

## Spiders (Araneae) and harvestmen (Opiliones) in arable crops and grasses in Canterbury, New Zealand

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**Abstract** As an initial step in assessing the impact of spiders and harvestmen as biological control agents for insect pests of arable crops, the population density and species richness of spiders and harvestmen were examined in a range of cereal crops and grasses at two sites in Canterbury, New Zealand, in 1996, 1997, and 1999 using a ground suction sampler. Twenty spiders (Order Araneae) and one harvestman (Order Opiliones) were identified from the grass and cereal samples. Thirteen were endemic species. Population densities were estimated in ryegrass, fescue, cocksfoot, prairie grass, wheat, and barley. Greatest population density and species richness were found in fescue and ungrazed ryegrass, in which mean densities of up to 180.8 spiders and harvestmen per square metre were recorded. Estimates of density and species richness were much higher in grasses than in cereals. The introduced linyphiid spider *Tenuiphantes tenuis* (Blackwall), comprised over half of the spiders and harvestmen

sampled. Other commonly found species were the introduced money spider (*Erigone wiltoni* Locket), and the endemic wolf spider *Anoteropsis hilaris* (L. Koch). The introduced harvestman *Phalangium opilio* L. was also common.

**Keywords** spiders; harvestmen; arable crops; grasses; species richness; density

### INTRODUCTION

Spiders are often the most abundant predators in agroecosystems (Wise 1993) and in some instances they have been shown to significantly reduce insect pest numbers (for a review see Sunderland 1999). The shortage of publications on spiders in New Zealand agroecosystems is surprising given that New Zealand has a large and diverse spider fauna estimated to include over 2500 species (Forster & Forster 1999) and more than 13.9 million hectares (52%) of New Zealand is farmland (Statistics New Zealand 2002). To date there have been only three research publications dealing specifically with spiders in New Zealand agroecosystems: Topping & Lövei (1997) investigated spider density and diversity in relation to disturbance in pasture and wheat agroecosystems in the lower North Island; Hodge & Vink (2000) assessed the spiders and harvestmen in Canterbury bean crops; and McLachlan & Wratten (2003) compared spider density and species composition between field margins and pasture in Canterbury. A few other papers have been published on predatory arthropods, including spiders and harvestmen, in New Zealand agroecosystems (e.g., Berry et al. 1996; Sivasubramaniam et al. 1997). Martin (1983) surveyed the pasture fauna in Nelson and recorded 45 spider species plus the European harvestman (*Phalangium opilio* L.). New Zealand's endemic harvestmen are found mainly in forests and the introduced *P. opilio* is the harvestman species most commonly found in arable lands (Forster 1962). However, overall very little is known of the spider

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**Fig. 1** Map of New Zealand showing the location of the two sampling sites.

fauna of New Zealand arable crops. Topping & Lövei (1997) identified 23 spider species in pasture and wheat in the lower North Island of New Zealand.

Work on spiders in New Zealand agroecosystems is made difficult by the present state of spider taxonomy. Only about 1300 species of the estimated 2500–3600 New Zealand species have been described (Platnick 1991; Forster & Forster 1999), and many of the large families (e.g., Theridiidae, Salticidae) have not been revised. Also, many species, genera, and even families cannot be identified from immature specimens.

Harvestmen are predators and scavengers and all spiders are predators. Several studies have shown that aphids are an important prey of spiders in cereal fields (e.g., Sunderland et al. 1986, 1987; Nyffeler & Benz 1988a,b). Knowledge of spider species richness and population densities, as well as factors that influence these parameters, is the first step in understanding the potential contribution of spiders to the biological control of pests such as aphids.

The aim of this study was to gather information on the faunal composition of spiders found in arable

land in Canterbury. We also wanted to measure the changes in the abundance of spiders (Order Araneae) and harvestmen (Order Opiliones) in these agroecosystems over time. This work is part of a larger study investigating the population dynamics of aphids inhabiting cereal and grass crops (D. A. J. Teulon & M. A. W. Stufkens unpubl. data).

