropogenic places
Phil. tenuicornis Mulsant & Rey, 1853	predator	11-14	common	decaying matters
Platydracus stercorarius (Olivier, 1795)	predator	12-15	common	decaying matters
Quedius ?curtipennis Bernhauer, 1908	predator	10-15	common	phytodetritus in meadows and wetlands
Q. levicollis (Brullé, 1832)	predator	10-16	very common	meadows and anthropogenic places
Q. meridiocarpathicus Smetana, 1958	predator	10.5-13	common	phytodetritus in meadows
Tasgius winkleri (Bernhauer, 1906)	predator	13 -20	common	phytodetritus in meadows
Xantholinus elegans (Olivier, 1795)	predator	9-12	not common	phytodetritus in dry places
X. linearis (Olivier, 1795)	predator	6-9	common	phytodetritus in meadows

(Table 7. Continued)

	Feeding group	Dimension (mm)	Diffusion	Micro and macro habitat
Tachyporinae				
Mycetoporus longulus Mannerheim, 1830	predator	4-5.5	common	phytodetritus in meadows
Tachinus corticinus Gravenhorst, 1802	predator	3-4	common	phytodetritus in meadows
Tach. subterraneus (Linnaeus, 1758)	predator	5-6.5	common	phytodetritus in meadows
Tachyporus atriceps Stephens, 1832	predator	2.5-2.8	common	phytodetritus in meadows
Tachyp. hypnorum (Fabricius, 1775)	predator	3-4	very common	phytodetritus in meadows
Tachyp. nitidulus (Fabricius, 1781)	predator	2-3	common	phytodetritus in meadows
Tachyp. pusillus Gravenhorst, 1806	predator	2-3	common	phytodetritus in meadows

Table 8 - Distribution of the species in dominant rate categories.

	BIO1	BIO2	CONV
Eudominant	*Dr. canaliculata*	*Ath. aeneicollis* *Dr. canaliculata*	*Ath. triangulum* *Om. caesum*
Dominant	*Oc. olens*	*Ath. fungi* *Oc. olens* *Q. levicollis*	*Anot. inustus* *Q. meridiocarpathicus*
Subdominant	*Ast. lyonessius;* *Ath.* (*Microdota*) sp. *Ath. aeneicollis* *Ath. triangulum* *Falagria thoracica* *Om. caesum* *Q. meridiocarpathicus* *Tachyp. nitidulus*	*Anot. tetracarinatus* *Ath.* (*Microdota*) sp. *Ath. amicula* *Om. caesum* *Z. limbatus*	*Aloc. gregaria* *Anot. rugosus* *Ath. aeneicollis* *Ath. atramentaria* *Ath. fungi* *F. sulcatula* *Platys. cornutus* *Pr. ovalis* *Tachyp. nitidulus*
Recedent	*Anot. sculpturatus* *Ath. fungi* *Pr. ovalis*	*Aleoc. spissicornis* *Ast. lyonessius* *Ath. oblita* *Ath. palustris* *Ath. triangulum* *Oligota* sp. *Om. rivulare* *Phil. tenuicornis* *Tachyp. nitidulus*	*Ath. orbata* *Car. corticinus* *Om. rivulare* *Oxyp. brevicornis* *Phil. carbonarius* *Platys. capito* *Platys. nitens* *S. laevigatus* *Tachyp. hypnorum* *X. elegans*
Subrecedent	*O. winkleri* *Aleoc. meshniggi* *Am. forticornis* *Anot. inustus* *Anot. tetracarinatus* *Ast. immaculatum* *Ath. coriaria* *Ath. crassicornis* *Ath. oblita* *Ath. trinotrata* *Bl. gallicus* *Bor. velox* *Cal. obscurus* *Din. angustula* *F. sulcatula* *Meg. bellevoyei* *Mic. marietti* *Myc. longulus* *Om. rivulare* *Oxyp. brevicornis* *Par. gayndahensis* *Platyd. stercorarius* *Platys. cornutus* *Platys. nitens*	*O. winkleri* *Aleoc. meshniggi* *Aleoc. sparsa* *An. nigra* *Anot. inustus* *Anot. rugosus* *Anot. sculpturatus* *Anth. a. atrocephalum* *Astr. ulmi* *Ath. occulta* *Ath. orbata* *Ath. trinotrata* *Bor. velox* *Cor. obscura* *F. caesa* *Gyr. fracticornis* *N. lividipennis* *Oth. punctulatus* *Oxyp. carbonaria* *Oxyt. sculptus* *Paed. fuscipes* *Paed. littoralis* *Par. gayndahensis* *Phac. parumpunctatus*	

(Table 8. Continued)

	BIO1	BIO2	CONV
Subrecedent	*Q. ?curtipennis* *Q. levicollis* *R. orbiculatus* *Tachin. subterraneus* *Tachip. atriceps* *Tas. winkleri* *X. elegans* *X. linearis*	*Platyd. stercorarius* *Pr. ovalis* *Q.?curtipennis* *R. orbiculatus* *Tachin. corticinus* *Tachin. subterraneus* *Tachyp. hypnorum* *Tachyp. pusillus* *Tam. cinnamomea* *Tas. winkleri* *X. elegans* *X. linearis*	

Table 9 - Biodiversity indexes.

		Margalef	Simpson		Shannon
		Mg	D	1-D	H
First year	BIO1	3.194	0.237	0.763	1.982
	BIO2	4.008	0.116	0.884	2.537
	CONV	2.169	0.313	0.687	1.608
Second year	BIO1	6.198	0.338	0.662	1.989
	BIO2	8.239	0.053	0.947	3.260
	CONV	5.315	0.067	0.933	2.791
Total	BIO1	6.526	0.291	0.709	2.087
	BIO2	8.384	0.068	0.932	3.188
	CONV	5.347	0.116	0.884	2.675

Table 10 - Sørensen similarity index.

	First year		Second year		Total	
	BIO2	CONV	BIO2	CONV	BIO2	CONV
BIO1	0.5853	0.5000	0.4706	0.4068	0.5052	0.4363
BIO2	-	0.2580	-	0.3030	-	0.3157

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