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Carabid population in a crop rotation system in northern Italy

Abstract - A four year research (1989-92) has been carried out in northern Italy in fields in which crop rotation is applied (tomato, winter wheat and alfalfa), to assess the influence of different crops on the composition of ground beetle population. A clear influence of the crop has been observed. In tomato fields 69,2% of insects caught were *Steropus melas*, followed by *Pseudophonus rufipes* (12,8%). In cereal field the most abundant species have been *Poecilus cupreus* (49,2%), *S. melas* (13,3%) and *Anchomenus dorsalis* (6,3%). Alfalfa showed a more balanced dominance figure, with *Harpalus distinguendus* (30,7%), *S. melas* (19.8%), *Brachinus sclopeta* (19,8%) and *P. rufipes* (12,4%). In cereal fields zoophagous (80,5%) and spring breeder (75%) species were markedly prevailing, as much as zoophagous (83,9%) autumn breeder (87,5%) in tomato; in alfalfa, less than half (47,2%) of the species are zoophagous and spring breeders were 64,9%.

Riassunto - *Popolamenti di carabidi in campi sottoposti a rotazione in Italia settentrionale.*

Una ricerca quadriennale (1989-92) è stata condotta in Italia settentrionale in campi sottoposti a rotazione delle colture (pomodoro, cereali e medica), per determinare l'effetto della coltura sulla composizione dei popolamenti di Coleotteri Carabidi. È emersa una marcata influenza della coltura: infatti nei campi di pomodoro 69,2% degli insetti catturati erano *Steropus melas*, seguito da *Pseudophonus rufipes* (12,8%). Nei campi di cereali le specie più abbondanti erano *Poecilus cupreus* (49,2%), *S. melas* (13,3%) e *Anchomenus dorsalis* (6,3%). Nella medica è stata osservata una distribuzione quantitativa delle specie più equilibrata, con *Harpalus distinguendus* (30,7%), *S. melas* (19.8%), *Brachinus sclopeta* (19,8%) and *P. rufipes* (12,4%). Nei campi a cereali erano nettamente prevalenti le specie zoofaghe (80,5%) e quelle a riproduzione primaverile (75%), così come nei campi a pomodoro gli zoofagi (83,9%) e i riproduttori autunnali (87,5%); nella medica, invece, meno della metà (47,2%) delle specie era zoofaga e i riproduttori primaverili erano il 64,9%.

Key words: *Carabidae*, populations, agriculture, tomato, cereals, alfalfa.

Ground beetles (Coleoptera Carabidae) are an outstanding component of the soil fauna in almost every ecosystem in temperate climates. Many authors say that

they may be important pest control agents, as they are particularly known as predators. On the other side, some species are mainly phytophagous (Johnson & Cameron, 1969; Domenichini, 1973). A considerable number of species exhibits an intermediate behaviour, feeding on animal as well as vegetal matter, according to fisiological condition, the period of the year, the abundance of food and other factors (Hengeveld, 1980). Anyway, the importance of carabid beetles in ecosystems is without any doubt fundamental. This convinction led to intensive studies on carabid populations in different environments. Agricultural systems have not been studied as thoroughly as natural environments, even if since last decades research have been carried out, especially in North America (Rivard, 1966; Dritschilo & Wanner, 1980; House & All, 1981; Lester & Morril, 1989) and Central-Northern Europe (Pietraszko & De Clercq, 1981; Desender & Alderweireldt, 1990); in Italy data on Carabidae in relation to agriculture are almost lacking, the few works being particularly on orchards and vineyards (Ghini, 1979; Daccordi & Zanetti, 1987; Molinari et al., 1989; Sciaky & Trematerra, 1991; Zandigiacomo et al., 1986/87).

A research has been carried out in northern Italy in fields in which crop rotation is applied, to assess the influence of different crops on the composition of ground beetle population.

MATERIAL AND METHODS

Research has been carried out from 1989 until 1992 in three farms in the Po valley, in the province of Piacenza, few kilometres far from one another.

Two farms – Razza (PC0003) and Zanetti (PC0012) – located at Querceto di Podenzano, practice the following crop rotation: alfalfa-tomato-winter cereal. The third, Tadini (PC0002), is an experimental farm located at Gariga di Podenzano, in which different trials are carried out and crop rotation is much more variable. During the present work, 10 fields, with loam to clay soil have been monitored; some of them were used in different years, for a total of 20 plot/crop combinations: 6 for tomato, 9 for winter cereals (8 wheat and 1 barley), 5 for alfalfa. The crops cultivated in each field in the different years are shown in table n. 1, as well as treatments applied during research period.

