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Responses of ground-dwelling spiders to four hedgerow species on sloped agricultural fields in Southwest China

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Abstract

Spiders are important predators in agroecosystems and contribute to the control of agricultural pest populations. Habitat management such as the creation of new semi-natural habitats around or within fields enhances spider abundance and species diversity. Using pitfall traps, we investigated the effects of four hedgerow plant species, which serve as undisturbed and permanent semi-natural habitats, on ground-dwelling spider activity density (a parameter of population density and relative activity) and species richness. Samples were collected over two winter wheat and two summer maize growing seasons during 2005–2007 in trial field 1 (slope gradient of 20%) and field 2 (slope gradient of 12%) at the Ziyang Experimental Site in Sichuan Province, China. The hedgerow species evaluated were *Amorpha fruticosa* (field 1), *Vetiveria zizanioides* (field 1), *Eulaliopsis binata* (field 2), and *Medicago sativa* (field 2). Compared to control plots, hedgerow plots had significantly higher activity density and species richness of ground-dwelling spiders within strips in both fields 1 and 2 during the wheat growing season. The presence of hedgerow strips did not augment the activity density and species richness of ground-dwelling spiders within the crop fields during the wheat or maize growing seasons. The ground-dwelling spider activity density within hedgerow strips was significantly higher in the *Vetiveria* than in the *Amorpha* plots and in the *Medicago* than in the *Eulaliopsis* plots, and the species richness was significantly higher in the *Vetiveria* than in the *Amorpha* plots during the wheat season. Our results suggest that hedgerows may serve as important overwintering sites for ground-dwelling spiders during the wheat growing season. In addition, the diversification of agroecosystems by using hedgerow strips may be a viable strategy for maintaining ground-dwelling spider populations in agricultural areas. However, ground-dwelling spiders did not move into adjacent crop fields; therefore, future work should address the mechanisms of attracting spiders into crop fields, thereby contributing to the bio-control of pests.

Keywords: Activity density; Araneae; Ground-dwelling; Hedgerow; Pitfall trapping; Species richness

1. Introduction

The simplification of cropping systems, the fragmentation and loss of semi-natural habitats, and the excessive use of agrochemicals have resulted in the reduced species diversity and abundance of arthropod predators [1,2], which may in turn reduce the natural control of important crop pests [3]. To encourage and conserve populations of arthropod predators, increasing attention has been paid to habitat management methods that improve the availability of resources required by predators [4]. The creation of new semi-natural habitats around or within agricultural fields can enhance the populations of arthropod predators and thereby improve their efficiency as pest-control agents in agroecosystems [5–7].

Spiders (Araneae) are abundant, species-rich predators in agroecosystems [8,9] and play an important role in

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limiting insect pests [10,11]. Semi-natural habitats around or within fields can enhance spider abundance or species diversity, e.g., nearby grasslands [12], field margins [13–15], and weed strips within a field [5–7,16,17]. These semi-natural habitats provide spiders with overwintering sites, alternative prey items, and refuges from agricultural practices such as pesticide spraying, tilling, and harvesting.

Since the early 1970s, hedgerow intercropping has been developed and promoted in the tropical areas of Africa, Asia, and Central and South America as a promising agronomic technique to improve soil fertility and reduce soil erosion on fragile uplands [18]. This method was introduced to China in the early 1990s as a management option for sloped croplands [19]. Considerable research has confirmed the effectiveness of hedgerow intercropping for soil conservation and the improvement of soil fertility [20]. However, the effects of hedgerow strips serving as undisturbed and permanent semi-natural habitats on the abundance and species richness of ground-dwelling spiders remain unexplored.

Our goals were to investigate the effects of four hedgerow plant species on the activity density and species richness of ground-dwelling spiders. The specific hypotheses tested were (1) hedgerows serve as refuges and sources of species for spiders and thus contribute to increase the activity density and species richness of spiders in adjacent fields and (2) different hedgerow species differentially affect the activity density and species richness of ground-dwelling spiders, thus allowing the informed selection of appropriate hedgerow species.

2. Materials and methods

2.1. Study sites

Field experiments were conducted at the Ziyang Experimental Site of the Institute of Soils and Fertilizers, Sichuan Academy of Agricultural Sciences, Ziyang, Sichuan Province (30°06′N, 104°35′E, 395 m elevation) in 2005–2007. Precipitation ranged from 725.2 to 1290.7 mm/year, with an annual average precipitation of 966 mm/year, 70% of which fell between June and September. The annual average temperature was 16.8 °C. Purple soil dominated the area and was 50–80 cm in depth with a relatively light texture and poor soil fertility.

2.2. Experimental design

Our study was based on a field experiment that evaluated the effect of different hedgerow plants on soil conservation in comparison with crop-only control. In 1997 and 2001, different hedgerow systems were established at the experimental site according to the slope gradients. The three treatments were established in trial field 1 (slope gradient of 20%): *Vetiveria* (*Vetiveria zizanioides*), *Amorpha* (*Amorpha fruticosa*) and control (no hedgerows). Three treatments were also established in trial field 2 (slope gradient of 12%): *Eulaliopsis* (*Eulaliopsis binata*), *Medicago* (*Medicago sativa*), and control (no hedgerows). These six treatments were arranged in a randomized block design with three replications. The plots were 7 m × 6.5 m and consisted of a single hedgerow strip plantem upslope of the plot. The width of the hedgerow strip was 0.5 m, and two rows were planted in each hedgerow strip with a spacing of 0.2 m within rows.

