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Epigeal fauna in a vegetable agroecosystem

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The density of activity of spiders, carabids, staphylinids and ants in a field of white cabbage was estimated by means of pitfall traps from the 8.6 to the 21.9.1994. The field was divided into three equal plots, one of which was treated with broad spectrum insecticides (fonofos, dimethoate and cypermethrin), another with selective insecticides (pirimicarb and *Bacillus thuringiensis*), while the third plot remained untreated. Thirty-one species of spiders, thirty-five species of carabids, and twenty-two species of staphylinids were found. Insecticide treatment did not fundamentally modify the composition of species. However, a reduction in the number of catches of web spiders, dominated by *Oedothorax apicatus* of the Linyphiidae family, was observed following treatment with broad spectrum insecticides. The same was true for carabid beetles, dominated by *Bembidion quadrimaculatum*, and this species is proposed as an indicator of springtime surface treatment effects on beneficial fauna. Staphylinids are sensitive to fonofos as an early soil treatment. Ants did not appear to be adapted for measurement of pesticide side effects.

Keywords: epigeal fauna, vegetable agroecosystem, white cabbage, spiders, *Oedothorax apicatus*, carabids, *Bembidion quadrimaculatum*, staphylinids, ants, insecticides, side effect

INTRODUCTION

Present agricultural policies seek to revitalise agricultural landscape, and at the same time maintain a healthy, economically-viable agriculture. The creation of areas removed from agricultural production aims not only to preserve but also to enrich biodiversity.

Epigeal fauna plays an important role in these schemes since it is thought that some of their arthropod members possess bioindicator characteristics which permit an evaluation of the quality of the environment. For this reason, over the last few years, the number of studies on this subject has increased.

The present study highlights the specific wealth of certain elements of the epigeal fauna in a white cabbage field. Furthermore, the experimental set-up allowed the effects of two different insecticide programmes on the arthropods to be followed up.

MATERIALS AND METHODS

The experiment described took place in 1994. The white cabbage field is located at an elevation of 380m a.s.l. on the former vegetable experimental farm of "Rives de Prangins" of the Federal Research Station for Plant Production of Chan-

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gins, Switzerland. On its northern side, the experimental field is bordered by a field of carrots. To the east lies a stretch of extensively managed meadow, preceding a hedge of bushes and trees. To the south lie some rows of onions and an extensively managed meadow, and to the west, a strip of grass and fallow land. The shores of Lake of Geneva lie some 250m to the south. Leek was cultivated previously on the experimental plot.

The soil has the following properties: Organic matter: 3.2%; pH: 8.1; total calcium carbonate ($CaCO_3$): 14%; granulometry after 2mm screening: 27% clay, 34% silt, 39% sand (a non-negligible part of gravel having been eliminated by screening). Soil classification lies between a loam and a clay loam, with a weak structure.

The size of the experimental field corresponds to that of other fields on the farm with a surface area of approximately 432 m^2 (12 x 36 m) and is oriented east-west. The land was ploughed in the autumn 1993. About 1,650 young plants of white cabbage, cv. 'Polinius F1', were mechanically planted on the 6.7.1994. Fertiliser spreading was split and made in two applications. The pre-emergence herbicide metazachlor (Butisan S) was applied on the 9.6. Frequency of watering was based on PET (potential evaporation transpiration) and occurred every 7 to 10 days between mid-June and the end of August.

The field was subdivided into 3 plots of 144 m^2 each (12 x 12 m) placed side by side. The untreated control plot (UT) is situated in between the plot treated with broad spectrum insecticides (BI) to the east and the plot treated with selective insecticides (SI) to the west.

The following applications were made in the BI treatment: fonofos (Dyfonate 5G) 1 g/plant, at the base of the stem, against cabbage root fly, *Delia radicum*, using a dosing stick (8.6); dimethoate (Perfekthion 0.1%), sprayed against the cabbage aphid, *Brevicoryne brassicae*, (29.6, 6.7, 20.7); and cypermethrin (Ripcord 0.075%) sprayed against caterpillars (cabbage moth, *Mamestra brassicae*; small cabbage-white, *Pieris rapae*; diamondback moth, *Plutella xylostella*) (6.7, 20.7, 15.8).

In the SI treatment, the following applications were made: pirimicarb (Pirimor 0.05%) against *B. brassicae* (29.6, 6.7, 20.7) and *Bacillus thuringiensis* var. *aizawai* (Turex 0.4%) against caterpillars (6.7, 20.7, 15.8).

The products were applied using a knapsack motor sprayer with handgun. The spray volume used depended on foliage volume and varied between 800 and 1,200 l/ha. To improve the wetting ability of the sprays Etalfix 0.1% was systematically added.

The dates of treatment against pests above ground were determined according to the first event sampling method (FREULER & FISCHER 1991).

The activity of the four most important groups of the epigeal fauna, that is, spiders, carabids, staphylinids and ants, was followed using pitfall traps. Four traps were placed on the 8.6 at each corner of a square, 4.5 x 4.5 m approximately, situated in the middle of each plot. The traps were emptied regularly every 6 to 7 days throughout the period of cultivation (105 days) from the 8.6 to the 21.9 (a total of 14 collections). The spiders and carabids captured were counted and identified to species; staphylinids and ants were counted only. However, an identification of species in a representative sample of staphylinids was made in order to provide a list of species.

Carabid identification was verified by Helfried WÖLKERING and staphylinid species identification by Joachim ZIMMERMANN of the BBA at Braunschweig.

In order to study the influence of insecticide treatments on the evolution of arthropod populations, the student SYSTAT program was used. Thus, a two-factor (date and treatment) and a single factor (treatment only) analysis of variance ANOVA was possible. Single factor analysis was followed up by a multiple comparison according to the Tukey test. Unless otherwise indicated, significant differences were at the level $P \leq 0.05$.

RESULTS

Spiders

Population

Over the whole of the experimental field, 31 species of the order Araneae were captured in the pitfall traps. Nine families were identified in all (Tab. 1) of which two were represented by immature individuals only. The family with the highest number of individuals captured were the Linyphiidae with 19 different species, followed by the Lycosidae with 7 species and the Tetragnathidae with one species (Tab. 2). All the other families were represented by a single species or by immature individuals of non identified species. In Tab. 3 the species are arranged in order of decreasing total number of adults captured. Their frequency and accumulated frequency, together with abundance, guild, ecological preference of habitat and ballooning capacity are also indicated. Of these 31 species in the community, 23 are found in the UT treatment, 22 in the BI treatment and 20 in the SI treatment. Five species made up more than 90% of catches in the UT and SI treatments and eight for the BI treatment (Fig. 1).

Activity

Table 4 summarises the global effect of the insecticide programmes on the total number of spider catches. Spiders accounted for the greatest number of organisms trapped, followed by carabids, staphylinids and ants. The two-factor (date and treatment) analysis of variance revealed significant differences ($P \leq 0.01$) for both factors and their interaction. This was a reflection of the population's seasonal movements influenced by the insecticide interventions.

The results of single factor (treatment) analysis of variance carried out on each day of capture, are presented in Fig. 2. In the absence of insecticide treatment, spider activity reached a peak during the month of July and then decreased gradually until the end of the period of capture. In the SI treatment, activity seemed unaffected. Conversely, the depressive effect of the BI treatment became noticeable from mid-July through to the end of August but only became statistically significant in the second half of July and on the 31.8. In order to further clarify analysis, the spider population was sub-divided into guilds according to HATELY & MACMAHON (1980) with some minor modifications. In this study, the guild of daytime active and nocturnal wandering spiders included both immature and adult Lycosidae and Zodariidae, Tetragnathidae adults and immature Gnaphosidae and Dysderidae. The guild of web spiders included immature and adult Linyphiidae, Agelenidae and Theridiidae, and immature Tetragnathidae of the genus *Pachygnatha*. Finally, the guild of ambush spiders comprised only seven immature and adult Thomisidae individuals and was not included in the analysis.

Wandering spiders. In the untreated control plot, the activity of wandering spiders reached a maximum during July, decreased rapidly afterwards and then picked

Tab. 1. List of adult spider species captured in 12 pitfall traps between the 8.6 and the 21.9.1994 on a white cabbage field on the "Rives de Prangins". Nomenclature according to PLATNICK (1993).
Ag = Agelenidae, **Li** = Linyphiidae, **Ly** = Lycosidae, **Te** = Tetragnathidae, **Ti** = Theridiidae, **Th** = Thomisidae, **Zo** = Zodariidae.

Species	Family
Araeoncus humilis (Blackwall, 1841)	Li
Bathyphantes gracilis (Blackwall, 1841)	Li
Dicymbium nigrum (Blackwall, 1834)	Li
Diplostyla concolor (Wider, 1834)	Li
Erigone atra Blackwall, 1833	Li
Erigone dentipalpis (Wider, 1834)	Li
Lepthyphantes arenicola Denis, 1962	Li
Lepthyphantes tenuis (Blackwall, 1852)	Li
Meioneta mollis (O.P.-Cambridge, 1871)	Li
Meioneta rurestris (C.L. Koch, 1836)	Li
Meioneta simplicitarsis (Simon, 1884)	Li
Micrargus subaequalis (Westring, 1851)	Li
Oedothorax apicatus (Blackwall, 1850)	Li
Oedothorax fuscus (Blackwall, 1834)	Li
Ostearius melanopygius (O.P.-Cambridge, 1879)	Li
Pachygnatha degeeri Sundevall, 1830	Te
Pardosa agrestis (Westring, 1862)	Ly
Pardosa hortensis (Thorell, 1872)	Ly
Pardosa palustris (Linnaeus, 1758)	Ly
Pardosa proxima (C. L. Koch, 1847)	Ly
Pelecopsis parallela (Wider, 1834)	Li
Porrhomma microphthalmum (O.P.-Cambridge, 1871)	Li
Robertus neglectus (O.P.-Cambridge, 1871)	Ti
Tegenaria atrica C.L. Koch, 1834	Ag
Trematocephalus cristatus (Wider, 1834)	Li
Trochosa ruricola (De Geer, 1778)	Ly
Trochosa terricola Thorell, 1856	Ly
Walckenaeria vigilax (Blackwall, 1853)	Li
Xerolycosa miniata (C.L. Koch, 1834)	Ly
Xysticus kochi Thorell, 1872	Th
Zodarion italicum (Canestrini, 1868)	Zo

up again during the second half of August (Fig. 3). These peaks were due to the presence of numerous young Lycosidae which fell into the traps while being carried by their mothers. The lower number of catches in the BI treatment and, to a lesser extent, the SI treatment, were not statistically valid.