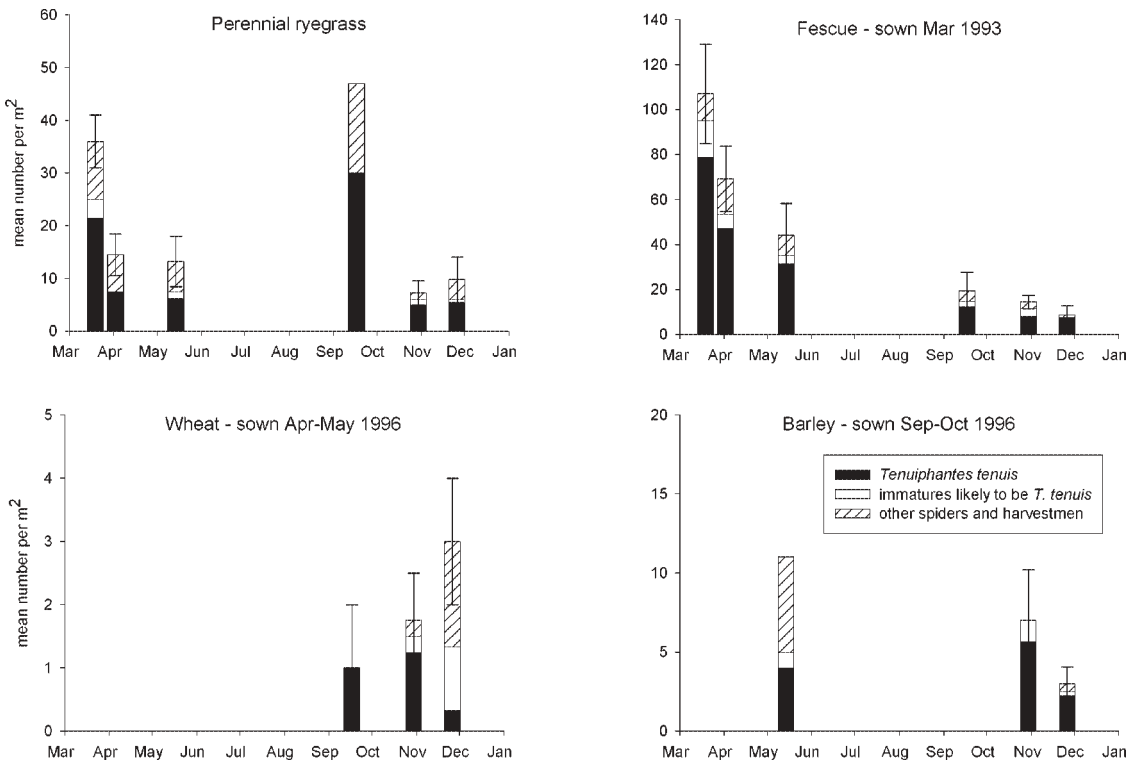
## METHODS

### Site descriptions

Two sites in Canterbury, the main arable crop growing region of New Zealand, were selected for sampling (Fig. 1). These were a commercial cropping farm near Geraldine (44°08'S, 171°11'E) and the Canterbury Agricultural Science Centre, Lincoln (43°38'S, 172°28'E). At the Geraldine site, three to four fields (size: 3–34 ha) of each of ryegrass pasture (*Lolium perenne* L.), fescue (*Festuca arundinacea* L.), wheat (*Triticum aestivum* L.), and barley (*Hordeum vulgare* L.) were sampled in 1996 and 1997. The ryegrass fields were grazed by sheep, fescue was grown for seed, and wheat and barley were grown for grain. At the Lincoln site, a replicated field trial (four crops × four replicates arranged randomly) was established which included plots of ryegrass, fescue, cocksfoot (*Dactylis glomerata* L.), prairie grass (*Bromus willdenowii* Kunth), wheat, and barley. Not all grasses or cereals were planted in each year. Plots were 18 m × 17.8 m and separated by 5-m strips. The Lincoln site was sampled in 1996 and 1999; the wheat samples in 1996 were taken from another nearby (<0.5 km away) crop. All grasses at Lincoln were ungrazed. Sowing dates for the wheat and barley at both sites are given in Fig. 2–5. Grass and cereal fields or plots were sampled at monthly or bi-monthly intervals between March and January the following year, depending on when each crop had been planted or if weather permitted sampling.

### Sampling procedure and spider identification

For each of the four replicate grass and cereal fields (Geraldine) or plots (Lincoln) 50 probes (total area: 1 m<sup>2</sup>), each of about 4 seconds duration and 10 m (Geraldine) or 1 m (Lincoln) apart, were made in the vegetation with a powered ground suction sampler similar to the design of Arnold (1994). The ground suction sampler does not work well on wet or damp crops and on some occasions during the winter months (June, July, August) there were very few days when conditions were dry enough to sample.