Pitfall traps have been placed in the fields: the traps were made from plastic cups of 10 cm diametre, filled to 1/3 with vinegar containing 4% formaldehyde and covered with a pantile (Greenslade, 1964; Skuhravy, 1970; Brandmayr, 1980).

In March 1989, 2 traps were placed in each field and visited every two weeks from April till October, monthly during winter (November-March). In 1990-1992 three traps were placed in each field. During tilling or hay-harvest the traps were removed (table 1).

The identification of carabids has been made according to different authors

Table 1 - Plots and relative crops monitored in the different years.Number of traps, days of exposure and treatments applied are shown (tr = trifluralin; lin = linuron; ox = oxytril; met = metribuzin; cy = cymoxonil; man = mancozeb; ben = benfuracarb).

farm	plot	year	traps	days	crop	herbicides	fungicides	soil insecticides
Tadini	2A	1989	2	107	wheat	1 (tr + lin)	no	no
	2A	1990	3	91	tomato	2 (met)	1 cupric + 2 (cy+man)	1 (ben)
	2A	1991	3	90	wheat	1 (ox)	no	no
	2A	1992	3	99	tomato	2 (met)	2 cupric + 2 (cy+man)	1 (ben)
	2B	1991	3	106	tomato	2 (met)	1 cupric + 2 (cy+man)	1 (ben)
	2C	1989	2	114	alfalfa	no	no	no
	2E	1992	3	126	wheat	no	no	no
	2F	1992	3	126	wheat	1 (ox)	no	no
Razza	3A	1989	2	73	alfalfa	no	no	no
	3A	1990	3	119	alfalfa	no	no	no
	3A	1991	3	183	tomato	2 (met)	1 cupric + 2 (cy+man)	1 (ben)
	3A	1992	3	121	wheat	no	no	no
	3B	1989	2	102	barley	no	no	no
	3B	1990	3	139	wheat	no	no	no
	3B	1991	3	181	alfalfa	no	no	no
	3B	1992	3	144	alfalfa	no	no	no
	3C	1990	3	99	tomato	2 (met)	2 cupric + 2 (cy+man)	1 (ben)
	3C	1991	3	108	wheat	no	no	no
Zanetti	12A	1992	3	64	wheat	1 (tr + lin)	no	no
	12B	1992	3	99	tomato	2 (met)	2 cupric + 2 (cy+man)	1 (ben)

(Porta, 1923, 1934, 1949; Jeannel, 1941-42; Magistretti, 1965; Lindroth, 1974; Casale et al., 1982) with the aid of a specialist for some uncertain specimen. Nomenclature suggested by the checklist of Vigna Taglianti (1993) has been used.

Data have been expressed in terms of *activity density* after Brandmayr & Brunello Zanitti (1982), referring catches per trap to a standard period of 10 days.

The dominance figures have been drawn in each situation plot/crop.

The affinity of carabid communities associated with different crop plants was compared with Sörensen quotient of similarity (Sörensen, 1948) and Renkonen number (Renkonen, 1938).

RESULTS AND DISCUSSION

During the 4 year study 23392 adult Carabids were caught in pitfall traps; 22 species have been identified (tables 2 and 3), of which 10 were common in the

Table 2 - 1989-92. Activity density of different species of ground beetles caught by pitfall traps in different plots. (PC0002= Tadini; PC00012= Zanetti).