Wheat was sown on 7 November 2005 and 5 November 2006 with a spacing of 0.2 m between rows. Maize was sown on 10 May 2006 and 5 May 2007 with a spacing of 0.75 m between rows and 0.25 m within rows. The crops were weeded manually, but were not protected against insect pests. The wheat was fertilized with 135 kg N and 67.5 kg P ha^{-1}, which was incorporated into the soil during land preparation; the maize received 186.3 kg N and 99 kg P ha^{-1} fertilizer.

2.3. Spider sampling

Ground-dwelling spiders were sampled using pitfall traps as described by Obrist and Duelli [21], with slight modifications. A glass funnel with a diameter of 110 mm and a depth of 100 mm was placed into a 500 ml plastic bottle for use as a holding container. The entire capture device was hung from a 5 mm rim into a PVC tube, which was then buried into the soil with its end flush with the surface. The trapping liquid was a preservative mixture of 4% formaldehyde, water, and soap to decrease surface tension, and the trap was covered by a 25 × 25 cm aluminum roof. One row of three traps was placed in the hedgerow strip (or bare soil in controls), and three more were positioned in the field at distances of 1.5, 3.0, and 4.5 m from the hedgerow strip (trap–trap distance = 1.5 m, group distance = 1.5 m).

Samples were collected from December 2005 to August 2007, which included two winter wheat and two summer maize growing seasons. During the wheat season, samples were collected at 14-day intervals from December to January and weekly from March to May. During the maize season, samples were collected weekly from June to August. The number of sampling times and the duration of the entire sampling period differed between the 2 years for the wheat season because of variation in the growing season. We sampled 11 times in 2005–2006 and 9 times in 2006–2007 for the wheat season and 10 times in each of the two maize seasons. Spider specimens were washed, sorted, and stored in 70% ethanol. All adult spiders were identified to species, and juvenile spiders were identified to genus when possible.

2.4. Data analysis

The activity density and species richness of spiders were analyzed separately for the wheat and maize seasons. The number of individuals captured in pitfall traps was considered as a measure of the activity density of spiders [22]. The number of species captured in pitfall traps was considered as a measure of the species richness of spiders.

The activity density and species richness of spiders were evaluated in the hedgerow strips or bare soil by summing the number of individuals and the number of species captured in the three traps positioned in the strips during the wheat or maize growing seasons. In the crop fields, these two variables were obtained by summing the number of individuals and the number of species captured in the nine traps positioned in the fields during the wheat or maize growing seasons. Because the sampling effort differed between the hedgerow strips and the crop fields, the number of individuals captured in one trap was compared between hedgerow strips and crop fields within an entire plot.

Activity densities were square-root-transformed prior to analysis to normalize the variances. The hedgerow and control treatments were compared using ANOVA with a randomized block design. In addition, simultaneous multiple comparisons among treatments within a field were conducted using least-significant difference tests (LSD) on the least-squares means [23]. Differences were considered significant at $P < 0.05$.

3. Results

During the wheat season, a total of 4517 spiders representing 45 species were collected in 2005–2006, and 4366 spiders representing 48 species were collected in 2006–2007 (see Appendix). *Pardosa astrigera* (23.58%), *Parameioneta bilobata* (20.46%), *Pirata subpiraticus* (10.80%), and *Ummeliata insecticeps* (10.10%) were the dominant species in 2005–2006. *Pardosa astrigera* (28.45%), *Pardosa laura* (11.43%), and *Parameioneta bilobata* (11.09%) were the dominant species in 2006–2007.

During the maize growing season, a total of 3972 spiders representing 47 species were captured in 2006, and 4030 spiders representing 39 species were captured in 2007 (see Appendix). *Pardosa astrigera* (27.34%*)*, *Pirata subpiraticus* (24.52%), and *Pardosa laura* (13.52%) were the dominant species in 2005–2006. *Pardosa astrigera* (36.82%*)*, *Pardosa laura* (14.96%), *Pirata subpiraticus* (11.29%), and *Coleosoma blandum* (10.77%) were the dominant species in 2006–2007.

3.1. Seasonal activity density of spiders at the plot level

To illustrate the general trends for entire plots, spiders captured in strips and fields were pooled (Fig. 1). There were strong seasonal fluctuations in total spider activity density at the plot level in 2005–2006 and 2006–2007. Because of low temperatures during the wheat season, spider activity was generally low in December, but increased with increasing temperatures in the spring. Spider activity peaked on 19 April 2006 in all plots examined (Fig. 1(a) and (b)), on 10 April 2007 in the hedgerows and control plots of field 1, and on 13 March 2007 in the hedgerows and control plots of field 2 (Fig. 1(c) and (d)). Subsequently, activity declined late in the season. Rainfall decreased the spider activity density on 22 March and 12 April 2006 and 3 April 2007. During the maize season, the activity density increased rapidly early in the season, with the highest activity density recorded on 11 June 2006 in all plots examined, with the exception of 4 June in the *Eulaliopsis* plots and 25 June in the *Medicago* plots (Fig. 1(a) and (b)). In 2007, peak spider activity density occurred on 19 June in all plots examined, with the exception of 4 June in the *Amorpha* plots and control plots of field 1 (Fig. 1(c) and (d)). These patterns were followed by a late-season decline, with an additional increase after 16 July in 2006 (Fig. 1(a) and (b)).

