Habitat Preferences of Generalist Predators in Reduced-Tillage Corn[1]

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ABSTRACT Habitat preferences of generalist predators were evaluated by comparing their abundance among four reduced-tillage corn systems which differed in the degree of soil disturbance, quantity and structure of the surface mulch due to tillage, and cover crop management practices. Two sampling methods were used to collect predators, pitfall trapping and vacuum sampling. Although there was considerable difference in the composition of species collected with each method, similar trends in overall predator abundance were observed. Generalist predator abundance followed the gradient of ground cover. The treatment with the highest degree of mulch ground cover had the highest overall predator abundance while the treatment which was disked and without surface mulch had the lowest. Although most of the common species preferred those systems with the most ground cover, several species preferred the system with the least amount of ground cover.

KEY WORDS Generalist predators, habitat manipulation, habitat preference, cover crop management, reduced-tillage, conservation tillage, corn.

Habitat manipulations to agroecosystems can have considerable influence on generalist predator abundance. The influence may be either direct such as from the use of pesticides toxic to predators (Asteraki et al. 1992), or indirect by influencing microclimate (Honek 1988), prey populations (Chiverton 1984, 1988), or habitat structure (Riechert and Bishop 1990). Some research has demonstrated that reduced-tillage agroecosystems tend to have higher generalist predator abundances than those conventionally-tilled (House and All 1981, House and Stinner 1983, Brust et al. 1985, Ferguson and McPherson 1985, House and Parmelee 1985, House and Alzugaray 1989). This may be due in part to reduced-tillage systems supporting a detritus-based prey source that is available to predators year-round (Stinner and House 1990). Crop residues left on the soil surface of reduced-tillage systems may also provide a preferred habitat for many generalist predators (Honek 1988, Riechert and Bishop 1990, Laub and Luna 1992). Other research has indicated that generalist predator abundance is relatively independent of tillage disturbances, although species compositions may be influenced (Barney and Pass 1986a).

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Armyworm (*Pseudaletia unipuncta* Haworth) and black cutworm (*Agrotis ipsilon* Hufnagel) are common pests of reduced-tillage corn in the mid-Atlantic region (Harrison et al. 1980, Tonhasca and Stinner 1991). Both pests are most destructive during their first generation which occurs in May or June in Virginia. Research has shown that generalist predators can be important in regulating populations of armyworm and black cutworm (Brust et al. 1985, 1986, Clark 1993). Thus, the use of agricultural practices that conserve or enhance generalist predator populations may reduce the damage caused by these pests. The objective of this study was to determine the habitat preferences of generalist predators by comparing their abundance in reduced-tillage corn systems with different degrees of ground cover and soil disturbance.

Materials and Methods

Experimental Site and Treatments. The experimental site was located at the Whitethorne Research Farm near Blacksburg, VA, in a field composed of Hayter loam soil which had been used to grow soybeans during the previous season. On 12 October 1991 the site was disked, limed (8,965 kg/ha), and fertilized (18 kg P/ha, 68 kg K/ha). Four treatments, representing reduced-tillage corn cropping systems, were established in a randomized block design with four replications. Plots were 11 × 15 m and were lined up side by side. The treatments, which differed in the degree of soil disturbance and ground cover due to fall and spring (prior to corn planting) soil and cover crop management practices, included: (1) rye planted in the fall at a seeding rate of 101 kg/ha and then "rolled down" with a cultipacker (Brillion PMWT124-0) the following spring (Rye/Roll); (2) rye planted in the fall at a seeding rate of 101 kg/ha and then killed with paraquat (0.35 kg [AI]/ha) the following spring (Rye/Paraquat); (3) rye planted in the fall at a seeding rate of 67 kg/ha and then mowed and removed the following spring, leaving stubble which was killed with paraquat (0.35 kg [AI]/ha) (Rye/Remove); and (4) winter fallow and spring disked (Fallow/Disk).