year	1989	1990	1991	1992	1991	1989	1990	1991	1992	1992
plot (PC)	2A	2A	2A	2A	2B	2C	2E	2F	12A	12B
crop	wheat	tomato	wheat	tomato	tomato	alfalfa	wheat	wheat	wheat	tomato
Agonum mulleri. Herbst.	0.05									
Amara sp.	3.62	0.04	0.26			1.33	0.05			
Metallina properans (Steph.)			0.26				0.61	0.5	0.05	
Brachinus crepitans (L.)						0.05	1.06	0.11		
Brachinus explodens (Duft.)							0.03			
Brachinus sclopeta (Fabr.)	0.14	0.03	2.67		0.44	0.96	0.21	0.16		
Calathus fuscipes (Goeze)	0.19	0.53	0.22	0.17	0.09	0.39	0.5	0.43		
Campalita auropunctata (Herbst)				0.1			0.03	0.08	0.1	
Dinodes decipiens (Duft.)										
Carabus violaceus L.							0.05	0.03		
Gynandromorphus etruscus (Quensel)							0.03			
Harpalus affinis (Schrank)		0.04			0.03					
Harpalus dimidiatus (Rossi)								0.06		
Harpalus distinguendus (Duft.)	2.3	0.18	1.11	0.1	0.03	3.84	1.19	1.06	0.16	0.1
Pseudophonus griseus (Panz.)		0.03								
Harpalus pygmaeus Dej.			0.19							
Pseudophonus rufipes (Deg.)	0.27	16.85	0.11	5.52	6.95		0.74	3.74		0.34
Harpalus sp.	0.14	0.12	0.04	0.07	0.09	0.82	0.03	0.03		0.03
Anchomenus dorsalis (Pont.)	1.9	0.04	2.52	0.07	0.28	0.62	0.37	0.93	0.1	0.07
Poecilus cupreus (L.)	27.49	10.43	11.74	4.04	2.55	0.91	32.3	15.03	2.81	0.07
Platysma macrum (Marsh.)		2.5		0.24	0.35		0.61	0.43		0.03
Steropus melas italicus (Dej.)	1.08	105.14	1.89	11.99	37.92	5.92	10.16	8.97	0.21	0.91
Platysma melanarium (Ill.)		11.21	1.26	0.3	0.13		2.57	1.69	0.42	0.07
Trechus quadristriatus (Schrank)							0.58	0.5	0.08	
total	37.18	147.14	22.27	22.6	48.86	14.84	51.12	33.75	3.85	1.62

Table 3 - 1989-92. Activity density of different species of ground beetles caught by pitfall traps in different plots. (PC0003= Razza)

year	1989	1990	1991	1992	1989	1990	1991	1992	1990	1991
plot	PC003A	PC003A	PC003A	PC003A	PC003B	PC003B	PC003B	PC003B	PC003C	PC003C
crop	alfalfa	alfalfa	tomato	wheat	barley	wheat	alfalfa	alfalfa	tomato	wheat
Agonum mulleri. Herbst.		0.03								
Amara sp.	1.99	0.41			0.2		0.15	0.49		
Metallina properans (Steph.)				0.03						
Brachinus crepitans (L.)	0.14	0.08	0.02	0.05	0.15	0.12	0.13			0.06
Brachinus explodens (Duft.)					0.1					
Brachinus sclopeta (Fabr.)	9.86	1.08	0.16	0.03		0.46	5.08	6.81		2.36
Calathus fuscipes (Goeze)	0.14	0.67	0.33	0.36	0.83	0.07	2.08	0.12	0.02	
Campalita auropunctata (Herbst)										
Dinodes decipiens (Duft.)					0.05					
Carabus violaceus L.										
Gynandromorphus etruscus (Quensel)										
Harpalus affinis (Schrank)		0.03		0.03						
Harpalus dimidiatus (Rossi)										
Harpalus distinguendus (Duft.)	14.52	10.95	0.98		0.05	0.14	5.21	2.45	0.25	0.31
Pseuodophonus griseus (Panz.)										
Harpalus pygmaeus Dej.							0.04			
Pseudophonus rufipes (Deg.)	0.14	3.42	1.42	0.08		3.09	7.66	0.69	1.6	0.2
Harpalus sp.			0.65	0.03	0.05		0.22	0.18		0.03
Anchomenus dorsalis (Pont.)	1.78	0.49		0.05	0.74	2.13	0.28	0.3	0.23	4.12
Poecilus cupreus (L.)	0.41	0.2		1.32	2.11	5.78	0.09	0.05	0.74	2.04
Platysma macrum (Marsh.)		0.62	0.38		0.1	0.14	2.06	0.21	1.53	0.06
Steropus melas italicus (Dej.)	0.27	4.41	9.11	0.77	0.25	3.67	12.5	0.74	11.01	0.22
Platysma melanarium (Ill.)		0.03	0.02			0.02			0.12	0.09
Trechus quadristriatus (Schrank)										
total	29.25	22.42	13.07	2.75	4.63	15.62	35.5	12.04	15.5	9.49

Table 4 - Overall dominance of the species found during the research.