Web spiders. In the absence of treatment, the overall web spider activity was at its maximum between the end of June and August (Fig. 3), decreasing gradually in September. The depressive effect in the BI treatment was significant in July and August. Treatments during the months of June and July caused a significant reduction in catches up to the beginning of August. The August treatment also affected the activity of these spiders significantly up to the end of the month. On the other hand, the SI treatment showed no difference from the UT treatment.

Tab. 2. Percentage of spider individuals caught per family. The following families come under "others": Agelenidae, Dysderidae, Gnaphosidae, Thomisidae, Theridiidae and Zodariidae. N = 5285.

Family	%
Linyphiidae	75,2
Lycosidae	22,7
Tetragnathidae	1,6
others	0,5

Some minor differences were noted in the periods of activity between male and female web spiders. The males were especially active during the first half of the observation period. The negative influence in the BI treatment was occasionally statistically noticeable during the period 29.6 to 10.8. Female activity was more regular and evenly spread out than that of the males and the effect in the BI treatment was sometimes statistically significant between early July and the end of August. In the SI treatment, the only day on which reduced catches were recorded was the 6.7.

The activity of immature web spiders was at a maximum in July and no obvious effect was produced by the two insecticide programmes.

Tab. 3. Recapitulation of spider species: number, frequency (%), accumulated frequency, abundance, guild, preferred ecological habitat and ballooning capacity.
a = frequent (> 1 specimen per day per trap), c = common (1,0 - 0,1 specimen per day per trap), o = occasional (0,1 - 0,02 specimen per day per trap), r = rare (< 0,02 specimen per day per trap); from Esau et al. (1975).
OA = open areas, FI = fields, P = prairies, U = ubiquitous, FO = forests, HC = houses/caves, R = ruderal. Where the ecology of a species is not adequately known, ecological preferences are combined to give a clearer idea. Established according to Hänggi et al. (1995), Maurer & Hänggi (1990) and Pozzi & Hänggi (1998) for *Lepthyphantes arenicola*.
* ballooning species, according to Blandenier & Fürst (1998).

Species	Number	(%)	Accum. (%)	Abundance		Guild	Ecology	Ballooning
				No. per day per trap	Rank			
Oedothorax apicatus	2411	67,33	67,33	1,913	a	web spider	OAFI	*
Pardosa proxima	328	9,16	76,49	0,260	c	wandering spider daytime	OAP	*
Erigone dentipalpis	211	5,89	82,38	0,167	c	web spider	OAFI	*
Pardosa hortensis	155	4,33	86,71	0,123	c	wandering spider daytime	OAR	
Meioneta rurestris	124	3,46	90,17	0,098	o	web spider	OAFI	*
Bathyphantes gracilis	69	1,93	92,10	0,055	o	web spider	OA	*
Erigone atra	57	1,59	93,69	0,045	o	web spider	OAFI	*
Pardosa agrestis	47	1,31	95,00	0,037	o	wandering spider daytime	OAFI	
Pachygnatha degeeri	39	1,09	96,09	0,031	o	wandering spider daytime	OAP	*
Trochosa ruricola	28	0,78	96,87	0,022	o	wandering spider daytime	OAFI	
Oedothorax fuscus	20	0,56	97,43	0,016	r	web spider	OAP	*
Araeoncus humilis	17	0,47	97,91	0,013	r	web spider	OAP	*
Meioneta simplicitarsis	16	0,45	98,35	0,013	r	web spider	OA	*
Porrhomma microphthalmum	13	0,36	98,72	0,010	r	web spider	OAFI	*
Lepthyphantes tenuis	11	0,31	99,02	0,009	r	web spider	U	*
Pardosa palustris	8	0,22	99,25	0,006	r	wandering spider daytime	OAP	
Robertus neglectus	4	0,11	99,36	0,003	r	web spider	FO	*
Walckenaeria vigilax	3	0,08	99,44	0,002	r	web spider	OAFI	*
Zodarion italicum	3	0,08	99,53	0,002	r	wandering spider daytime	OA	
Dicymbium nigrum	2	0,06	99,58	0,002	r	web spider	OAP	*
Micrargus subaequalis	2	0,06	99,64	0,002	r	web spider	OAP	*
Diplostyla concolor	2	0,06	99,69	0,002	r	web spider	UFO	*
Lepthyphantes arenicola	2	0,06	99,75	0,002	r	web spider	P	
Xysticus kochi	2	0,06	99,80	0,002	r	ambush spider	OAFI	
Tegenaria atrica	1	0,03	99,83	0,001	r	web spider	HC	
Ostearius melanopygius	1	0,03	99,86	0,001	r	web spider	FO	
Pelecopsis parallela	1	0,03	99,89	0,001	r	web spider	OAP	*
Trematocephalus cristatus	1	0,03	99,92	0,001	r	web spider	P	*
Meioneta mollis	1	0,03	99,94	0,001	r	web spider	OA	*
Trochosa terricola	1	0,03	99,97	0,001	r	wandering spider daytime	U	
Xerolycosa miniata	1	0,03	100	0,001	r	wandering spider daytime	R	

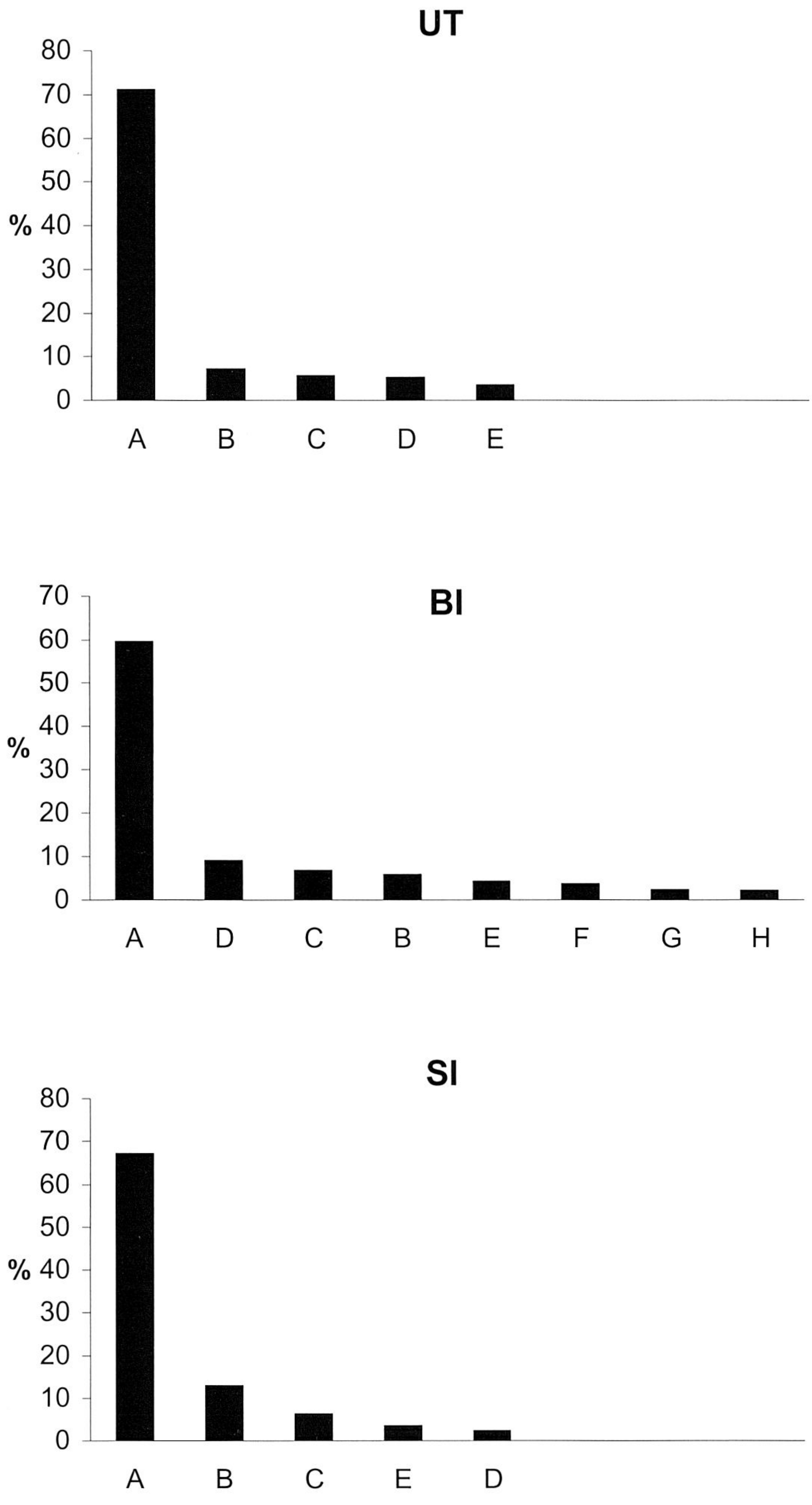

Fig. 1. Frequency (%) of spider species (dominance structure) representing over 90% of numbers in the untreated control (UT), broad spectrum insecticide treatment (BI) and selective insecticide treatment (SI) on the "Rives de Prangins" in 1994. Species are ranked in order of decreasing numbers. A = *Oedothorax apicatus*, B = *Pardosa proxima*, C = *Erigone dentipalpis*, D = *Pardosa hortensis*, E = *Meioneta rurestris*, F = *Bathypantes gracilis*, G = *Pachygnatha degeeri*.