Fall cover crops were planted on 18 October 1991 with a grain drill (John Deere FB). All spring cover crop manipulations and disking were conducted on 12 May. Corn ('Pioneer 3140') was planted on 13 May with a two-row, no-till planter (John Deere 71) modified for high-residue seed beds. The Rye/Paraquat, Rye/Remove, and Fallow/Disk treatments were sprayed with the herbicides atrazine (2.2 kg [AI]/ha) and simazine (2.2 kg [AI]/ha) for weed control, and all treatments received granular urea fertilizer (15.5 kg N/ha) at corn planting. No herbicides were applied to the Rye/Roll treatment because the dense mulch layer created in this system provided adequate weed control (Luna et al. 1992).

Generalist Predator Sampling. Two methods were used to sample generalist predators: pitfall trapping and vacuum sampling. The pitfall trapping consisted of five, 72-h trapping periods, 10 to 12 days apart, which were conducted between 1 May and 8 July. A single un-baited plastic cup (474 ml, 11 cm rim diameter), positioned near the center of each plot, was placed into the ground so that the rim of the cup was flush with the soil surface. Ethylene glycol, diluted with water, was used as a killing agent and preservative. Plywood rain covers (20 × 20 cm), painted white, were supported

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above the pits on 7.5 cm long nails. Pitfall traps were removed between trapping periods and the contents returned to the laboratory for identification.

Vacuum sampling procedures were conducted every 15 to 20 days between 30 April and 22 June for a total of four sampling dates. Sampling consisted of isolating a randomly chosen subsample with a cylinder, constructed of 20 gauge, galvanized sheet steel and measuring 0.20 m^2 in area and 0.60 m in height. The cylinder was manually driven into the ground to prevent arthropods from moving out of the sampling area. Arthropods were collected using a modified gasoline-powered vacuum (Weed Eater; GBI 22). The ground surface, vegetation, and debris were vacuumed for 30 s at each subsample. Three sub-samples were taken and combined from each plot on each sampling date. All samples were taken between 1100 and 1600 h. Samples were placed into 474-ml plastic containers, deposited in a cooler, and sorted in the laboratory while the specimens were still alive.

Analysis. All predators comprising one percent or more of the total collected were identified to species or genus level, except the Linyphiidae, which were identified to family level. Voucher specimens were placed in the Virginia Museum of Natural History, Blacksburg, VA. Habitat preferences of families, common species or genera, and total predators were determined by comparing pitfall trap and vacuum sample catches among the four treatments. Only adults were considered for comparisons made at species or genus and family levels. Immature stages (nymphal and larval) were included in comparisons of the total number of predators. All data were subjected to analysis of variance (ANOVA) after square root transformation $(x + 0.5)^{1/2}$. Duncan's multiple range test (DMRT) (Duncan 1955) was used to separate means when $P < 0.05$. All analyses were performed on Statistical Analysis System (SAS Institute 1982).

Results

The four most abundant predatory families collected, Carabidae, Staphylinidae (Coleoptera), Lycosidae, and Linyphiidae (Araneae), were the same for both pitfall trapping and vacuum sampling. The fifth most abundant family was Phalangiidae (Opiliones) for pitfall trapping and Coccinellidae (Coleoptera) for vacuum sampling. These five families comprised 90% and 86% of all predators collected by pitfall trapping and vacuum sampling, respectively. Other predatory groups which were collected in small numbers were Histeridae, Chilopoda, and other Araneae including Thomisidae, Gnaphosidae, Araneidae, Oxyopidae, and Tetragnathidae. The taxa which represented 1% or more of the total number of predators collected, excluding the linyphiids, comprised 64.6% and 56.6% of all predators collected by pitfall trapping and vacuum sampling, respectively (Table 1). However, only four taxa, *Philonthus cognatus* Stephens (Staphylinidae), *Pardosa* spp. (Lycosidae), *Phalangium opilio* L. (Phalangiidae), and *Amara familiaris* Duftschmid (Carabidae), were collected with both sampling methods.

Pitfall trap catches were significantly different among treatments for staphylinids only ($F = 7.35$; df = 3,9; $P = 0.008$), whereas vacuum sampling results differed significantly for the staphylinids ($F = 6.32$; df = 3, 9; $P = 0.01$), lycosids ($F = 6.21$; df = 3,9; $P = 0.01$), and linyphiids ($F = 4.40$; df = 3, 9; $P = 0.04$)

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Table 1. The taxa (excluding Linyphiidae) representing one percent or more of the total predators collected by pitfall trapping and vacuum sampling, in the four corn systems, Whitethorne, VA, 1992.