Species	%	Dominance
Steropus melas italicus (Dej.)	38,42%	Eudominant
Poecilus cupreus (L.)	22,04%	Eudominant
Pseudophonus rufipes (Deg.)	10,05%	Eudominant
Harpalus distinguendus (Duft.)	7,24%	Dominant
Brachinus sclopeta (Fabr.)	5,39%	Dominant
Platysma melanarium (Ill.)	4,38%	Subdominant
Anchomenus dorsalis (Pont.)	2,84%	Subdominant
Amara sp.	2,37%	Subdominant
Platysma macrum (Marsh.)	2,07%	Subdominant
Calathus fuscipes (Goeze)	1,15%	Recedent
Trechus quadristriatus (Schrank)	0,86%	Subrecedent
Metallina properans (Steph.)	0,74%	Subrecedent
Brachinus crepitans (L.)	0,69%	Subrecedent
Harpalus sp.	0,54%	Subrecedent
Harpalus pygmaeus Dej.	0,32%	Subrecedent
Campalita auropunctata (Herbst)	0,24%	Subrecedent
Brachinus explodens (Duft.)	0,18%	Subrecedent
Agonum mulleri Herbst.	0,11%	Subrecedent
Harpalus affinis (Schrank)	0,09%	Subrecedent
Harpalus dimidiatus (Rossi)	0,08%	Subrecedent
Dinodes decipiens (Duf.)	0,07%	Subrecedent
Carabus violaceus L.	0,06%	Subrecedent
Gynandromorphus etruscus (Quensel)	0,04%	Subrecedent
Pseudophonus griseus (Panz.)	0,04%	Subrecedent
Total	100,00%	

three farms and 7 were found only in 2 of them. The level of catches, independently of crop, was different among the plots: the lowest in the plot PC0012A in 1992 (DAat = 1,62) and the highest in PC0002A, in 1990 (DAat = 147.14).

In the 6 tomato plots 47,6% of total catches have been recorded, the other captures have been equally shared out between the 9 cereal and 5 alfalfa plots.

The low number of traps placed in each plot could have lessened the probability of catching occasional species, but the long period of exposure allows to draw a reliable figure of dominant species.

In the complex of the area investigated, only 5 dominant species were found: *Steropus melas italicus* Dej., *Poecilus cupreus* (L.), *Pseudophonus rufipes* Mull., *Harpalus distinguendus* Duft., *Brachinus sclopeta* Fabr. and they represent 83,1% of total catches (table 5), while *Platysma melanarium* L., *Anchomenus dorsalis* Pont., *Platysma macrum* Marsh. and *Amara* sp. were in some location dominant or subdominant.

There is a fundamental resemblance and some differences of our data with the

Table 5 - Dominance of carabid species in cereals (winter wheat and barley), tomato and alfalfa.

			cereals	tomato	alfalfa
Steropus melas italicus (Dej.)	A.B.	z	13,32%	69,15%	19,80%
Poecilus cupreus (L.)	S.B.	z	49,23%	8,40%	1,38%
Pseudophonus rufipes (Deg.)	A.B.	p/z	5,18%	12,83%	12,37%
Harpalus distinguendus (Duft.)	S.B.	p	3,48%	0,64%	30,71%
Brachinus sclopeta (Fabr.)	S.B.	z	3,79%	0,49%	19,76%
Platysma melanarium (Ill.)	A.B.	z	4,44%	4,65%	0,12%
Anchomenus dorsalis (Pont.)	S.B.	z	6,29%	0,33%	2,88%
Amara sp.	S.B.	p/z	4,55%	1,98%	4,00%
Platysma macrum (Marsh.)	—	p	1,18%	0,09%	3,63%
Calathus fuscipes (Goeze)	A.B.	z	1,64%	0,54%	2,82%
Trechus quadristriatus (Schrank)	—	p/z	1,70%	0,45%	1,69%
Metallina properans (Steph.)	S.B.	p/z	1,28%	0,00%	0,00%
Brachinus crepitans (L.)	S.B.	z	1,14%	0,05%	0,42%
Harpalus sp.	S.B.	p/z	0,22%	0,00%	0,00%
Harpalus pygmaeus Dej.	S.B.	p/z	0,84%	0,00%	0,17%
Campalita auropunctata (Herbst)	A.B.	z	0,31%	0,24%	0,00%
Brachinus explodens (Duft.)	S.B.	p	0,29%	0,08%	0,12%
Agonum mulleri Herbst.	S.B.	p/z	0,22%	0,00%	0,12%
Harpalus affinis (Schrank)	S.B.	z	0,13%	0,00%	0,00%
Harpalus dimidiatus (Rossi)	S.B.	p/z	0,26%	0,00%	0,00%
Dinodes decipiens (Duf.)	S.B.	p/z	0,22%	0,00%	0,00%
Carabus violaceus L.	A.B.	z	0,18%	0,00%	0,00%
Gynandromorphus etruscus (Quensel)	S.B.	p/z	0,13%	0,00%	0,00%
Pseudophonus griseus (Panz.)	A.B.	p	0,00%	0,07%	0,00%
			100,00%	100,00%	100,00%
	n		%	%	%
S.B. = spring breeders	18		75,12%	12,52%	64,88%
A.B. = autumn breeders	6		24,88%	87,48%	35,12%
		n	%	%	%
z = zoophages		10	80,46%	83,85%	47,19%
p/z = mixed diet		10	14,60%	15,26%	18,35%
p = phytophages		4	4,94%	0,89%	34,46%