Carabids

Population

The carabid family from the whole of the experimental field was composed of 35 species; Tab. 5 gives a list of the species in alphabetical order. Table 6 lists the species in decreasing order of number of individual catches. Also itemised are frequency (%), accumulated frequency, abundance and size of species.

Bembidion quadrimaculatum is the only frequently occurring species and accounted for 81.6% of catches. *Tachys bistriatus* is commonly found, followed by five species occasionally found and 28 rare species. Species of small size (< 6 mm) make up the greater part of captured individuals (94.3%). Figure 4 illustrates the phenology of the seven most frequently occurring species and allows an overall view of the carabid seasonal evolution over the whole experimental field.

Of the 35 species in the community 25 were found in the UT and BI treatments, and 26 in the SI treatment. In the UT and SI treatments, 90% of catches were composed of three species and in the BI treatment, eight species made up 90% of catches (Fig. 5).

Activity

The global influence of treatments BI and SI on the total number of captured carabids is summarised in Tab. 4. This family of Coleoptera constitutes the second most numerous group of arthropods.

As for the spiders, two-factors (date and treatment) analysis of variance revealed significant differences ($P \leq 0.01$) for the factors and their interaction. Figure 2 shows single factor (treatment) analysis of variance according to date of capture. In the UT treatment, overall carabid activity began increasing mid-June and reached a maximum towards mid-July, falling off again to its initial low level as from mid-August. There were no significant differences between the UT and the SI treatments. In the BI treatment, from the second half of June and up to the end of August, the negative influence was noticeable by the reduction in the number of catches compared with the other two treatments. The distinct effects recorded in the BI treatment before insecticide application on foliage could be due to soil treatment with fonofos.

The influence of the insecticide programmes on catches of the seven most common species is illustrated in Fig. 6. Considering the predominance of *B. quadrimaculatum*, its reaction to treatment influenced the whole carabid community. Dur-

Tab. 4. Number of individuals per arthropod group caught in four pitfall traps from the 8.6 to 21.9.1994 and their proportion (%) in the untreated control plot (UT), the broad spectrum insecticide treatment plot (BI) and the selective insecticide treatment plot (SI).

Arthropod group	Treatment						Total	
	UT		BI		SI			
spiders	2224	(42,8)	981	(32,9)	2080	(39,7)	5285	(39,4)
carabids	1513	(29,2)	494	(16,5)	1749	(33,3)	3756	(28,0)
staphylinids	1117	(21,5)	784	(26,3)	1137	(21,7)	3038	(22,6)
ants	335	(6,5)	724	(24,3)	276	(5,3)	1335	(10,0)

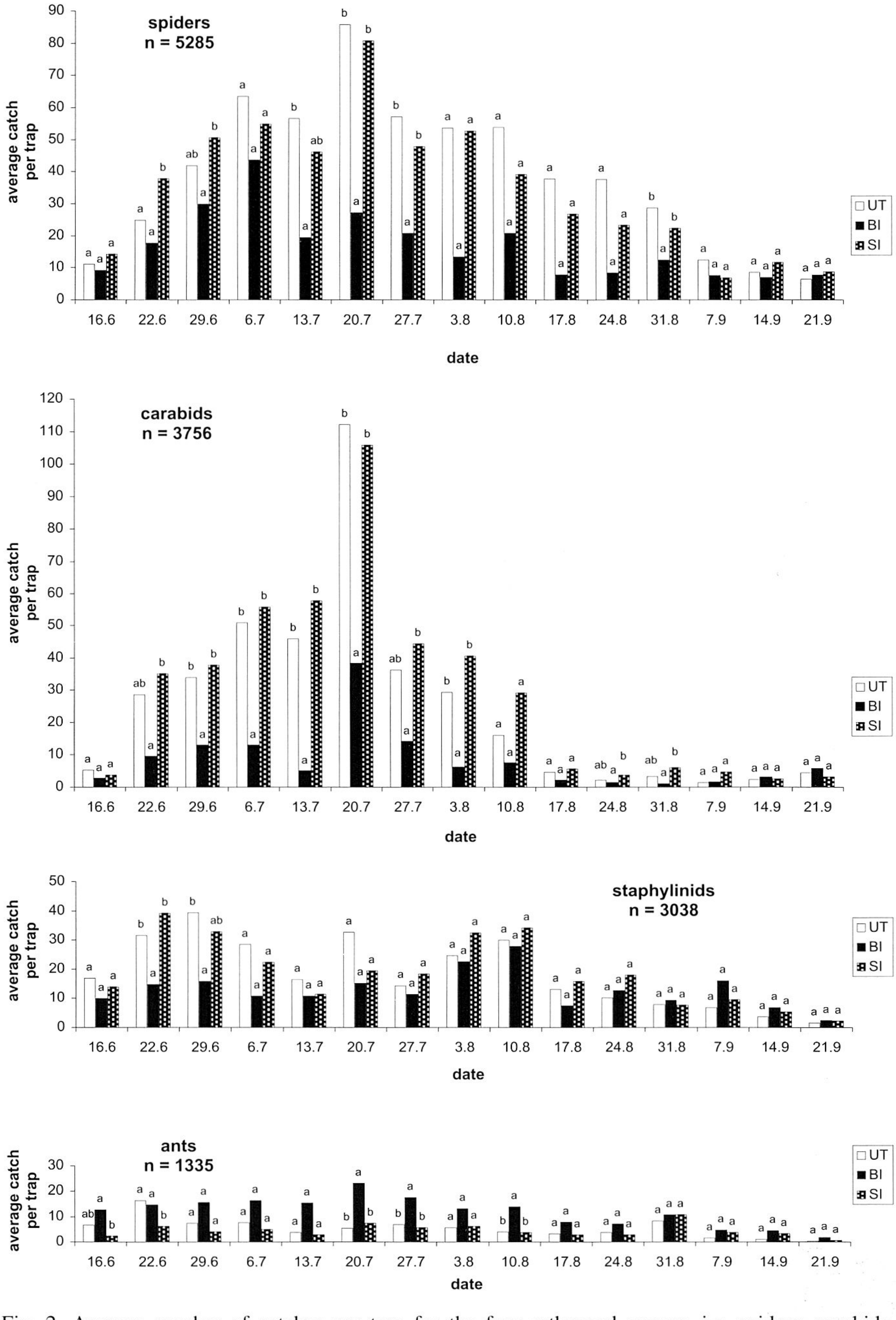

Fig. 2. Average number of catches per trap for the four arthropod groups, i.e. spiders, carabids, staphylinids and ants, arranged according to date of trap emptying for the untreated control (UT), broad-spectrum insecticide treatment (BI) and selective insecticide treatment (SI) on the "Rives de Prangins" in 1994.
For each date, columns marked with dissimilar letters differed significantly from each other.

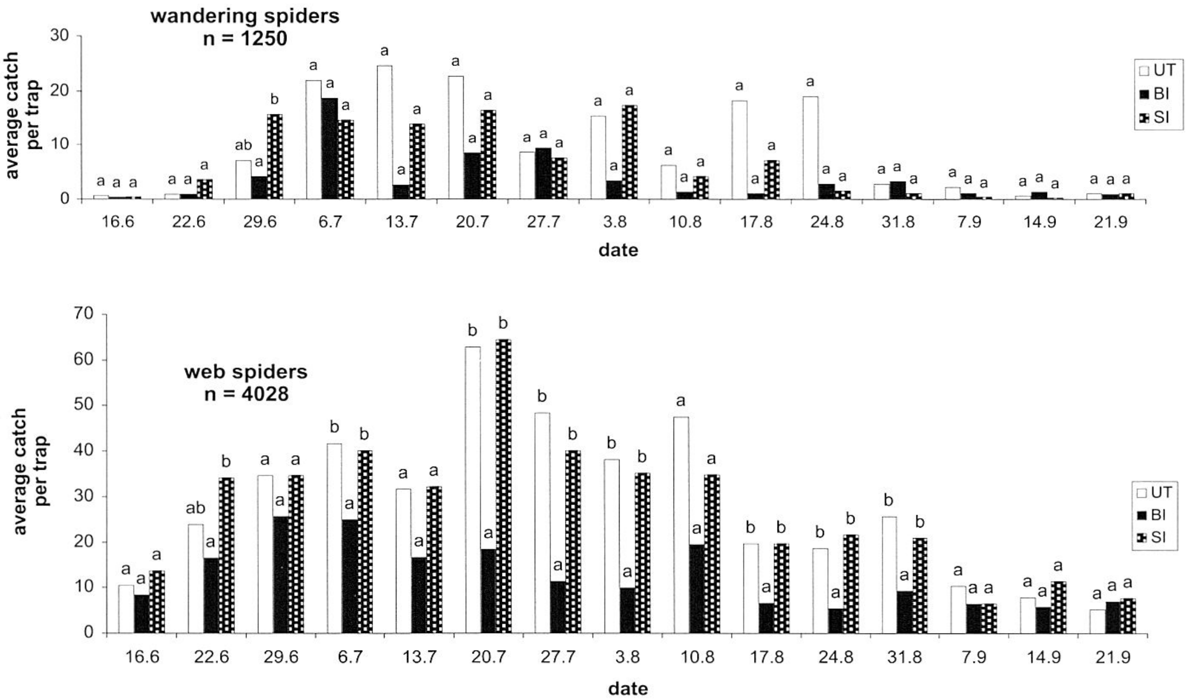

Fig. 3. Average number of catches per trap for wandering and web spiders, arranged according to date of trap emptying for the untreated control (UT), broad-spectrum insecticide treatment (BI) and selective insecticide treatment (SI) on the "Rives de Prangins" in 1994.
For each date, columns marked with dissimilar letters differed significantly from each other.