Taxa	Percentage of total predators	
	Pitfall trapping	Vacuum sampling
Coleoptera		
Carabidae		
Pterostichus chalcites Say	5.2	0
Pterostichus lucublandus Say	2.2	0
Amara cupreolata Putzeys	3.9	0
Amara familiaris Duftschmid	1.2	7.4
Scarites subterraneus F.	1.9	0
Agonum punctiforme Say	1.7	0
Pseudaptinus sp.	0	3.9
Colliuris pensylvanica Linné	0	1.5
Staphylinidae		
Philonthus cognatus Stephens	22.6	1.0
Philonthus lomatus Erichson	2.2	0
Platydracus maculosus Gravenhorst	1.0	0
Stenus flavicornis Erichson	0	15.7
Coccinellidae		
Coleomegilla maculata DeGeer	0	5.9
Coccinella septempunctata L.	0	1.5
Araneae		
Lycosidae		
Pardosa spp.*	12.9	16.2
Schizocosa avida Walckenaer	0	2.5
Opiliones		
Phalangiidae		
Phalanigium opilio L.	9.8	1.0
Total	64.6	56.6

*Includes *P. milvina* Hentz and *P. saxatilis* Hentz.

(Fig. 1). Vacuumed specimens of staphylinids and lycosids were more abundant in the three treatments which had winter cover crops than in the Fallow/Disk treatment. The linyphiids were more abundant in the Rye/Roll treatment than in all others.

The staphylinid, *P. cognatus,* represented over 50% of all staphylinids and

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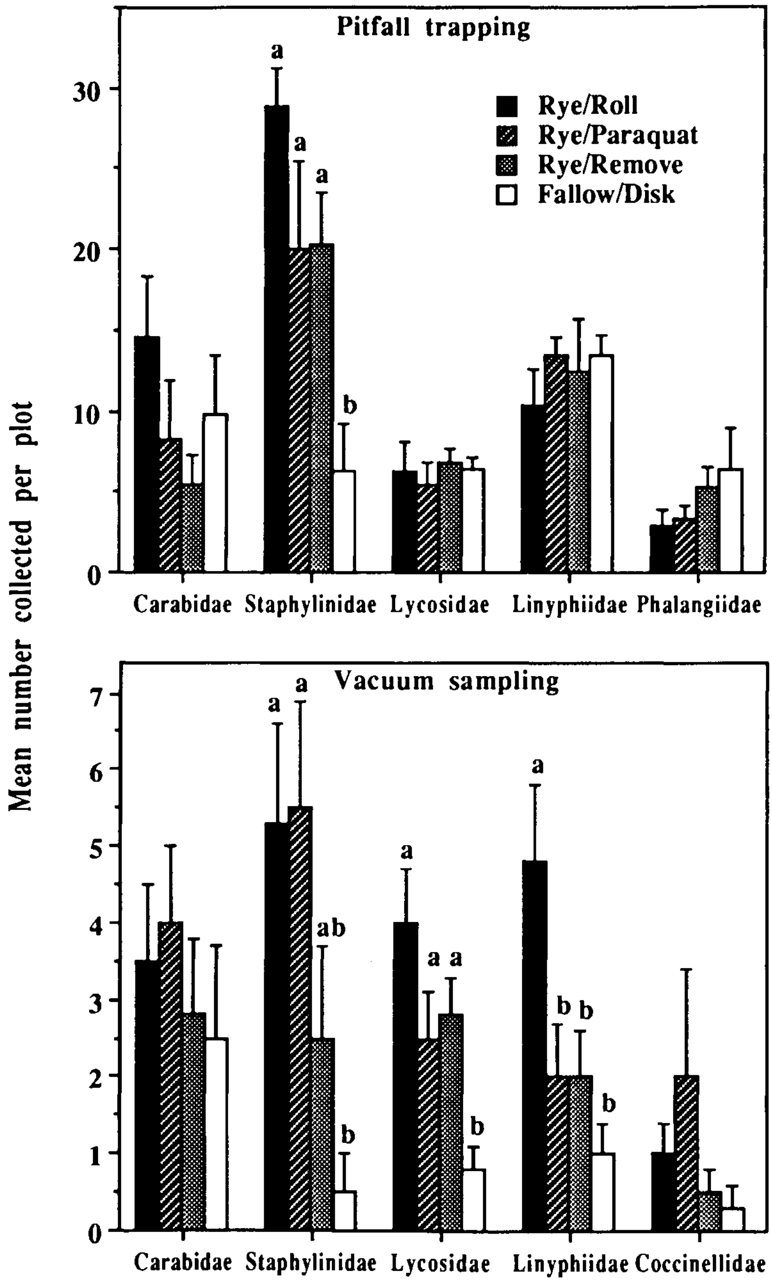