list of Carabidae of agricultural regions of Europe in Thiele (1977), the most carachteristic feature being the important presence of *Steropus melas var.* italicus, almost substituting for *Platysma melanarium*.

Table 5 shows the species present and their abundance in the different crops.

In tomato plots the prevailing species is *S. melas* (near 70% of total catches),

followed by *P. rufipes* (12,8%) and *P. cupreus* (8,4%); other 12 species represent only 10%. The specimens collected in tomato fields are almost half of total catches, and 90% of them are due to 3 species. This leads to an obvious prevalence of autumn breeders. As to the feeding habit, less than 1% is phytophagous.

In cereal fields *P. cupreus* (49,2%), *S. melas* (13,3%), *A. dorsale* (6,3%) and *P. rufipes* (5,2%) have been the dominant species. 3/4 of the insects caught are spring breeders and more than 80% has a zoophagous diet.

In alfalfa a more balanced presence of dominant species can be observed: *H. distinguendus* makes up 30,7% of catches, followed by *S. melas* (19,8%), *B. sclopeta* (19,8%), *P. rufipes* (12,4%); The ratio spring breeders/autumn breeders is 3/2. Also in the feeding habit all the categories are well represented, 34,5% being phytophagous, 47% zoophagous and 18 % with a mixed diet.

Sörensen quotient of similarity (table 6) is always high for all the combinations plot/crop tested, ranging from 68,84 between cereals to 80,51 between alfalfa plots. No appreciable difference can be seen in species composition. The R number of Renkonen, based on the relative abundance shows more variability. The higher values, that indicate high affinity of dominant species, are found out comparing plots with the same crop (59,41 between cereal, 52,27 alfalfa and 80,25 tomato fields); between different crops R number is significantly lower (23,56 cereal-alfalfa, 30,11 cereal-tomato, 34,27 alfalfa-tomato).

Table 6 - Average values of Sörensen and Renkonen indexes for different fields and different crops.

	Sörensen quotient of similarity QS			Renkonen number R		
	avg	s.d.	s.e.	avg	s.d.	s.e.
CEREALS - CEREALS	68,84	10,59	1,74	59,41	14,40	2,40
CEREALS - ALFALFA	72,10	11,21	1,69	23,56	11,36	1,75
CEREALS - TOMATO	70,03	11,05	1,50	30,11	17,65	2,45
ALFALFA - ALFALFA	80,51	9,02	3,01	52,27	10,53	3,33
ALFALFA - TOMATO	73,71	10,47	1,91	34,27	20,26	3,70
TOMATO - TOMATO	80,13	9,40	2,43	80,25	7,51	1,94

S. melas was the most frequently found species (38,42%), but 2/3 of its catches were in tomato fields (78,28%). It is a zoophagous autumn breeder and shows a peak of activity in mid and late summer. *P. cupreus*, (22,04%) is zoophagous too, but is a spring breeder. This species has been found especially in cereal fields (75,83%), and in tomato (22,12%).

The third species (10, 05%) is an autumn breeder with a mixed diet, *P. rufipes*, and is reported as a synantropic species (Sciaky and Trematerra, 1991); its catches

were high in tomato (56,74%) but significative also in alfalfa (31,02%) and cereals (12,25%).

H. distinguendus was found numerous in alfalfa (86,51%), in some number in cereals (10,30%) and very rarely in tomato (3,2%). It is a phytophagous spring breeder.