3.2. Activity density and species richness of spiders in the strips

In the 2005–2006 wheat season, the activity density of spiders was significantly higher in the hedgerow strips than in the bare soil in both field 1 ($P < 0.001$) and field 2 ($P < 0.001$; Fig. 2(a)). Spider species richness was also significantly higher in the hedgerow strips than in the bare soil in field 1 ($P < 0.001$) and field 2 ($P < 0.05$; Fig. 2(b)). During the maize season, the activity density of spiders was significantly higher in the hedgerow strips than in the bare soil in field 2 ($P < 0.01$; Fig. 2(a)), but not in field 1. The species richness of spiders did not differ significantly between the hedgerow strips and the bare soil in either field 1 or field 2 (Fig. 2(b)).

In the 2006–2007 wheat season, the activity density was significantly higher in the hedgerow strips than in the bare soil in both field 1 ($P < 0.01$) and field 2 ($P < 0.01$). Moreover, hedgerow strips of *Vetiveria* plots had significantly higher activity densities than those of *Amorpha* plots in field 1, and hedgerow strips of *Medicago* plots had significantly higher activity densities than those of *Eulaliopsis* plots in field 2 (Fig. 2(a)). Species richness was significantly higher in the hedgerow strips than in the bare soil in field 1 ($P < 0.001$) and field 2 ($P < 0.05$). In addition, hedgerow strips of *Vetiveria* plots had significantly higher species richness than those of *Amorpha* plots in field 1 (Fig. 2(b)). During the maize season, neither activity density nor species richness differed significantly between hedgerow strips and bare soil in either field 1 or field 2 (Fig. 2).

3.3. Activity density and species richness of spiders in crop fields

In the 2005–2006 wheat and maize seasons, the activity density and species richness of spiders in the crop fields did not differ significantly between hedgerow and control plots in either field 1 or field 2 (Fig. 3). Similarly, in the