Fig. 1. Mean number of the five most abundant generalist predator families collected per plot by pitfall trapping and vacuum sampling. T-bars are standard errors of the mean. Means within a family with different letters are significantly different (ANOVA and DMRT, $P < 0.05$).

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22.6% of all predators collected by pitfall trapping. Pitfall trap catches indicated that this species preferred the three treatments with surface residues over the Fallow/Disk treatment (F = 10.78; df = 3,9; P = 0.003) (Fig. 2). A similar trend was evident for the carabid, *Pterostichus lucublandus* Say (F = 7.74; df = 3,9; P = 0.007), but it was not collected in the Rye/Remove treatment. The staphylinid, *Platydracus maculosus* Gravenhorst (F = 6.37; df = 3,9; P = 0.01), and the carabid, *Pterostichus chalcites* Say (F = 7.35; df = 3,9; P = 0.009), showed a distinct preference for the Rye/Roll treatment (Fig. 2). Two carabids, *Amara cupreolata* Putzeys and *Scarites subterraneus* F., and the phalangiid, *P. opilio,* showed opposite trends with the highest numbers collected from the Fallow/Disk treatment and the lowest numbers from the Rye/Roll treatment. However, these trends were not statistically significant (Fig. 2).

Three of the five most abundant predator taxa (excluding Linyphiidae) collected by vacuum sampling exhibited preferences for the three treatments with surface residues over the Fallow/Disk treatment (Fig. 3). These taxa were *Pardosa* spp. (Lycosidae) (F = 7.96; df = 3,9; P = 0.007), *Stenus flavicornis* Erichson (Staphylinidae) (F = 6.03; df = 3,9; P = 0.02) and *Pseudaptinus* sp. (Carabidae) (F = 5.02, df = 3,9, P = 0.03). The coccinellid, *Coleomegilla maculata* DeGeer, showed a similar trend, although the model did not meet the statistical criteria for using DMRT (F = 3.59; df = 3,9; P = 0.06). The carabid *A. familiaris,* showed the opposite trend with the highest numbers collected from the Fallow/Disk treatment and the lowest from the Rye/Roll and Rye/Paraquat treatments (Fig. 3); however, this trend was not statistically significant.

Pitfall trapping and vacuum sampling showed similar overall trends in mean predator abundance with the Rye/Roll treatment having the greatest number, followed by the Rye/Paraquat, Rye/Remove, and Fallow/Disk treatments, respectively (Fig. 4). However, differences were statistically significant only for vacuum sampling (F = 11.14; df = 3,9; P = 0.002). In addition, significant differences in predator abundance were not detected at the same times with the two sampling methods (Fig. 5). From the pitfall trapping data, it was determined that all three cover crop treatments had significantly higher predator abundances than the Fallow/Disk treatment prior to the tillage and cover crop management operations (F = 4.09; df = 3,9; P = 0.04). However, no differences were observed following the farming operations. Vacuum sampling data showed significant differences following the farming operations, on 3 June (F = 7.30; df = 3,9; P = 0.009) and 22 June (F = 4.10; df = 3,9; P = 0.04) (Fig. 5).

Discussion

Both pitfall trapping and vacuum sampling showed similar trends in overall generalist predator abundances among the four treatments. Predator abundances were higher in treatments with the greatest amount of ground cover. In addition, the same four dominant arthropod families, Carabidae, Staphylinidae, Lycosidae, and Linyphiidae, were collected in relatively similar proportions, although abundance patterns among the treatments were not always the same for the two methods. Species compositions of the samples differed considerably between the two methods. Pitfall trapping tended to collect more large species, whereas vacuum sampling collected smaller ones.