ing the period of observation, the loss of catches of this species in the BI treatment reached 73% compared with the control plot. On the other hand, the SI treatment did not have a significant effect on the number of catches. *Tachys bistriatus* showed an even greater sensitivity than the above-mentioned species to insecticide treatment with an 88% drop in catches in the BI treatment. In the SI treatment, the only significant depressive reaction was observed on the 27.7, following treatment the previous week. As for the species *Tachys parvulus*, the number of catches varied according to the insecticide programme (- 48% in the BI treatment and - 13% in the SI treatment). However these differences are not statistically valid since the numbers of individuals caught were too low. Because of its seasonal behaviour, *Harpalus rufipes* largely escaped treatment. A significant increase in the number of catches was nevertheless recorded in the SI treatment, especially at the end of the season. *Trechus quadristriatus* made its appearance too late to be affected by treatments; on the contrary, a rise of 189% in the number of catches was noted in the BI treatment compared with the control. The differences were not, however, statistically valid. In general, the catches of *Poecilus cupreus* and *Microlestes minutulus* were too low to allow treatment effects to be seen.

Staphylinids

Population

A list of staphylinids captured over the whole experimental field throughout the period of trapping comprised 22 species (Tab. 7).

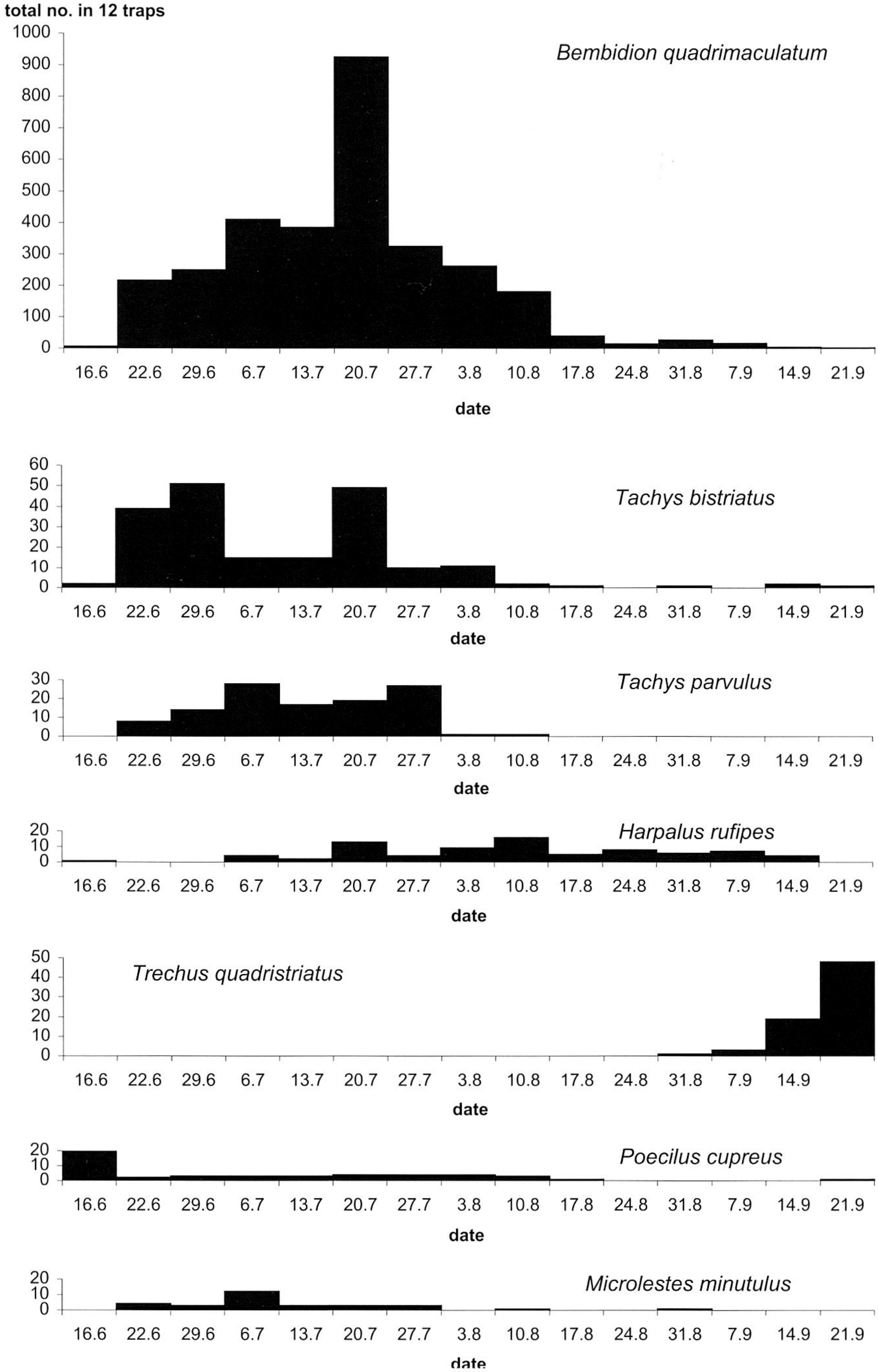

Fig. 4. Evolution in catches of the 7 most frequently occurring carabid species in 12 pitfall traps, caught in a white cabbage field on the "Rives de Prangins" between 8.6 and 21.9.1994.

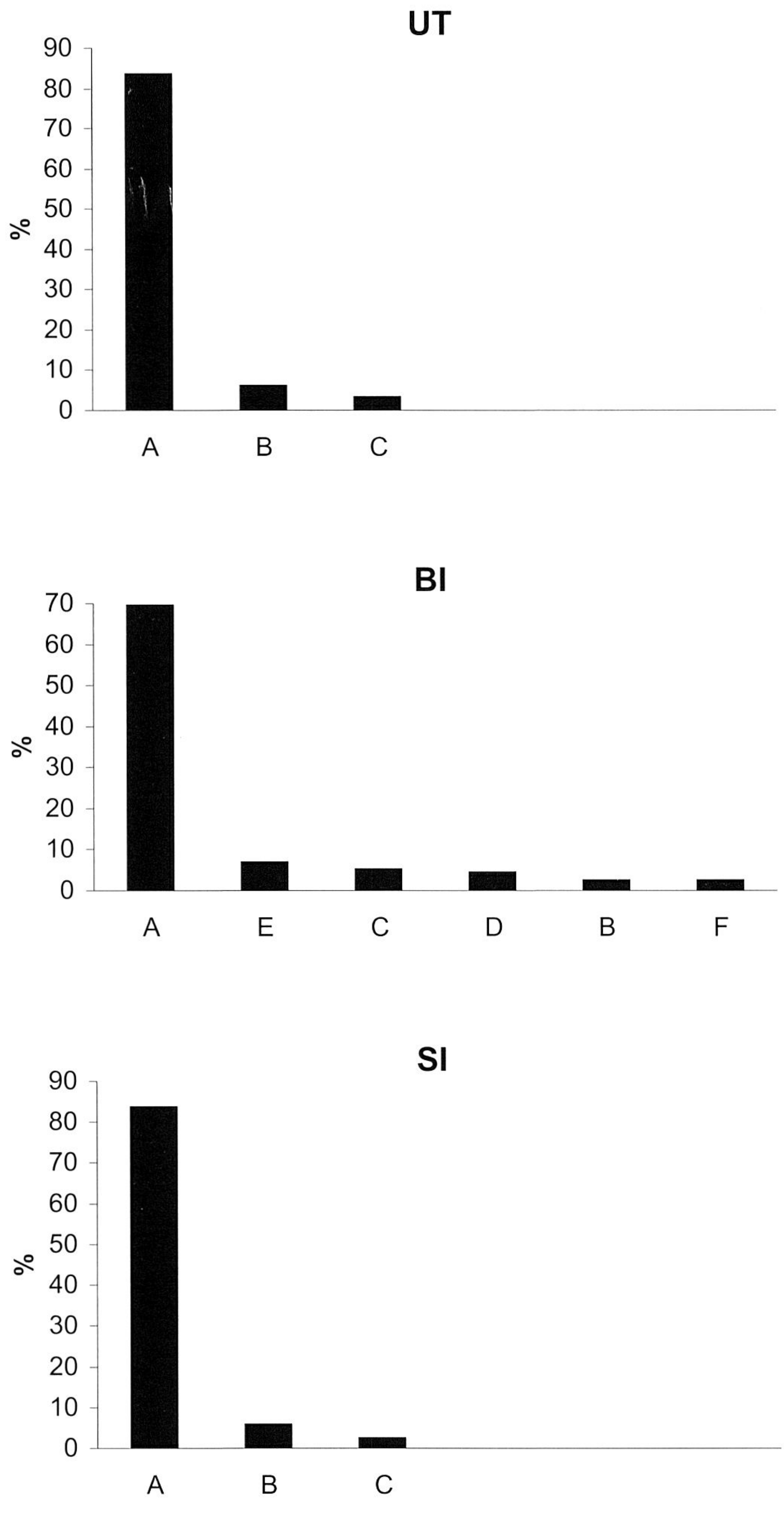

Fig. 5. Frequency (%) of carabid species (dominance structure) representing over 90% of numbers in the untreated control (UT), broad spectrum treatment (BI) and selective insecticide treatment (SI) on the "Rives de Prangins" in 1994. Species are ranked in order of decreasing numbers.
A = *Bembidion quadrimaculatum*, B = *Tachys bistriatus*, C = *Tachys parvulus*, D = *Harpalus rufipes*, E = *Trechus quadristriatus*, F = *Microlestes minutulus*.