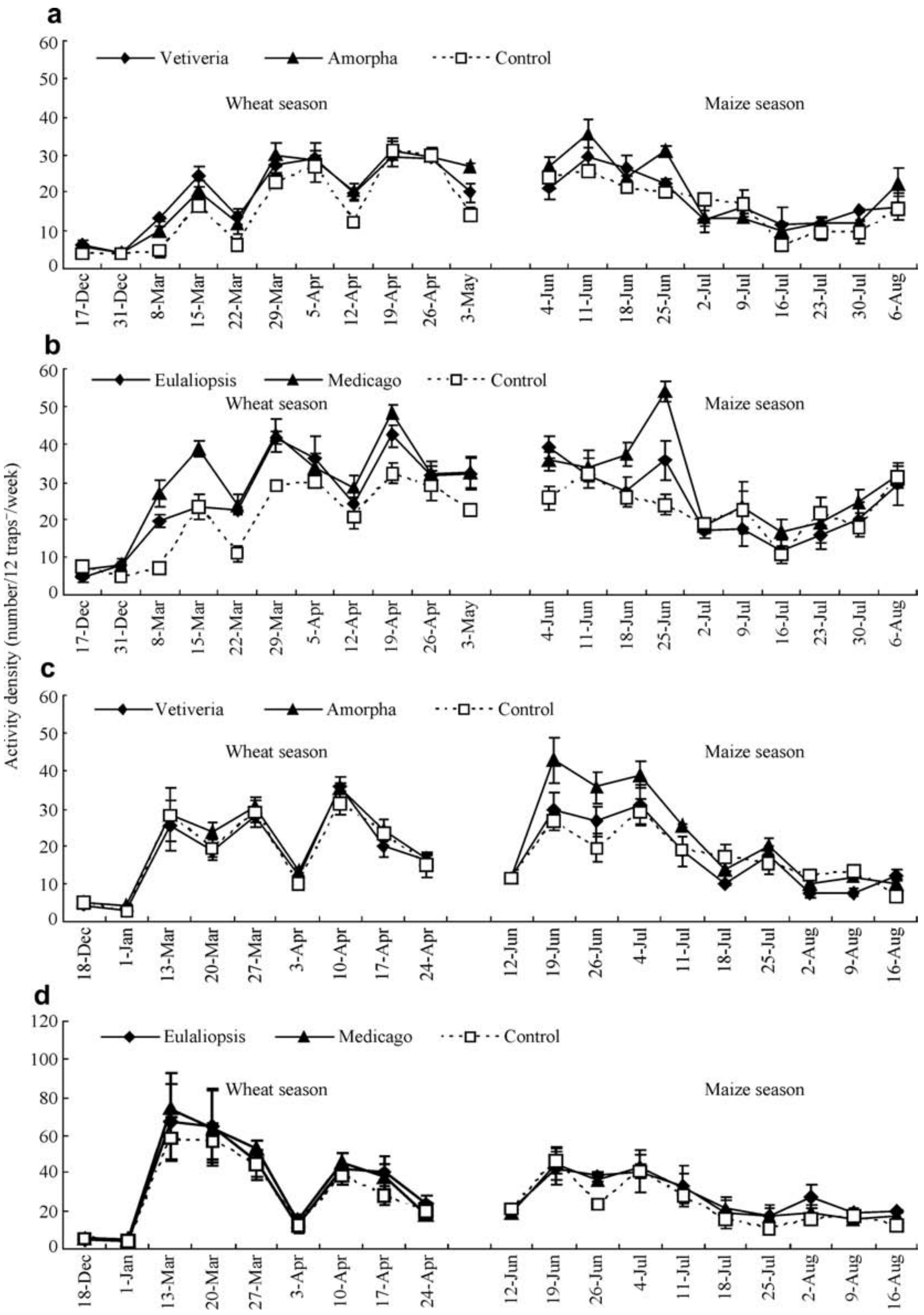

Fig. 1. Seasonal dynamics of spider activity density (±SE) in whole plots (combining hedgerow strip and crop area; $n = 12$ traps) of hedgerow and control treatments during the wheat and maize seasons of 2005–2006 and 2006–2007. (a) Field 1, 2005–2006; (b) field 2, 2005–2006; (c) field 1, 2006–2007; and (d) field 2, 2006–2007.

2006–2007 wheat season, these two variables did not differ significantly between hedgerow and control plots in either field 1 or field 2 (Fig. 3). During the maize season, however, crop fields of *Vetiveria* plots had significantly higher activity densities than did the crop fields of *Amorpha* and control plots in field 1 ($P < 0.01$), but there were no significant differences among crop fields in field 2 (Fig. 3(a)). Species richness in the crop fields did not differ

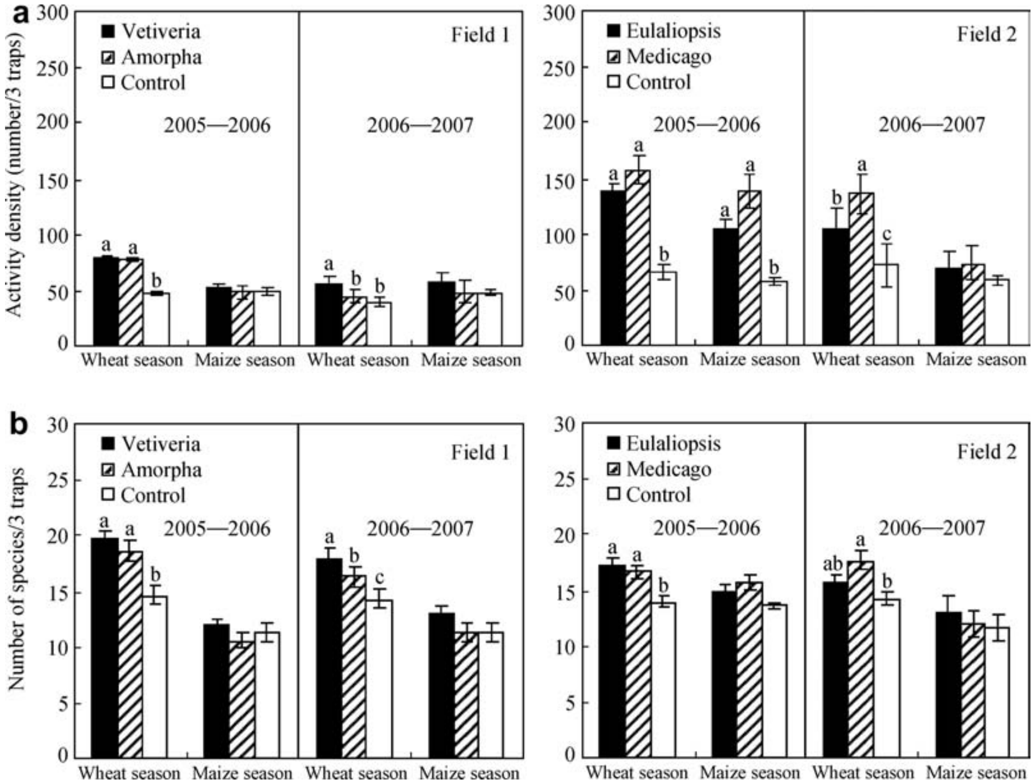

Fig. 2. Mean (±SE) spider activity density (a) and species richness (b) in hedgerow and control strips ($n = 3$ traps) in the wheat and maize growing seasons of 2005–2006 and 2006–2007. Different letters indicate significant differences based on the least-significant difference of square-root-transformed (activity density) and untransformed (species richness) data, $P < 0.05$. Values are means ($n = 3$).

significantly between hedgerow and control plots in either field 1 or field 2 (Fig. 3(b)).