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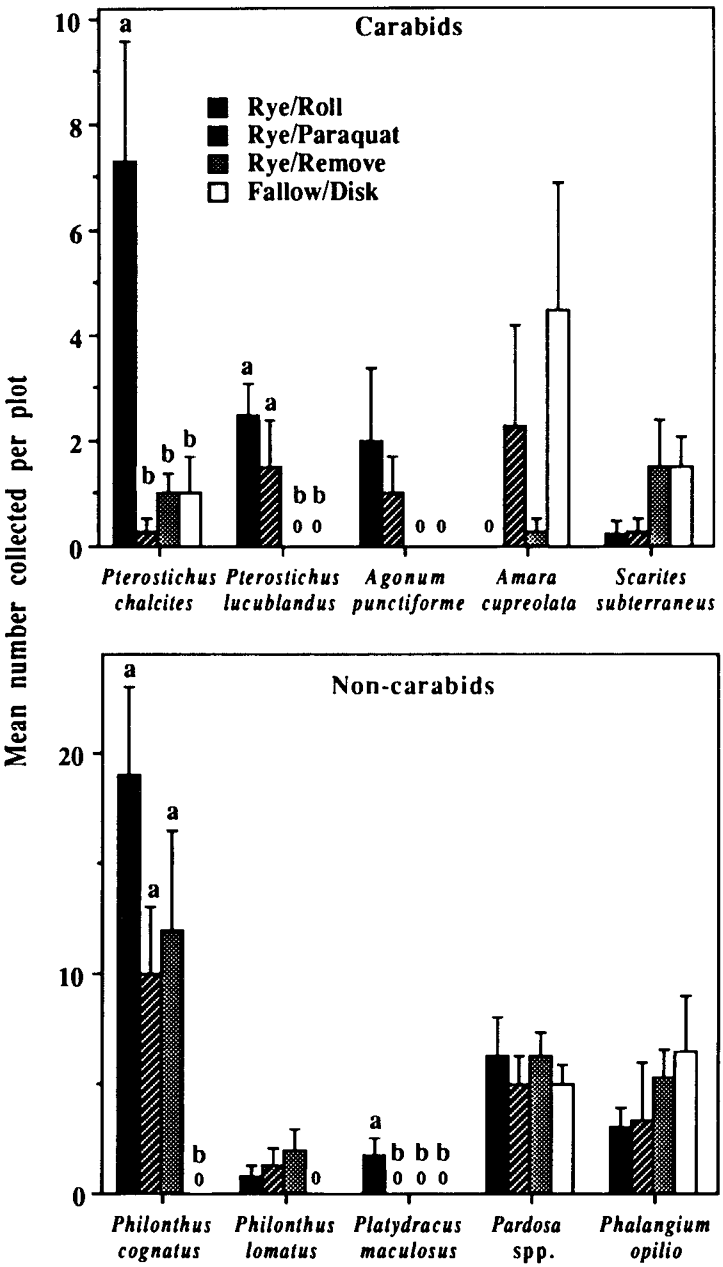

Fig. 2. Mean number of the five most abundant carabid and non-carabid predators (excluding linyphiid species) collected per plot by pitfall trapping. T-bars are standard errors of the mean. Means within a taxa with different letters are significantly different (ANOVA and DMRT, $P < 0.05$).