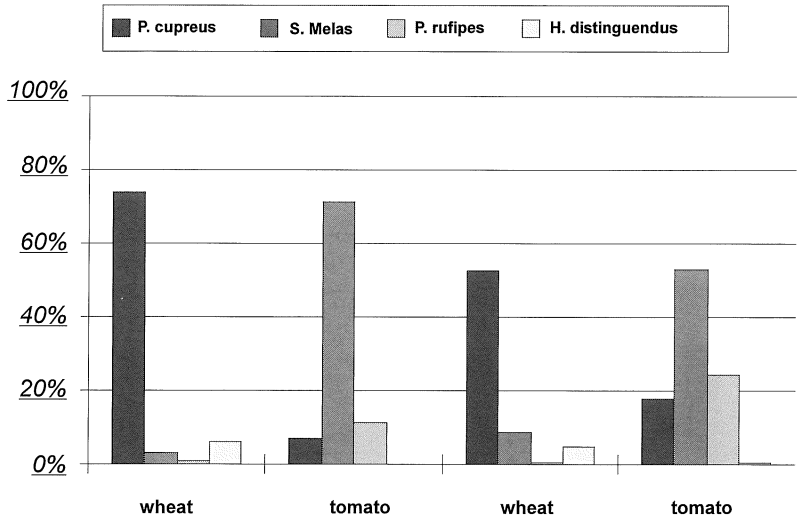

Fig. 1 - Relative abundance of the main species of Carabidae in the plot PC0002A in relation to crop in the different years (1989-1992).

Brachinus sclopeta (5,39%), zoophagous spring breeder, with gregarious habits, has been found mainly in alfalfa (80%), then in cereal fields (15%), and in tomato only 3,6% of its catches have been recorded.

It is evident that some species are active within a single crop (*S. melas* in tomato, *P. cupreus* in cereals, *H. distinguendus* e *B. sclopeta* in alfalfa).

A particularly clear example of the influence of the crop on the activity density of carabid species is represented by plot PC0002A that, in the four years of the study, was alternatively cultivated with wheat and tomato (table 1). Figure 1 shows the abundances in this plot of the dominant species through the four years. In 1989 (wheat) *P. cupreus* was the prevailing species (74%); only 6% of specimens were *H. distinguendus*, 2,9% *S. melas* and 0,7% *P. rufipes*.

Next year (tomato) *S. melas* (70,9%) with *P. rufipes* (11,4%) became eudominant while *P. cupreus* fell down to 7% and *H. distinguendus* was near absent.

In 1991, the presence of wheat on the same plot coincided again with high captures of *P. cupreus* (52,7%), *H. distinguendus* (5%), *S. melas* (8%).

In 1992 (tomato), *S. melas* returned the most abundant species (53%) fol-

lowed by *P. rufipes* (22,4%) and *P. cupreus* (17,9%); *H. distinguendus* had only 0,4% presence.

Another significative example is the plot PC0003A (Fig. 2).

The change of crop (tomato) in 1991 determines an increase of *S. melas* (70%) and *P. rufipes* (10,85%); *H. distinguendus* falls to 7% and no catch of *P. cupreus* is recorded. In 1992, with the plot occupied by wheat, *P. cupreus* (48%) is eudominant with *S. melas* (28%). *P. rufipes* is rare and *H. distinguendus* is absent.

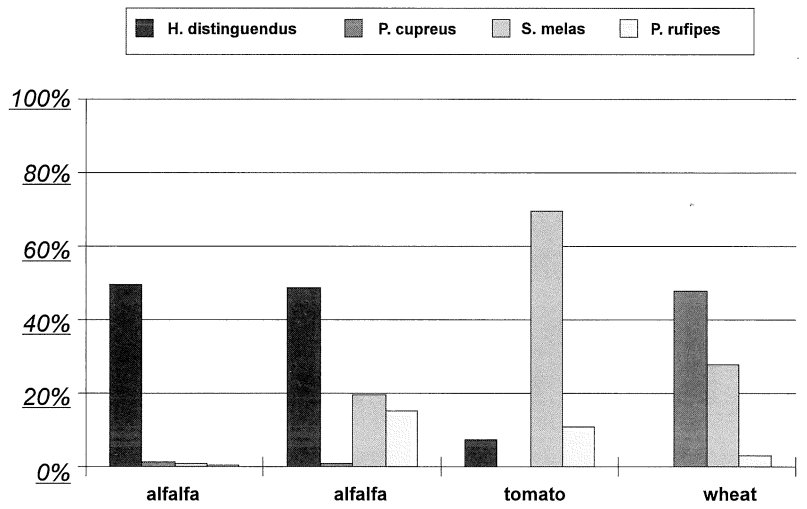

Fig. 2 - Relative abundance of the main species of Carabidae in the plot PC0003A in relation to crop in the different years (1989-1992).