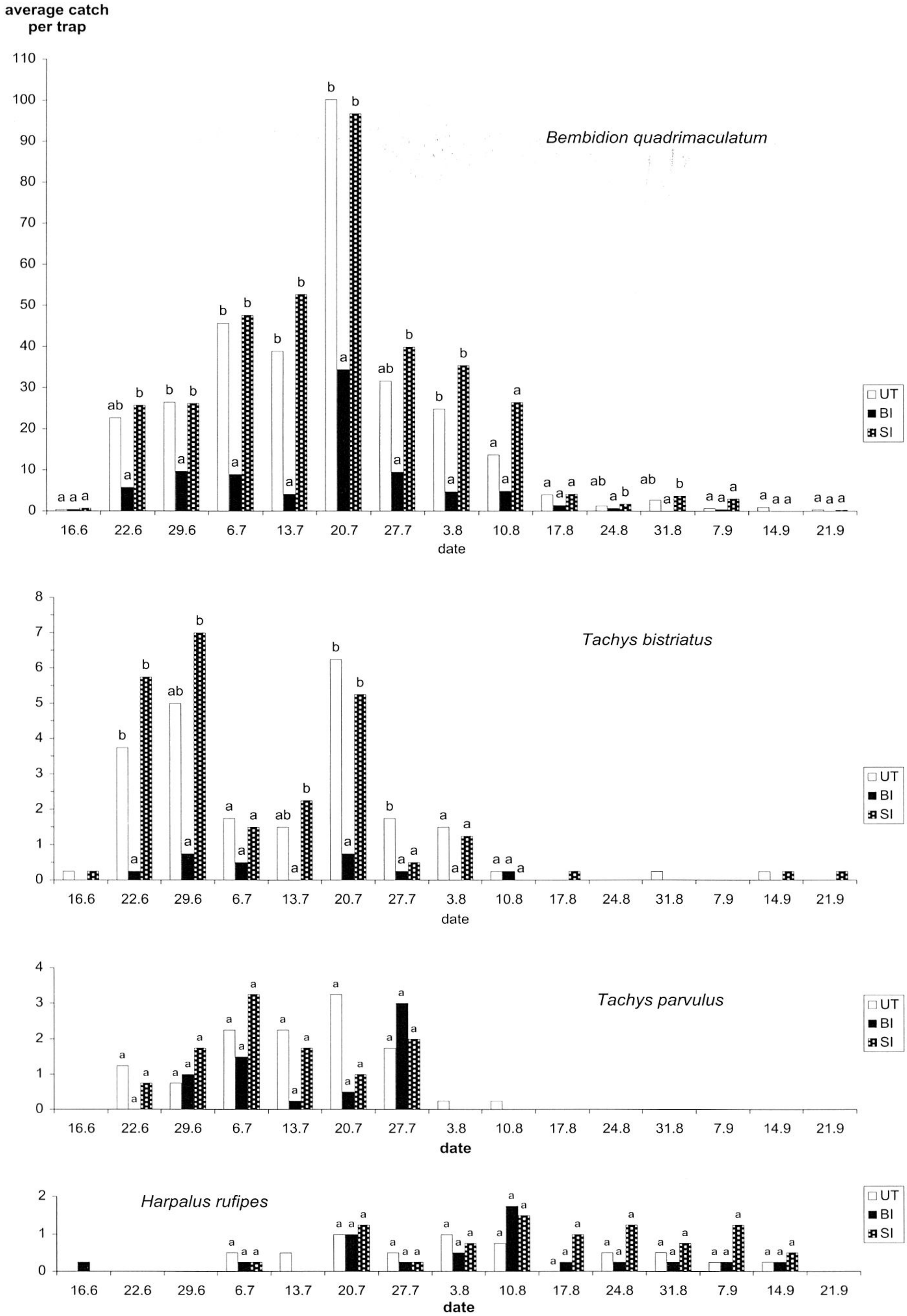

Fig. 6a (follow on Fig. 6b). Average number of catches per trap for the 7 most frequently occurring carabid species, arranged according to date of trap emptying for the untreated control (UT), broad-spectrum insecticide treatment (BI) and selective insecticide treatment (SI) on the "Rives de Prangins" in 1994.

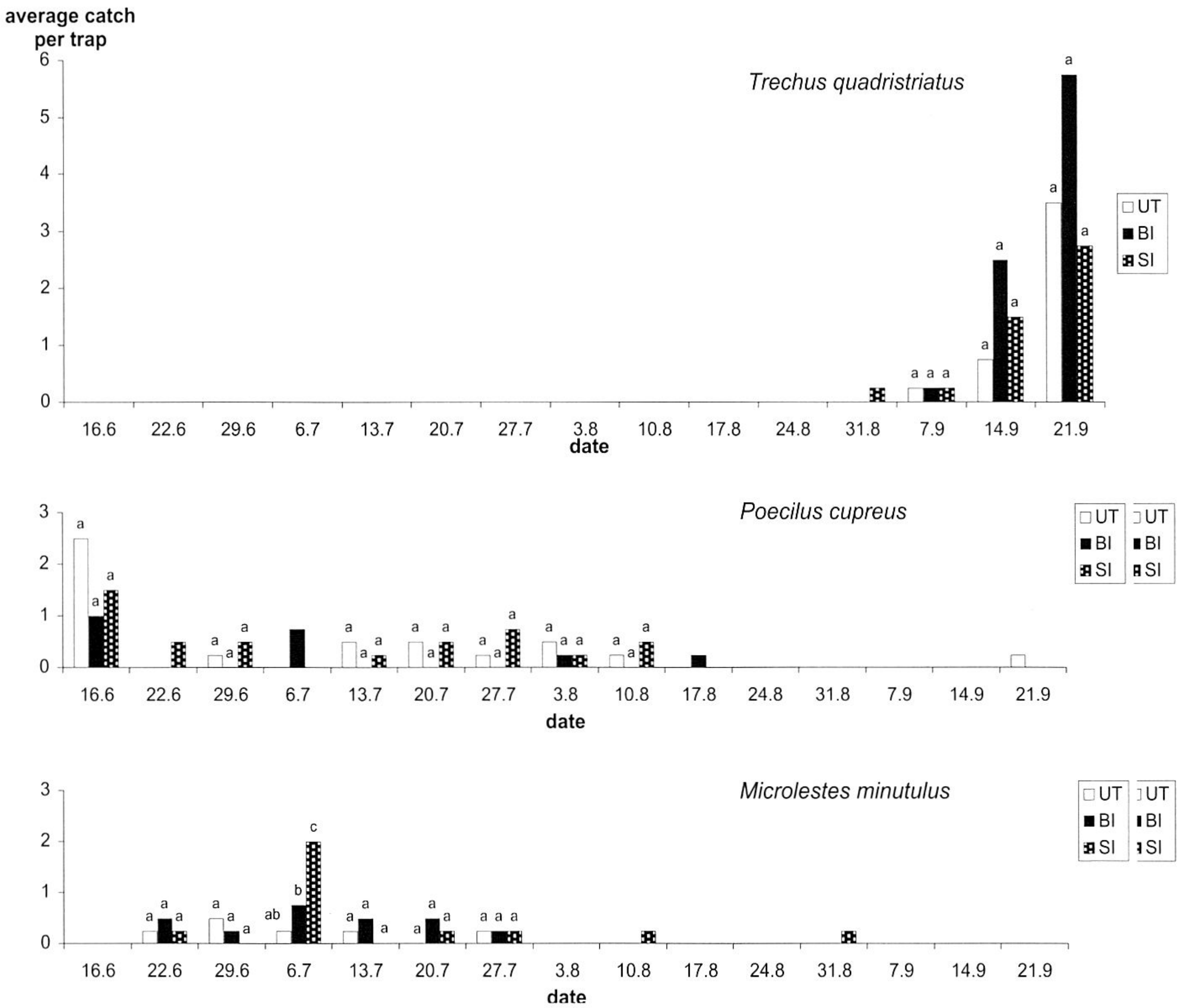

Fig. 6b (follow to Fig. 6a). Average number of catches per trap for the 7 most frequently occurring carabid species, arranged according to date of trap emptying for the untreated control (UT), broad-spectrum insecticide treatment (BI) and selective insecticide treatment (SI) on the "Rives de Prangins" in 1994.

Activity

The overall effect of insecticide programmes on the total number of captured staphylinids is summarised in Tab. 4. The number of individuals in this group accounts for approximately half that of spiders.

The results of two-factor analysis of variance were similar to those of the two preceding groups. The details of influence of single factor analysis of variance by date of capture are given in Fig. 2.

In the UT treatment, there were fewer representatives of the staphylinid family than spiders and carabids. There would appear to be two periods of activity during the period of capture: from the first half of June to early July, and from the second half of July to September.

The effect of foliage treatment was not significant. The lack of catches in the BI treatment before foliage sprays could be due to soil application of fonofos.

Tab. 5. List of carabid species captured in 12 pitfall traps between the 8.6 and the 21.9.1994 on a white cabbage field on the "Rives de Prangins".