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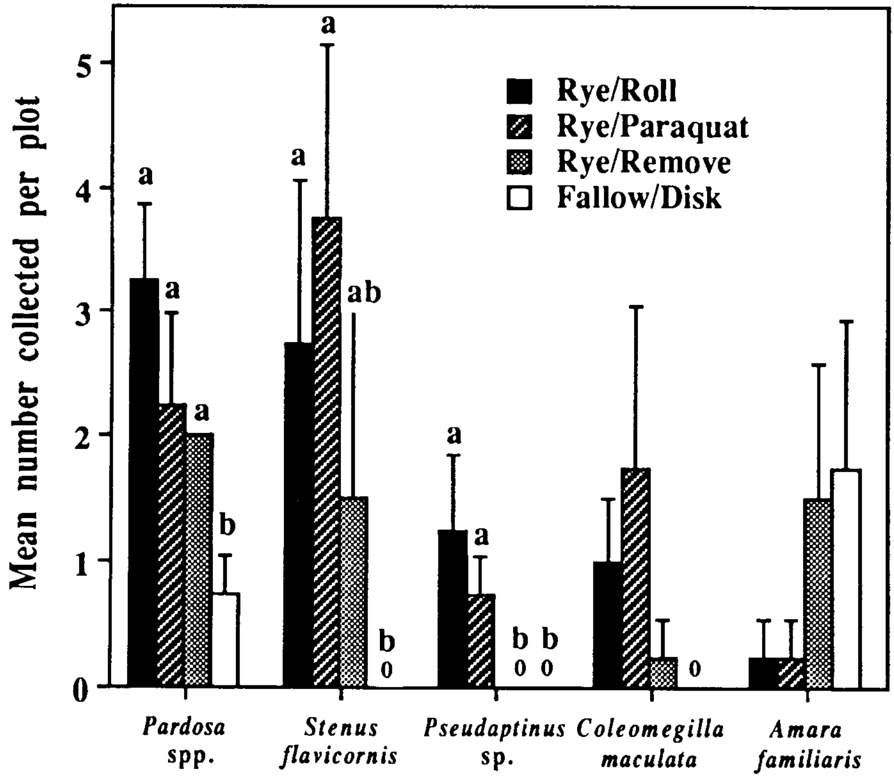

Fig. 3. Mean number of the five most abundant predators (excluding linyphiid species) collected per plot by vacuum sampling. T-bars are standard errors of the mean. Means within a taxa with different letters are significantly different (Anova and DMRT, $P. < 0.05$).

Therefore, it was not possible to compare abundance patterns between the two sampling methods for most taxa collected.

There are several possible explanations for the difference in species composition. First, larger species may have been too heavy to be collected by the vacuum sampler, especially when clinging to or hiding under debris or vegetation. There also is evidence that larger species generally are more susceptible to pitfall trapping than smaller ones (Luff 1975). Thus, it is likely that smaller species were underrepresented in pitfall catches relative to larger species. Secondly, vacuum sampling was conducted only under mid-day hours while pitfall trapping periods extended equally over the entire day. Some arthropods, including certain carabids and staphylinids, may have been inactive and in underground refuges during mid-day hours when vacuum sampling was conducted. Finally, pitfall trap catches are dependent not only on arthropod density but also on activity (Honek 1988) and behavior (Halsall and Wratten 1988), whereas vacuum sampling catches likely would not be

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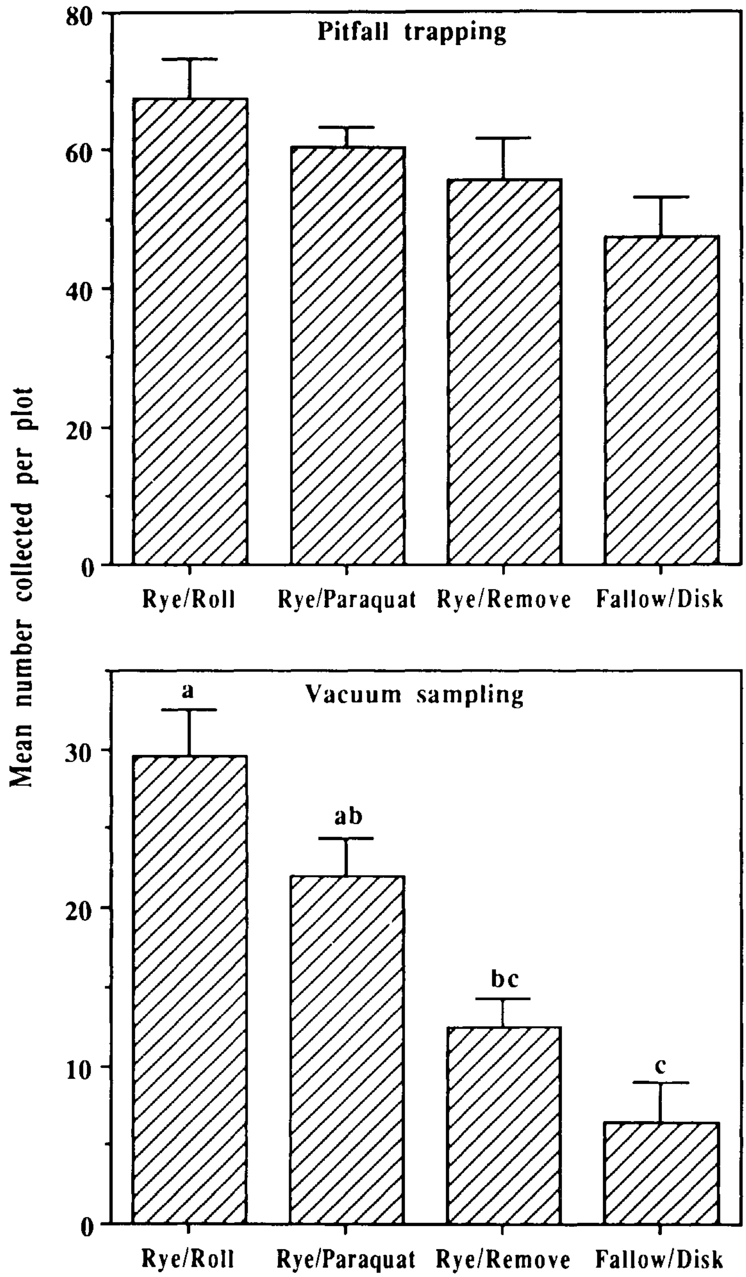