3.4. Spider distribution between hedgerow strips and adjacent crop fields

In the 2005–2006 wheat season, the activity density of spiders was significantly higher in the hedgerow strips of *Vetiveria* ($P < 0.01$), *Amorpha* ($P < 0.05$), *Eulaliopsis* ($P < 0.01$) and *Medicago* ($P < 0.01$) plots than in the adjacent crop fields in both field 1 and field 2 (Fig. 4(a)). During the maize season, the activity density did not differ significantly between hedgerow strips and the adjacent crop fields in either the *Vetiveria* or *Amorpha* plots in field 1. The activity density was significantly higher in the hedgerow strips of *Eulaliopsis* ($P < 0.01$) and *Medicago* ($P = 0.01$) plots than in the adjacent crop fields in field 2 (Fig. 4(b)).

In the 2006–2007 wheat seasons, the activity density of spiders did not differ significantly between hedgerow strips and the adjacent crop fields in either the *Vetiveria* or *Amorpha* plots in field 1. However, the activity density was significantly higher in the hedgerow strips of *Eulaliopsis* ($P < 0.05$) and *Medicago* ($P < 0.01$) plots than in the adjacent crop fields in field 2 (Fig. 4(c)). During the maize season, the activity density did not differ significantly between hedgerow strips and the adjacent crop fields in any of the hedgerow plots (Fig. 4(d)).

4. Discussion

In both study years, the activity density and species richness of ground-dwelling spiders were significantly greater in the hedgerow strips than in the bare soil strips during the wheat season in both fields 1 and 2. In addition, the activity density was significantly higher in the hedgerow strips than in the adjacent crop fields (except for activity density in field 1 in 2006–2007). These results suggest that hedgerow strips may act as refuge habitat for ground-dwelling spiders during the wheat season, perhaps because of the reduced temperature variability and shelter provided by tussock-like grasses and/or the litter layer, which can enhance the overwintering survival of spiders compared to bare soil and crop fields [5–7,16,17,24]. Previous studies have emphasized the importance of semi-natural habitats for overwintering spiders [7,14,25,26]. As a result, more spiders would be expected to aggregate in hedgerow strips than in bare soil or adjacent crop fields in the spring. Lys and Nentwig [27] also reported a significantly higher density of overwintering spiders in a 2-year-old wildflower strip than in an adjacent crop of winter barley. Similarly, Tóth and Kiss [13] found higher spider abundance and species rich-

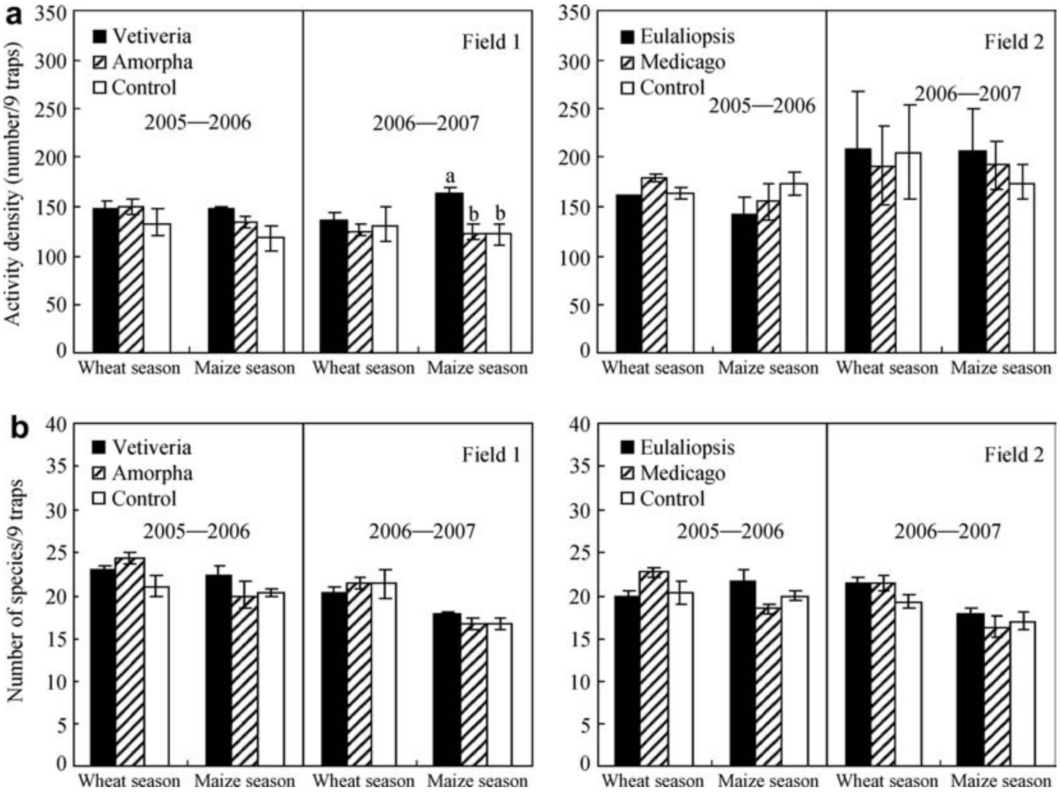

Fig. 3. Mean (±SE) spider activity density (a) and species richness (b) in hedgerow and control crop fields ($n = 9$ traps) in the wheat and maize seasons of 2005–2006 and 2006–2007. Different letters indicate significant differences based on the least-significant difference of square-root-transformed (activity density) and untransformed (species richness) data, $P < 0.05$. Values are means ($n = 3$).