Species
Acupalpus meridianus L.
Agonum muelleri Herbst
Agonum sexpunctatum L.
Amara aenea De Geer
Amara convexior Steph.
Amara similata Gyll.
Anisodactylus binotatus Fabr.
Badister bullatus Schrank
Bembidion lampros/properans Herbst/Steph.
Bembidion latinum Net.
Bembidion lunulatum Fourcr.
Bembidion quadrimaculatum L.
Bembidion tetracolum Say
Brachinus elegans Chaud.
Clivina fossor L.
Dyschirius aeneus Dej.
Harpalus affinis Schrank
Harpalus distinguendus Duft.
Harpalus griseus Panz.
Harpalus rufipes De Geer
Loricera pilicornis Fabr.
Microlestes minutulus Goeze
Nebria brevicollis Fabr.
Ophonus ardosianus Luts.
Ophonus azureus Fabr.
Ophonus puncticeps Steph.
Platynus dorsalis Pont.
Poecilus cupreus L.
Pterostichus madidus F.
Pterostichus melanarius Illig.
Stomis pumicatus Panz.
Tachys bistriatus Duft.
Tachys parvulus Dej.
Trechus quadristriatus Schrank

Ants

Activity

The overall effect of the insecticide programmes on the total number of ants is summarised in Tab. 4.

Tab. 6. Some characteristics of captured carabids: number, frequency (%), accumulated frequency, abundance and average size.
a = frequent (> 1 specimen per day per trap), c = common (1,0 - 0,1 specimen per day per trap), o = occasional (0,1 - 0,02 specimen per day per trap), r = rare (< 0,02 specimen per day per trap); from ESAU et al. (1975).
p = small species (< 6 mm), m = middle-sized species (6 - 12 mm), g = large species (> 12 mm); from HOLOPAINEN & VARIS (1986).

Species	Number	(%)	Accum. (%)	Abundance		Size	
				No. per day per trap	Rank	Average (mm)	Rank
Bembidion quadrimaculatum	3065	81,60	81,60	2,4	a	3,2	p
Tachys bistriatus	199	5,30	86,90	0,16	c	1,9	p
Tachys parvulus	115	3,06	89,96	0,09	o	2,5	p
Harpalus rufipes	79	2,10	92,07	0,06	o	13,5	g
Trechus quadristriatus	71	1,89	93,96	0,06	o	4,0	p
Poecilus cupreus	48	1,28	95,23	0,04	o	11,0	m
Microlestes minutulus	30	0,80	96,03	0,024	o	3,1	p
Bembidion lampros/properans	19	0,51	96,54	0,015	r	3,8	p
Acupalpus meridianus	18	0,48	97,02	0,014	r	3,7	p
Harpalus affinis	16	0,43	97,44	0,013	r	10,5	m
Bembidion lunulatum	14	0,37	97,82	0,011	r	3,6	p
Platynus dorsalis	13	0,35	98,16	0,010	r	6,7	m
Harpalus distinguendus	12	0,32	98,48	0,010	r	9,8	m
Harpalus griseus	8	0,21	98,70	0,006	r	10,0	m
Ophonus ardosianus	8	0,21	98,91	0,006	r	15,0	g
Clivinia fossor	7	0,19	99,09	0,006	r	5,8	p
Pterostichus melanarius	5	0,13	99,23	0,004	r	15,0	g
Agonum muelleri	4	0,11	99,33	0,003	r	8,0	m
Pterostichus madidus	4	0,11	99,44	0,003	r	15,5	g
Brachinus elegans	3	0,08	99,52	0,002	r	7,3	m
Amara similata	2	0,05	99,57	0,002	r	8,8	m
Loricera pilicornis	2	0,05	99,63	0,002	r	7,0	m
Nebria brevicollis	2	0,05	99,68	0,002	r	11,5	m
Ophonus azureus	2	0,05	99,73	0,002	r	8,0	m
Agonum sexpunctatum	1	0,03	99,76	0,001	r	8,3	m
Amara aenea	1	0,03	99,79	0,001	r	7,3	m
Amara convexior	1	0,03	99,81	0,001	r	8,0	m
Anisodactylus binotatus	1	0,03	99,84	0,001	r	11,0	m
Badister bullatus	1	0,03	99,87	0,001	r	5,4	p
Bembidion latinum	1	0,03	99,89	0,001	r	5,3	p
Bembidion tetracolum	1	0,03	99,92	0,001	r	5,5	p
Dyschirius aeneus	1	0,03	99,95	0,001	r	3,0	p
Ophonus puncticeps	1	0,03	99,97	0,001	r	8,3	m
Stomis pumicatus	1	0,03	100,00	0,001	r	7,8	m

Significant differences ($P \leq 0.01$) for factors and their interaction showed up using two-factor analysis of variance. Results of single factor analysis of variance for each date of capture appear in Fig. 2. The activity of ants did not appear to be affected by the insecticide programmes.

DISCUSSION

Being well adapted to the capture of wandering spiders, the majority of carabids, staphylinids and ants, the pitfall trap is commonly used in studies of this kind. Nonetheless it has been the subject of some criticism due to its limitations (DINTER & POEHLING 1992, for example) and a thorough overview of these can be found in ADIS (1979) and EKSCHMITT et al. (1997). As the pitfall trap was designed as a trap

Tab. 7. List of staphylinid species captured in pitfall traps between the 8.6 and the 21.9.1994 in a white cabbage field on the "Rives de Prangins".

Species
Aleochara bipustulata (L.)
Aleochara laevigata Gyllenhal
Aleochara verna Say
Anotylus rugosus (Grav.)
Atheta oblita (Er.)
Carpelimus bilineatus (Steph.)
Carpelimus corticinus (Grav.)
Carpelimus gracilis (Mannh.)
Coprophilus striatulus (F.)
Drusilla canaliculata (F.)
Gauropterus fulgidus (F.)
Nehemitropia sordida (Mannh.)
Ocypus ater (Grav.)
Ocypus olens (Müll.)
Paederus litoralis Grav.
Philonthus atratus (Grav.)
Platystethus alutaceus Thoms.
Platystethus nitens (Sahlb.)
Scopaeus laevigatus Gyll.
Stenus biguttatus (L.)
Sunius (Hypomelon) bicolor (Ol.)
Tachyporus pusillus (Grav.)

for surface active animals, the results obtained should be interpreted in terms of the density of activity of the organisms to be studied. With this in mind, the study of side effects of insecticide treatment on epigeal fauna obviously cannot differentiate between direct effects (mortality) and indirect effects (sublethal, repellent, variations in prey quantities, reduced reproductive levels, effects of antagonists on the epigeal fauna), but only permits analysis of differences in density of activity following treatment.

The results obtained from a single season's observations should be considered as an isolated case and cannot be used to infer conclusions about long term effects of insecticides on epigeal fauna.

In spite of the relatively small size of the experimental field, results were quite clear concerning the intensity and length of pesticide effect on spiders and carabids. In comparison with the UT treatment, the latter suffered a 67.3% drop in the BI treatment, followed by spiders with a 55.9% drop and staphylinids with 29.8%. The differences noted in the numbers of ants caught were probably a reflection of the initial unique situation of each plot.

Although selective insecticides spare the epigeal fauna, their low efficacy against caterpillars reduced the cabbage crop yield. The arrival of a new selective compound on the market against these Lepidoptera could help to remedy this situation (FREULER et al. 2000).

Further studies on their widely varying habitats will be necessary before the biology and ecology of the principal species of epigeal fauna are fully understood. Epigeal fauna constitutes a considerable resource for agriculture which, it is hoped, man will be able to better manage in the long term.

Spiders

Population

The vast majority of the observed species are commonly found in fields and meadows locally (BLANDENIER & DERRON 1997) and in Switzerland in general (MAURER & HÄNGGI 1990). Most of the species are found in open habitats (Tab. 3) with a preference for arable fields or prairies. There was also a small number of ubiquitous or ruderal species.

Some 61% of these taxa have already been observed while ballooning at the adult stage using a suction trap placed at 2.5 km directly to the west of the experimental field (BLANDENIER & DERRON 1998). Out of 19 species, 17 were Linyphiidae. No local data on the aerial dispersion of Gnaphosidae, Zodariidae and Agelenidae were available.

A particular mention is made here concerning *Lepthyphantes arenicola* of which the first published Swiss record come from POZZI & HÄNGGI (1998). The authors identified this species, which belongs to a group difficult to identify, in different kinds of meadows in the cantons of Vaud and Geneva, and in neighbouring France. It would appear that this species presents morphological differences locally; it is to be noted that the palps of the two males caught in this study were very similar to those described originally by DENIS (1962).

During the period of experimentation, the composition of epigeal species was found to be typical of the habitat studied and was not fundamentally modified by insecticide applications. Perhaps, over a period of time, a change would become noticeable, but it is also possible that the species present in these habitats are well adapted in the event of environmental disturbances. The web spider *Oedothorax apicatus*, considered by LUCZAK (1979) as an agrobiont, is by far the most commonly occurring one and is dominant in all three treatments (accounting for between 60 and 70% of individuals). This spider's dominance has been noted in other fields of this region (BLANDENIER & DERRON 1997). In the BI treatment, fewer individuals were caught which meant that a larger number of different species than in the UT and SI treatments were necessary to reach 90% of catches. This explains why some other species, in particular the wandering spider *Pardosa hortensis*, are especially well represented in the BI treatment in relation to the other treatments.

Activity

Overall, as a result of treatment with broad spectrum insecticides, a general decrease in spider activity was observed and this was true for the major part of the study period. Such an effect may, in part, be outweighed by ballooning (see each guild) and by immigration of certain species from the edges of the experimental field (considering its small size) or from the neighbouring plots. This is true for wandering spiders which were thus less affected by treatment than the web spiders. The length of effect of each treatment can be estimated at over two weeks; while, throughout the whole growing period and up to the natural fall-off in the spider population, the effects of the insecticide programmes were measurable. This could be due to the timing of treatments, to the combination of products used and/or the phenology of the spiders. Thus, the combination of dimethoate with cypermethrin appeared to be more harmful than separate applications of the two products.