Fig. 4. Overall mean number of generalist predators collected per plot in each treatment by pitfall trapping and vacuum sampling. T-bars are standard errors of the mean. Means with different letters are significantly different (ANOVA and DMRT, $P < 0.05$).

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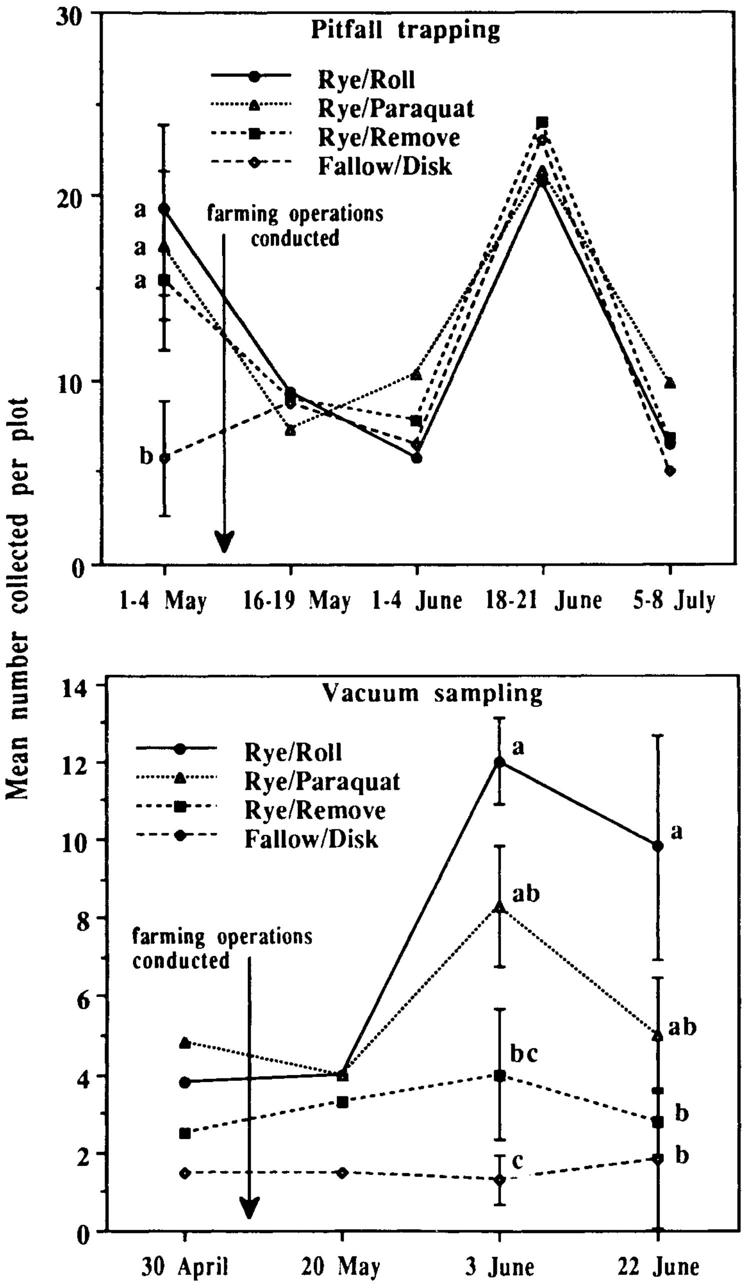