In conclusion, the species found as dominant in our research characterize agrarian biotopes; they have been often found in cultivated fields in Europe by many researchers (Thiele, 1977; Pietrazko & De Clerk, 1981; Sekulic et al., 1987; Dajoz, 1989; Hance et al., 1990). From the *qualitative* point of view, that is presence/absence, the populations in the different plots are quite the same. There are considerable differences with the findings of other researches in orchards and vineyards in northern Italy (Zandigiacomo et al., 1986/87; Daccordi & Zanetti, 1987; Molinari et al., 1989; Sciaky & Trematerra, 1991).

A clear influence of the crop on the relative abundance of the species can be seen. A first consideration can be on the ratio spring breeders/autumn breeders: in cereal fields spring breeders are preponderant, as in tomato autumn breeders, while in alfalfa both categories, spring and autumn breeders, are well represented. This situation is completely predictable, as it is reported by several authors (Hance & Gregoire-Wibo, 1987, Hance et al., 1990) that, due to seasonal distur-

bance by tilling, winter-spring crop favour adult overwintering species and summer-autumn crops have the same effect on larval-overwintering ones. Moreover, in the rich habitat created by alfalfa, fitophagous and mixed-diet species reach the same weight as zoophagous ones, that are quite prevailing in the two other crops.

Among the crops considered, tomato is by far the most treated, with 1 soil insecticide, 2 herbicides and some fungicides per season, against no or few treatments on wheat and no treatment on alfalfa (table 1). The huge catches of *S. melas* in tomato can partially be ascribed to the great portion of bare soil, that forces searching activity for the prey (Luff, 1975; Chiverton, 1984). This crop is widely cultivated in many areas in Italy, and has a great economic importance. Further analysis is already being carried out on the role of dominant species, their periods of activity in different crops and their movements in relation to surroundings.

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REFERENCES

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, 1980.

BRANDMAYR P., BRUNELLO ZANITTI C., 1982 - Le comunità a coleotteri Carabidi di alcuni Querco-Carpineti della bassa pianura del Friuli. - Quaderni sulla struttura delle zoocenosi terrestri, C.N.R

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

CHAMBON J.P., 1982 - Recherches sur les biocénoses céréalières. I.-Incidence à long terme des rotations maïs-blé sur les niveaux de populations d'insectes ravageurs. - Agronomie 2 (4): 373-378.

CHIVERTON P.A., 1984 - Pitfall-trap catches of the carabid beetle *Pterostichus melanarius*, in relation to gut contents and prey densities, in insecticide treated and untreated spring barley. - Entomol. exp. appl. 36: 23-30.

DACCORDI M., ZANETTI A., 1987 - Catture con trappole a caduta in un vigneto nella provincia di Verona. - Quaderni dell'Azienda Agraria Sperimentale di Villafranca, 3 Verona: p. 44.

DAJOZ R., 1989 - Les coléoptères carabidae d'une région cultivée à Mandres-les-Roses (Val-de-Marne). - Chaiers des Naturalistes 45 (2): 25-37.

DESENDER K., ALDERWEIRELDT M., 1990 - The carabid fauna of maize fields under different rotation regimes. - Med. Fac. Landbouww. Rijksuniv. Gent, 55 (2b): 493-500.

DOMENICHINI G., 1973 - La *Clivina fossor*, nuovo nemico del Mais. - Informatore Agrario 30: 13145-6

DRITSCHILO W., WANNER D., 1980 - Ground beetle abundance in organic and conventional corn fields. - Ann. Entomol. Soc. Am. 9 (5): 629-631.

GHINI G., 1979 - Lotta integrata nel pescheto. Interrelazioni tra organismi epigei ed ipogei: gli artropodi entomofagi del terreno. - Tesi di laurea, Università Cattolica del Sacro Cuore, Facoltà di Agraria, Piacenza, 60 pp.

GREENSLADE P.J.M., 1964 - Pitfall trapping as a method for studying populations of Carabidae (Coleoptera). - J. Animal Ecol. 33: 301-310.

HANCE TH., GREGOIRE-WIBO C., 1987 - Effect of agricultural practices on carabid populations. - Acta Phytopath. Entom. Hung. 22 (1-4): 147-160.

HANCE TH., GREGOIRE-WIBO C., LEBRUN PH., 1990 - Agriculture and ground-beetles populations. The consequence of crop types and surrounding habitats on activity and species composition. - Pedobiologia 34: 337-346.