Wandering spiders. In spite of the fact that fewer catches of wandering spiders were recorded in the BI treatment compared with the control plot, it seems that they were relatively unaffected by treatment with broad spectrum insecticides. In a situation such as this, with small-sized plots and close proximity of reservoir zones such as the meadow and hedge to the east of the BI treatment, together with the great capacity of these spiders, e.g. *Pardosa proxima* and *P. hortensis*, for recolonisation, it is possible that part of the insecticide effect on spider activity is masked. BLANDENIER & DERRON (1997) have demonstrated the role played by shelters in field crop habitats. In 1994, air dispersal by ballooning (essentially young individuals) took place towards the end of September and during October (G. BLANDENIER, unpublished data). Thus, dispersal had no great influence on the number of spiders in this guild during the study period.

HEIMBACH et al. (1992) have shown by studies in the laboratory and in semi-field studies that Lycosidae of the genus *Pardosa* are affected by pesticides such as endosulfan or lamba cyhalothrin. The importance of the effect would appear to depend on the type of pesticide and the type of soil, the latter influencing the availability of the active substance to epigeal arthropods. Using data from other authors, TISCHLER (1965) noted that wandering spiders are more affected than web spiders by pesticides prepared with sulphur, by DDT and parathion.

Web spiders. A distinct reduction in activity was noted in the guild of wandering spiders (dominated by the linyphiids) and was noticeable after each application of pesticide in the plot treated with broad spectrum insecticides. Although this guild of spiders has a great capacity for aerial dispersion and recolonisation, it was not sufficient to overcome the effect of pesticides. In the year 1994, the whole period during which our experimental observations were made corresponded to a time in which the ballooning activity of web spiders was high. Ballooning was particularly busy at the end of July and the beginning of August and in the second half of September (G. BLANDENIER, unpublished data).

After treatment with dimethoate, DENNIS et al. (1993) have noted recolonisation of linyphiid spiders 28 days later. Different authors (WILES & JEPSON 1992, DINTER & POEHLING 1995, ULBER et al. 1990) have demonstrated in the laboratory the sensitivity of several species of Linyphiidae to different insecticides (parathion, oxydemethon-methyl, deltamethrin and various other pyrethroids). The species tested by these authors were well represented in our catches. In the majority of cases, treatment with insecticide led to the death or reduced activity of these animals. EVERTS (1990) has noted that *O. apicatus* suffered from paralysis and uncoordinated movements during the four days which followed application of deltamethrin. ULBER et al. (1990), however, observed an increase in the activity of *O. apicatus* after treatment using a mixture of parathion and oxydemethon-methyl.

It was difficult to establish with certainty any difference in sensitivity to broad spectrum insecticides between males and females. In the laboratory, DIN-

TER & POEHLING (1995) have shown that male *Erigone atra* and *O. apicatus* are more sensitive than the females to pyrethroids and that this type of pesticide is toxic to the young. Lambda cyhalothrin prevents young *E. atra* from coming out of their cocoon. Pirimicarb remained without effect on these species. Our findings concerning males were in contradiction with those of DINTER & POEHLING (1995).

Carabids

Populations

All of the species captured on the experimental field are known in the cultivated habitats of our region (DERRON & GOY 1996). *Brachinus elegans* and *Bembidion latinum* are on the red list of animal species, third degree (threatened) (DUELLI 1994). Their characterisation was taken from FREUDE et al. (1976), KOCH (1989), MARGGI (1992), WACHMANN et al. (1995) and literature originating mainly from Northern Europe. All species were eurytopic with the exception of two stenotopic species *Tachys bistriatus* and *Brachinus elegans*. There was no information concerning *Bembidion latinum*.

The xerophilous species *B. quadrimaculatum* was the most frequently caught in traps; the experimental field provided a favourable environment for its development. This beetle is able to adapt to rapid changes in its habitat and prefers open areas with sparse vegetation and strong light intensity. It hibernates in its larval and adult form in fields and nearby arable land, appears early in the season and reproduces in the spring. It does not seem to have two generations as described by FRANK (1971) for central Alberta, Canada. Colonisation of the various habitats takes place at the same period and also includes aerial locomotion since this beetle is caught - as many others are - in the 12 m high suction trap (LACMAN 1986). According to PAUER's (1975) classification, it belongs to the category of beetle which is characterised by massive activity in some places and fields and an absence of activity in others. Active during the day, it hunts insects at varying stages of development. It is found frequently in certain field crops and several field vegetable crops: carrots (RÄMERT 1996, BAINES et al. 1990), cabbage (HOKKANEN & HOLOPAINEN 1986, HOLOPAINEN & VARIS 1986), cauliflower (RÄMERT 1996), swede (FREULER 1974, RÄMERT 1996) and onion (SZWEJDA 1984), without, however, ever reaching the dominance observed during our experiments.

Tachys bistriatus is also an early breeding species but rather hygrophilous. It is the second most numerous species in the traps but nevertheless much less abundant than *B. quadrimaculatum*. Grassy habitats bordering the experimental field and the proximity of the lake could favour the species which can also fly.

Tachys parvulus is also hygrophilous but sufficiently adaptable to maintain a small population.

Harpalus rufipes appeared later in the season, following on the three above-mentioned species. It hibernates in the adult and larval stage and reproduces in the autumn. This species can fly and is mainly active at night. It feeds on aphids, insect larvae, seeds and achenes of strawberry (HOLOPAINEN & HELENIUS 1992). It is often found in various types of crops, preferably where plants are already well developed: potato (CRITCHLEY 1972), sugar beet, timothy grass (HOLOPAINEN & VARIS 1986), rape and wheat (PAUER 1975), cabbage (HOLOPAINEN & VARIS 1986; RÄMERT 1996), cauliflower, swede and carrot (RÄMERT 1996) and onion (SZWEJDA 1984).

The typically late-appearing species *Trechus quadristriatus* reproduces in the autumn and hibernates in the field mainly in its larval stage. It is found in all types of cultivated land with rather open vegetation (DESENDER & ALDERWEIRELDT 1990). Its powers of dispersion are exceptional (SUNDERLAND 1992) aided by its ability to fly since it is present in 12 m high suction traps (LACMAN 1986, SUNDERLAND 1992). It is a predator of eggs and insect larvae and is often found in field crops and field vegetable crops: cabbage (HOKKANEN & HOLOPAINEN 1986, HOLOPAINEN & VARIS 1986), cauliflower, swede and carrot (RÄMERT 1996), and onion (SZWEJDA 1984).

Poecilus cupreus belongs to the group of early-appearing beetles. This hygrophilous species depends on ruderal areas, damp meadows and borders of forests. It reproduces in the spring and is phytophagous and zoophagous (e.g. spiders and ants). As suggested by BOMMARCO (1988), it can be supposed that this species profits from the complex environment offered by this experimental site.

Microlestes minutulus appears early enough in the season to reproduce in the spring after having hibernated in the adult stage. Being xerophilous and photophilous, it prefers the open habitat offered by fields and ruderal areas. This flying species has been caught in 12 m suction traps (LACMAN 1986).

The 28 remaining rare species found suitable habitats and microhabitats surrounding the experimental field, where they were trapped from time to time either because they were often found in general in arable fields (*Bembidion lampros / properans*, *B. tetracolum*, *Platynus dorsalis*, *Clivina fossor*, *Agonum muelleri*, *Loricera pilicornis* and *Pterostichus melanarius*) or because they had a great capacity for dispersion (e.g. *Platynus dorsalis*, SUNDERLAND 1992). Furthermore, they may have immigrated aerially (*B. lampros*, *B. lunulatum*, *Agonum muelleri*, *Amara aenea*, *L. pilicornis*, *Dyschirius aeneus* (LACMAN 1986), *Pterostichus melanarius* (HOLOPAINEN & VARIS 1986) and *B. latinum*) or else have been associated with a plant-host regularly cultivated on the farm (e.g. carrots: *Ophonus ardosianus*, *O. puncticeps*; *Brassica*: *Amara similata*).

The specific richness in all three trial treatments was found to be fairly similar and unaffected by treatments. Furthermore, it was even felt that agricultural practices could be a more important influence than pesticides. Over a greater part of the year, the soil is rendered unfavourable to large species by tilling and weeding (BRUST 1990, SUNDERLAND 1992). As large species disperse relatively slowly, they are replaced by smaller ones which display great capabilities of colonisation (EYRE et al. 1990). As the season advances a mosaic of microhabitats is created which leads to the coexistence of species and reduced competition among them, particularly in the autumn (LEVINS & WILSON 1980).

In the present trial, the stratification of the different observed species reflected the conditions of development of the previous year. It could be argued that cultivating the land in a similar way from one year to another creates certain standard environmental constraints. In their turn, these produce one sort of community which can then be considered typical for that place. This community would then belong to a metapopulation, as supposed by SHERRAT & JEPSON (1993), where groups of local populations interact by dispersion. These populations are not distributed homogeneously throughout the habitats on a regional scale, nor do they submit to disturbances distributed homogeneously.

Bembidion quadrimaculatum was by far the most dominant species everywhere with frequencies of 69% (BI treatment) and 83% (UT and SI treatments). The fall-off in its catches in the BI treatment provoked a "biodiversity artefact" since a greater number of species was necessary to make up 90% of catches than in the UT and SI treatments. From the biodiversity point of view, the composition of the beetle community on the experimental field was of limited interest. On the other hand, because of its size and frequency, *B. quadrimaculatum* is a formidable predator, a fact to which it owes its high agronomical value (CRITCHLEY 1972, BURN 1982).