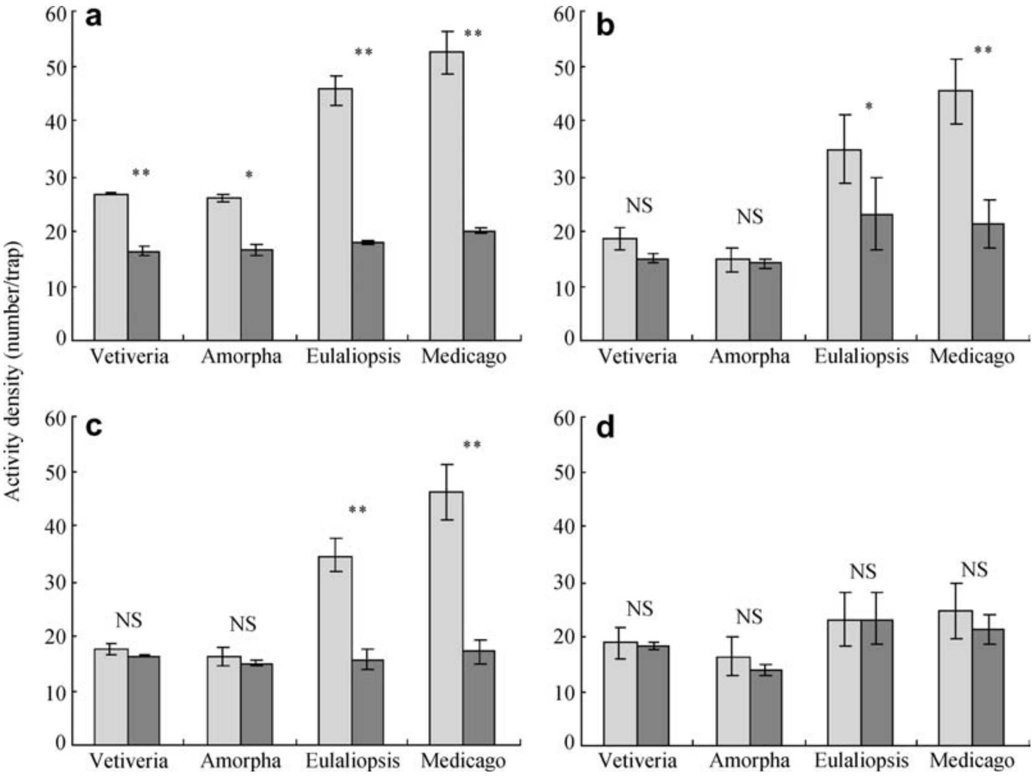

Fig. 4. Mean (±SE) spiders activity density per trap in the hedgerow strips (open bars) and crop fields (solid bars) in 2005–2006 and 2006–2007. Significant differences between strips and crop fields were determined using ANOVA, $^{**}P \leqslant 0.01$; $^{*}P \leqslant 0.05$; NS, not significant. Values are means ($n = 3$). (a) Wheat season, 2005–2006; (b) maize season, 2006; (c) wheat season, 2006–2007; (d) maize season, 2007.

ness in field margins than in adjacent winter wheat fields in northern Hungary.

However, in both study years, spider activity density was similar between hedgerow strips and bare soil strips or adjacent crop fields, and species richness was similar between hedgerow strips and bare soil strips during the maize season in both fields 1 and 2 (except for activity density in field 2 in 2006). Several factors may have contributed to these results. First, overwintering spiders in the hedgerow strips had already dispersed into the fields. Second, the crop fields were not treated with pesticides, and the survey was conducted nearly 1 month after the wheat harvest; thus, the role of hedgerow strips as a spider refuge from pesticides and harvest [28] was likely unimportant at the time of the survey. Third, the sampling efficiency may have decreased as vegetation density increased with growth [25].

In terms of biological control, the effect of hedgerow strips on adjacent fields is particularly important. Previous studies have shown that weed strips are an important source of spiders for fields [5,24,25]. Furthermore, Huusela-Veistola [29] demonstrated that perennial grass strips increase the numbers of spiders in fields. Girma et al. [30] also found that fields with hedgerows have higher numbers of spiders than do fields without hedgerows during long periods of rain. However, in both study years, the ground-dwelling spider activity density and species richness were generally similar in the crop fields with and without hedgerow strips during both the wheat and maize seasons and in fields 1 and 2 (with the exception of activity density in the *Vetiveria* plots in the 2006 maize season). These results indicate that increases in spider density and species richness in the hedgerow strips did not translate into increases in these variables in the crop fields. Given the shelter, favorable microclimate, and abundant prey within hedgerow strips [6], spiders may not have needed to move from the strips to forage in the adjacent crop fields [9]. Similarly, in several previous studies, spiders remained in the vicinity of field margins or weed strips, rather than moving further out into fields [31–33].