Fig. 5. Mean number of generalist predators collected over time in each treatment by pitfall trapping and vacuum sampling. Standard error bars and different letters are presented where significant differences were observed (ANOVA and DMRT, $P < 0.05$).

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influenced by these factors. Honek (1988) found crop density to be an important influence on pitfall trap catches of carabids, staphylinids, and lycosids in cereal fields. The numbers of carabids and lycosids collected in crop rows without crops were generally much higher than those in dense cereal stands. The author suggested that this was possibly due to microclimatic factors which influenced both density and activity. Researchers who have compared pitfall trapping to other sampling methods, including visual searching within quadrats (Greenslade 1964) and insecticidal ground sprays followed by visual searches (Lesiewicz et al. 1983), have found that pitfall trap catches are inaccurate indicators of both relative and absolute densities.

In this study, pitfall trap catches were probably unreliable indicators of predator abundance because of the differences in microclimate, prey abundance, and habitat structure among the four treatments. Predator abundance according to pitfall trap catches may have been disproportionately higher in treatments with little ground surface habitat, compared to treatments with more surface mulch due to low prey availability, higher soil surface temperatures, and a lack of suitable hiding places, which subsequently increased activity. Vacuum sampling likely gave a better indication of predator relative densities than pitfall trapping because samples were collected from well-defined, isolated areas. For example, *Pardosa* spp., which were commonly collected with both methods, showed an obvious preference for treatments with ground cover according to the vacuum sampling method, yet were collected in nearly equal numbers among the four treatments by pitfall trapping. This indicates that although abundance was greater in treatments with more ground cover, activity may have been higher where there was less ground cover. This may partially explain the apparent contradiction between the two sampling methods in the comparisons of total predators over time (Fig. 5).

The trends observed in overall generalist predator abundance support other studies which have found mulch to increase predator abundance (Riechert and Bishop 1990). According to the vacuum sampling data, abundances of the two dominant spider families, Lycosidae and Linyphiidae, increased with greater degrees of mulch ground cover. The staphylinids followed a similar trend according to both sampling methods. Although no trend was recognized based on the abundance of Carabidae collected for either sampling method, several carabid species showed obvious trends. This reinforces the need to study predators at a species level rather than generalizing at the family level (Barney and Pass 1986b).

Although herbicides can influence generalist predator abundance, most research indicates that the mechanism is indirect and that the elimination of vegetation reduces habitat and herbivorous prey populations, thus reducing predators as well (Ahmed et al. 1987, Christiansen et al. 1989, Showler and Reagan 1991). Powell et al. (1985) studied the effect of several herbicide treatments on generalist predators, including carabids, staphylinids, and spiders in winter wheat in England. They found no differences in overall predator abundance among the treatments, but did find certain species preferred particular treatments. It is unlikely that the herbicides used in this study directly influenced generalist predator abundance; however, the herbicides may have directly reduced microinvertebrate populations which

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served as prey (Subagja and Snider 1981) causing predators to move out of the sprayed plots. The small plot size and the close proximity of the study site to an unmanaged, weedy strip, which was less than 5 m from all plots, would have allowed rapid recolonization of the herbicide-treated plots, if predators were directly or indirectly reduced by the herbicide applications.

In summary, results from both sampling methods indicate that the quantity and structure of surface mulch in reduced-tillage corn agroecosystems can significantly influence generalist predator abundance and activity. Although certain species, such as *A. cupreolata, A. familiaris, S. subterraneus,* and *P. opilio,* showed a preference for less ground cover, corn systems with greater ground cover had greater overall generalist predator abundance. Further research is needed to determine if increased predator abundance achieved through such habitat manipulations will provide increased biological control of pests.

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