Activity

The activity of *B. quadrimaculatum* was greatly reduced in the BI treatment as a result of broad spectrum treatments. Several reasons may explain this observation. First of all, the beetle was affected by insecticides during the period when its activity at surface level was increasing (MOWAT & COAKER 1967) and at its time of reproduction. Also, small-sized beetles are more sensitive (HAGLEY et al. 1980, WILES & JEPSON 1992). It has already been proved that this species is sensitive to the organophosphorus insecticides thionazin (CRITCHLEY 1972), azinphos-methyl, diazinon and dimethoate, and to the pyrethroid permethrin (HAGLEY et al. 1980). A lowering of the species' preying activity throughout the season was probably the result of its strong reaction to some insecticides. This reaction has incited KÖNIG (1983) to propose *B. quadrimaculatum*, in tandem with *B. lampros*, as indicators of springtime surface treatment effects on beneficial fauna.

During the present trial, *Trechus quadristriatus* managed to escape treatments and increased its activity, no doubt making the most of the gap left by more sensitive species. This fact was also picked up by PURVIS (1996). HOKKAINEN & HOLOPAINEN (1986) also discovered that there were fewer individuals in biological plots than conventional ones in the autumn. The species is, however, sensitive to

Tab. 8. Side effects of some organochlorine and organophosphorus insecticides, carabamates and pyrethroids on carabid beetles as described in the literature. Effects are estimated from reductions in catches in pitfall traps or D-vac suction traps in the fields, or from biotest mortality rates.
- = nil, * = little, ** = medium, *** = severe, **** = very severe.
1) carabids, staphylinids and linyphiid spiders.
2) nematicide.

Active compound	n % or ranked by appreciation														% mortality in biotests				
	Pitfall												D-vac						
	BASEDOW *et al.* (1976)	VICKERMAN & SUNDERLAND (1977)	RZEHAK & BASEDOW (1982)	BASEDOW *et al.* (1985)	SHIRES (1985)	COLE *et al.* (1986) 1)	PURVIS *et al.* (1988)	CASTEELS & DE CLERQ (1990)	JEPSON & THACKER (1990)	ULBER *et al.* (1990)	HUSSEIN & WETZEL (1993)	BALANÇA & VISSER (1995)	SHIRES (1985)	VICKERMANN *et al.* (1987)	MOWAT & COAKER (1967)	FLOATE *et al.* (1989)	JEPSON & MEAD-BRIGGS (1992)	WILES & JEPSON (1992)	RÖMBKE & HEIMBACH (1996)
methoxychlor	0 - 86		***																
azinphos-methyl															**				
chlorfenvinphos															-				
chlorpyrifos																83 - 100			
diazinon															* à ***				
dimethoate		76				9 - 10		28	env. 30 - 40		****			77		73	20 - 95		
fenitrothion	14 - 43																		
methamidophos											****								
oxydemeton-methyl										**									
parathion-ethyl	54 - 82		***					29		***									100
parathion-methyl					env. 90									****					
phosalone								0											
thionazin 2)															***				
carbofuran																83 - 100			
pirimicarb								11		-				27					
cypermethrin					env. 50	4 - 6	34						**						
deltamethrin			*	-			28					0		22		30		< 10	
fenvalerate								1											
lambda cyhalothrin												55							100
permethrin										*									

thionazin (CRITCHLEY 1972) and to pirimicarb (ULBER et al. 1990) but not to lambda cyhalothrin which does nevertheless bring about a great deal of emigration (SUNDERLAND 1992).

The effects of pesticides on carabids in general have been studied by several authors. Table 8 gives an overview - far from complete - of the observed reduced catches and mortality. Any comparison of figures should be made with care since effects of insecticides depend on a number of variables: time of application, dosage, carabid species studied and abiotic conditions, e.g. soil humidity. Organophosphorus insecticides had a greater effect than pyrethroids. Neurologically active insecticides, such as pyrethroids for example, caused hyperactivity which may have been the cause of increased carabid catches recorded in traps, thus giving a misleading impression of pesticide effect. However, the period of hyperactivity probably only lasted a few days in which case, if the pitfall traps stayed open for a long time, catches would be affected for a short while only (FLOATE et al. 1989, HENEGHAN 1992).

Lambda cyhalothrin has a powerful knock down effect on carabids. Numerous cases of paralysis are observed, 37% of which, however, recover in the laboratory (BALANCA & DE VISSER 1995).

In general, recovery of the population takes place from within the plot, e.g. by hatching of adults or by immigration (HENEGHAN 1992). Recovery is governed by the availability of resources and the rate of dispersion, and the scale of insecticide treatment, and can only begin once the repellent effects of the product are no longer felt, and provided there is no lack of food and no mortality due to residual toxicity (JEPSON & THACKER 1990). As an example, recovery after treatment with dimethoate is slow and delayed (JEPSON & THACKER 1990), and takes eight weeks for *T. quadristriatus* after autumn treatment with cypermethrin (PURVIS et al. 1988).

In the present trial, the *B. quadrimaculatum* population never fully recovered during the period of observation. The timing of insecticide applications coincided with most of their active period up until the natural fall-off in population in the autumn. This meant that any individuals which came from untreated fields, or, less importantly, from field borders (THACKER & JEPSON 1993), were also exposed to treatment. Nonetheless, taking into account the nature of the experimental site and the colonising ability of this species, it can be supposed that the population would have recovered by the following spring. *B. quadrimaculatum* is not endangered, even if treatment is repeated annually, as long as applications remain on a small scale (PURVIS 1992).

Staphylinids

Activity

Foliage treatment did not appear to have any effect on this Coleoptera family. It is possible that some species were at a stage where they were little exposed (egg or larva) (EKSCHMITT et al. 1997) or that the size of the experimental field was not adapted to a study of insecticide effect on these insects which are extremely mobile at the adult stage. Nevertheless, a reduction in catches or abundance of staphylinids has been observed by some authors as a result of treatment with organophosphorus insecticides, carbamates and pyrethroids. For parathion, catches can temporarily be lowered by more than 60% (RZEHAK & BASEDOW 1982, SHIRES 1985, CASTEELS & DE CLERCQ 1990). The effects of dimethoate have been described by VICKERMAN & SUNDERLAND (1977), COLE et al. (1986), CASTEELS & DE CLERCQ (1990), DENNIS et al. (1993) and HUSSEIN & WETZEL (1993). Catches can temporarily be reduced by over 30% and abundance, measured by the D-vac suction trap, reduced by more than 40%.

As for the effects of cypermethrin, PURVIS et al. (1988) and COLE et al. (1986) have noted little influence with autumn treatment. Treatment with deltamethrin in the spring lowers catches (BASEDOW et al. 1985, RZEHAK & BASEDOW 1982) but not in the autumn (PURVIS et al. 1988). VICKERMAN et al. (1987) found there was a reduction of 20% in catches using a D-vac suction trap. The effects of pirimicarb are comparable to those of deltamethrin (VICKERMAN et al. 1987, CASTEELS & DE CLERCQ 1990).

Ants

The significant differences measured in ant catches between the treatments were probably a reflection of the initial situation; this would be a logical conclusion for species living in colonies on a field of small dimensions.

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RÉSUMÉ

La faune épigée en milieu maraîcher.- La densité d'activité des araignées, carabes, staphylins et fourmis épigés est estimée à l'aide de pièges Barber dans une culture de chou blanc du 8.6 au 21.9.1994. Le champ est subdivisé en 3 parcelles dont l'une est traitée avec des insecticides polyvalents (fonofos, diméthoate et cyperméthrine), l'autre avec des insecticides sélectifs (pirimicarbe et *Bacillus thuringiensis*) et la troisième est restée sans traitement. Trente-et-une espèces d'araignées, trente-cinq espèces de carabes et vingt-deux espèces de staphylins ont été récoltées. La composition spécifique n'est pas fondamentalement modifiée par les traitements. En revanche, les insecticides polyvalents provoquent un déficit de captures chez les araignées tisseuses dominées par *Oedothorax apicatus* de la famille des Linyphiidae et chez les carabes dominés par *Bembidion quadrimaculatum*. Cette dernière espèce est proposée comme indicateur d'effet des traitements de surface au printemps sur la faune utile. Les staphylins sont sensibles au fonofos en traitement précoce du sol. Les fourmis ne semblent pas s'adapter à la mesure des effets secondaires des pesticides.

ZUSAMMENFASSUNG

Die epigäische Fauna im Gemüsebau.- Die Aktivitätsdichte der Spinnen, Laufkäfer, Staphyliniden und Ameisen wurde mittels Barberfallen in einer Weisskohlkultur vom 8.Juni bis 21.September 1994 geschätzt. Das Feld wurde in drei Parzellen geteilt, wovon die eine mit polyvalenten Insektiziden (Fonofos, Dimethoat und Cypermethrin) behandelt wurde, eine andere mit selektiven Präparaten (Pirimicarb, *Bacillus thuringiensis*) und die letzte blieb unbehandelt. Es wurden 31 Spinnen-, 35 Laufkäfer- und 22 Staphylinidenarten gefangen. Die Artenzusammensetzung wird von den Behandlungen nicht wesentlich beeinflusst. Die Fänge gehen hingegen bei der Anwendung der breitenwirksamen Insektizide teilweise stark zurück. Betroffen sind vor allem die Linyphiiden, welche von der Baldachinspinne *Oedothorax apicatus* dominiert werden, und die Laufkäfer angeführt von *Bembidion quadrimaculatum*. Letztere Art wird als Indikator der Nebenwirkungen von Oberflächenbehandlungen im Frühjahr auf die Nützlingsfauna vorgeschlagen. Die Staphyliniden sind sensibel auf Fonofos bei früher Bodenbehandlung. Die Ameisen scheinen sich für eine Messung der Nebenwirkung von Pestiziden nicht zu eignen.

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