Overall, the ground-dwelling spider activity density in hedgerow strips or crop fields was lower in field 1 than in field 2. Two factors may potentially explain this consistent difference. First, the slope gradient was higher in field 1 (20%) than in field 2 (12%), which may have affected the capture rate of pitfall traps. Second, the locations of the pitfall traps in the hedgerow strips differed between fields 1 and 2. The bare soil between the two hedgerow rows was too narrow for the placement of pitfall traps in field 1; thus, they were located outside the hedgerow strips. In contrast, the width of bare soil between the two hedgerow rows was large enough for pitfall traps in field 2. Consequently, we cannot directly compare the hedgerows between field 1 and field 2.

Vegetation structure is one of the most important factors affecting spider communities [34,35], and vegetation height [28], density [36] and cover [37] are all correlated with spider diversity or abundance. During the 2006–2007 wheat seasons, the ground-dwelling spider activity density was significantly higher in the *Vetiveria* than in the *Amorpha* hedgerow strips and in the *Medicago* than in the *Eulaliopsis* strips, and the species richness was significantly higher in the *Vetiveria* than in the *Amorpha* strips. However, the activity density and species richness were similar among plots in 2005–2006, which may have been related to the climatic and hedgerow growth conditions. These results are different from those found during a quadrat survey of spiders (ground-dwelling and foliage-dwelling): the numbers of spider individuals and species per square meter were highest in the *Vetiveria* and *Eulaliopsis* strips, intermediate in the *Medicago* strips, and lowest in the *Amorpha* strips in both 2006 and 2007 (our unpublished data). The capture rate of pitfall traps can be affected by the vegetation structure [22,38], and ground-dwelling spiders appeared to be captured at a lower frequency in the *Eulaliopsis* than in the *Medicago* strips because dense vegetation restricted movement on the soil surface [25]. This finding indicates that spider activity density and species richness varied among the hedgerow species, and grass hedgerow species may be more important to spiders than to shrub hedgerow species.

In conclusion, our experiments indicated that hedgerow strips may act as refuge habitats for ground-dwelling spiders during the winter wheat season. Thus, hedgerow strips play an important role in maintaining ground-dwelling spider populations in agroecosystems. However, the presence of hedgerow strips did not increase the activity density and species richness of spiders in the adjacent crop fields. Therefore, future work should address the methods of attracting spiders into crop fields, thereby contributing to the bio-control of pests. The activity density and species richness of ground-dwelling spiders were differentially affected by the hedgerow species; thus, future studies should examine a greater number of hedgerow species to determine which are most suitable for enhancing spider populations.

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Appendix A

Spider species trapped in all plots during the winter wheat and summer maize seasons at the ZiYang Experimental Station of the Institute of Soils and Fertilizers, Sichuan Academy of Agricultural Sciences in 2005–2007.

Family	Wheat		Maize	
Species	2005–2006	2006–2007	2006	2007
Ctenizidae				
*Latouchia pavlov*i (Schenkel)	1[a] (0.02)[b]	2 (0.05)		
Dictynidae				
Lathys puta (O.P. Cambridge)	20 (0.44)	12 (0.27)	1 (0.03)	
Uloboridae				
Octonoba varians (Boes. et Str)	1 (0.02)	3 (0.07)	4 (0.10)	
Sicariidae				
Scytodes thoracica (Latreille)	4 (0.09)	4 (0.09)	17 (0.43)	42 (1.04)
Araneidae				
Araneus lugubris (Walckenaer)		1 (0.02)	1 (0.03)	4 (0.10)
Larinia argiopiformis (Boes. et Str)				4 (0.10)
Neoscone doenitzi (Boes. et Str)	6 (0.13)	4 (0.09)		
Singa pygmaea (Sundeval)			4 (0.10)	1 (0.02)
Singa sanguinea (C. Koch)	12 (0.27)	3 (0.07)	2 (0.05)	
Tetragnathidae				
Leucauge blanda (L. Koch)	9 (0.20)			
Tetragnatha praedonia (L. Koch)	3 (0.07)	3 (0.07)		
Tetragnatha sp.	8 (0.18)			
Tetragnatha squamata (L. Koch)	2 (0.04)	1 (0.02)		1 (0.02)
Theridiidae				
Coleosoma blandum (O.P. Cambridge)	73 (1.62)	273 (6.25)	180 (4.53)	434 (10.77)
Coleosoma octomaculatum (Boes. et Str)	20 (0.44)	12 (0.27)	30 (0.76)	4 (0.10)
Enoplognatha diodonta (Zhu. et Zhang)		12 (0.27)		
Enoplognatha japonica (Boes. et Str)	6 (0.13)	1 (0.02)	1 (0.03)	
Euryopis sp.		14 (0.32)	26 (0.66)	25 (0.62)
Steatoda cavernicola (Boes. et Str)		1 (0.02)	6 (0.15)	7 (0.17)
Stemmops nigradbomenus sp.nov				7 (0.17)
Stemmops nipponicus (Yaginuma)		33 (0.76)	23 (0.58)	98 (2.43)
Theridion sp.	6 (0.13)	23 (0.53)	18 (0.45)	16 (0.40)
Nesticidae				
Nesticus mogera (Yaginuma)	72 (1.59)	36 (0.82)	62 (1.56)	12 (0.30)
Linyphiidae				
Gnathonarium sp.		3 (0.07)		
Hylyphantes graminicolum (Sundeval)	233 (5.16)	229 (5.25)	49 (1.23)	3 (0.07)
Nematogmun sanguinolentus (Walckenaer)	29 (0.64)	20 (0.46)	4 (0.10)	
Neriene jinjooensis (Paik)	1 (0.02)		1 (0.03)	
Neriene sp1.	5 (0.01)	2 (0.05)	2 (0.05)	1 (0.02)
Neriene sp2.	291 (6.44)	338 (7.74)	12 (0.30)	
Parameioneta bilobata (Li. et Zhu)	924 (20.46)	484 (11.09)	328 (8.26)	40 (0.99)
Ummeliata insecticeps (Boes. et Str)	456 (10.10)	266 (6.09)	70 (1.77)	
Agelenidae				
Agelena sivatica (Oliger)			6 (0.15)	25 (0.62)
Coelotes sp.	61 (1.35)	55 (1.26)		
Hahniidae				
Hahnia yueluensis (Yin. et Wang)	8 (0.18)	5 (0.11)	3 (0.08)	
Lycosidae				
Alopecosa albostriata (Grube)	81 (1.79)	138 (3.16)	144 (3.63)	164 (4.07)
Alopecosa sp.	58 (1.28)	78 (1.79)	82 (2.06)	132 (3.28)