HENGEVELD R., 1980 - Qualitative and quantitative aspects of the food of ground beetles (Coleoptera, Carabidae): a review. - Neth. J. Zool. 30 (4): 555-563.

HENGEVELD R., 1980 - Polyphagy, oligophagy and food specialization in ground beetles (Coleoptera, Carabidae). - Neth. J. Zool. 30 (4): 564-584.

HOUSE G.J., ALL J.N., 1981 - Carabid beetles in soybean agroecosystems. - Environ. Entomol. 10: 194-196.

JEANNEL R., 1941-42 - Faune de France, 39-40. Coléoptères Carabiques. Libr. Fac. Sc., Paris, 1173 pp.

JOHNSON N.E., CAMERON R.S., 1969 - Phytophagous ground beetles. - Ann. Entomol. Soc. Am. 62: 909-914.

LESIEWICZ D.S., VAN DUYN J.W., BRADLEY J.R. JR., 1983 - Determinations on cornfield carabid populations in northeastern North Carolina. - Environ. Entomol. 12: 1636-1640.

LESTER D.G., MORRIL W.L., 1989 - Activity density of ground beetles (Coleoptera: Carabidae) in alfalfa and sainfoin. - J. Agric. Entomol. 6 (2): 71-76.

LINDROTH C.H., 1974 - Coleoptera Carabidae. - Handbk. Ident. Br. Insects. 4 (2) 148 pp.

LUFF M.L., 1975 - Some features influencing the efficiency of pitfall traps. - Oecologia 19: 345-357.

MAGISTRETTI M., 1965 - Fauna d'Italia. Coleoptera Cicindelidae, Carabidae. - Catalogo topografico. Bologna: Edizioni Calderini.

MOLINARI F., CRAVEDI P., SPADA G.L., 1989 - Studi sulle popolazioni di Coleotteri Carabidi in pescheti dell'Italia Settentrionale. - Frustula Entomologica (Nuova Serie) 12 (25): 1-19.

PIETRASZKO R., DE CLERQ R., 1981 - Carabidae of arable land in Belgium. - Parasitica 37 (2): 45-58.

PORTA A., 1923, 1934 - Fauna Coleopterorum Italica. I. Adephaga, Carabidae. Piacenza: Stab. Tip. Piac., Piacenza: 41-293. Suppl., ibid: 4-100. Suppl. II (1949) e III (1959), Stab. Tip. Soc. A.G. Gandolfi, Sanremo: 12-83 e 12-39.

RENKONEN O., 1938 - Statistisch-ökologische Untersuchungen über die terrestrische Käferwelt der finnischen Bruchmoore. - Ann. Zool. Soc. Zool.-Bot. Fenn. Vanamo 6: 1-231.

RIVARD I., 1966 - Ground beetles (Coleoptera: Carabidae) in relation to agricultural crops. - Canad. Ent. 98: 189-195.

SCHERNEY F., 1961 - Beiträge zur Biologie und ökonomischen Bedeutung räuberisch lebender Käferarten. - Z. angew. Ent. 48: 163-175.

SCIAKY R., TREMATERRA P., 1991 - Coleotteri Carabidi presenti nei meleti della Valtellina. - Boll. Zool. agr. Bachic., Ser. II, 23 (2): 95- 111.

SEKULIC R., CAMPRAG D., KERESI T., TALOSI B., 1987 - Fluctuations of Carabid population density in winter wheat fields in the region of Backa, northeastern Jugoslavia. - Acta Phytopath. Entom. Hung. 22 (1-4): 265-271.

SKUHRAVY V., 1970 - Zur Anlockungsfähigkeit von Formalin für Carabiden in Bodenfallen. - Beitr. Entomol. 20: 371-374.

SÖRENSEN T., 1948 - A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analyses of the vegetation on Danish commons. - Vidensk. Selsk. Biol. Skr. 5: 1-34.

THIELE H.U., 1977 - Carabid beetles in their environments. - Springer-Verlag, Berlin-Heidemberg-New York, 389 pp.

VIGNA TAGLIANTI A., 1993 - Coleoptera Archostemata, Adephaga 1 (Carabidae). In MINELLI A., RUFFO S., LA POSTA S. (eds.) - Checklist delle specie della fauna italiana, 44. Calderini, Bologna.

ZANDIGIACOMO P., BARBATTINI R., PARMEGIANI P., 1986-1987 - Indagine sui Coleotteri Carabidi in vigneti friulani a diversa conduzione agronomica. - Boll. Zool. agr. Bachic., Ser. II, 19: 119-144.

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