Appendix A (*continued*)

Family	Wheat		Maize	
Species	2005–2006	2006–2007	2006	2007
Pardosa astrigera (L. Koch)	1065 (23.58)	1242 (28.45)	1086 (27.34)	1484 (36.82)
Pardosa laura (Karsch)	253 (5.60)	499 (11.43)	537 (13.52)	603 (14.96)
Pardosa sp1.	9 (0.20)		11 (0.28)	
Pardosa sp2.	31 (0.69)	53 (1.21)	65 (1.64)	87 (2.16)
Pirata subpiraticus (Boes. et Str)	488 (10.80)	181 (4.15)	974 (24.52)	455 (11.29)
Pisauridae				
Dolomedes sulfureus (Boes. et Str)	24 (0.53)	6 (0.14)	6 (0.16)	2 (0.05)
Oxyopidae				
Oxyopes sertatus (L. Koch)	4 (0.09)	1 (0.02)	30 (0.76)	27 (0.67)
Gnaphosidae				
Gnapkosa kompirensis (Boes. et Str)	68 (1.51)	82 (1.88)	35 (0.88)	116 (2.88)
Gnapkosa sp.	12 (0.27)	16 (0.37)	21 (0.53)	55 (1.36)
Clubionodae				
Clubiona pseudogermanica (Schenlcel)	11 (0.24)	5 (0.11)	1 (0.03)	
Heteropodidae				
Heteropoda venatoria (Linnaeus)	1 (0.02)		10 (0.25)	2 (0.05)
Ctenidae				
Anahtita fauna (Karsch)	2 (0.04)			
Thomisidae				
Misumenopos tricuspidata (Fahricius)	1 (0.02)	1 (0.02)		2 (0.05)
Ozyptila atomaria (Panzer)	35 (0.77)	8 (0.18)	11 (0.28)	2 (0.05)
Synaema sp.			7 (0.18)	
Xysticus ephippiatus (Simon)	17 (0.38)	30 (0.69)	16 (0.40)	23 (0.57)
Salticidae				
Asianellus festivus (C. L. Koch)	85 (1.88)	168 (3.85)	24 (0.60)	96 (2.38)
Bianor aenescens (Simon)		6 (0.14)	10 (0.25)	21 (0.52)
Carrhotus xanthogramma (Latreille)		2 (0.05)	1 (0.03)	2 (0.05)
Dendryphantes fusconotatus (Grube)			2 (0.05)	
Evarcha albaria (L. Koch)	5 (0.11)	2 (0.05)	11 (0.28)	4 (0.10)
Marpissa magister (Karsch)				1 (0.02)
Phintella arenicolor (Grube)	13 (0.29)	4 (0.09)	33 (0.83)	
Plexippus setipes (Karsch)	3 (0.07)	2 (0.05)	1 (0.03)	13 (0.32)
Sibianor pullus (Boes. et Str)			4 (0.10)	5 (0.12)
Sitticus penicillatus (Simon)		2 (0.05)		10 (0.25)
Individual number	4517	4366	3972	4030
Species number	45	48	47	39

[a] Total number of individuals per species caught in all plots during the wheat and maize growing seasons in each year.

[b] Numbers in parentheses are proportions of the total number per species caught for each growing season in each year.

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