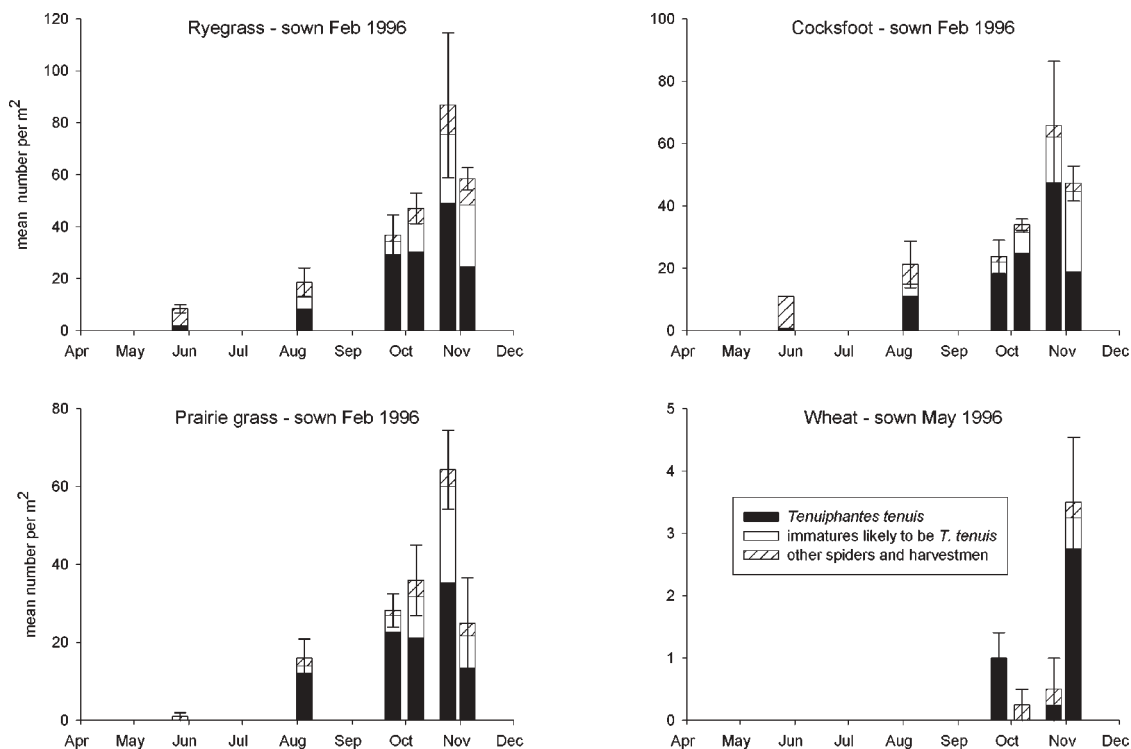
**Fig. 2** Mean estimated densities ( $\pm$ SE) of spiders and harvestmen in grazed perennial ryegrass, fescue seed crops, and wheat and barley crops at the Geraldine site in 1996. Estimate based on only one, 1 m<sup>2</sup> replicate for perennial ryegrass on 17 September and for barley on 14 May. The May 1996 barley sample was from an earlier sown crop. Note: the y-axis scales differ.

Samples were frozen and spiders, aphids, and other invertebrates were later extracted by sieving and hand sorting.

Spiders were identified in the laboratory using a stereomicroscope. Where possible, specimens were identified to species using the taxonomic literature (Millidge 1988; Platnick & Forster 1989; Vink 2002). It was not possible to identify all specimens to species or genus due to limitations in the taxonomic literature and/or the absence of adult specimens. Identification of female *Haplisis* specimens to species is extremely difficult and is often only possible by dissecting and examining the internal female genitalia (A. D. Blest pers. comm.). Some *Haplisis* specimens ( $n = 46$ ) were identified to species (Blest 1979; Blest & Vink 2002) and retained as vouchers, but most female specimens were only recorded as *Haplisis* sp. All immature specimens from the family Lycosidae (wolf spiders) were identified as *Anoteropsis hilaris* (L. Koch) as

this is the only New Zealand wolf spider species found in arable farmland in Canterbury and it has a characteristic colour pattern (Vink 2002).

Medium-sized and larger immatures of *Tenuiphantes tenuis* (Blackwall) (formerly *Lepthyphantes tenuis*, see Saaristo & Tanasevitch 1996) were identified by the presence of a prolateral femoral spine on the first leg (Millidge 1988). It was not possible to be certain of the identity of specimens recorded as “immature Linyphiidae not Mynogleninae” but they were likely to be *T. tenuis*. Most unidentified immatures were almost certainly immature Linyphiidae (including *T. tenuis*). Both mature and immature specimens of *P. opilio* were identified by their silvery white dorsal surface, which is unique amongst harvestmen in New Zealand (Forster 1962). Voucher specimens of specimens identified to species were deposited in the New Zealand Arthropod Collection, Auckland, New Zealand.



**Fig. 3** Mean estimated densities ( $\pm$ SE) of spiders and harvestmen in ryegrass, cocksfoot, prairie grass, and wheat at the Lincoln site in 1996. Estimate based on only one, 1 m<sup>2</sup> replicate for cocksfoot on 27 May. Note: the y-axes scales differ.

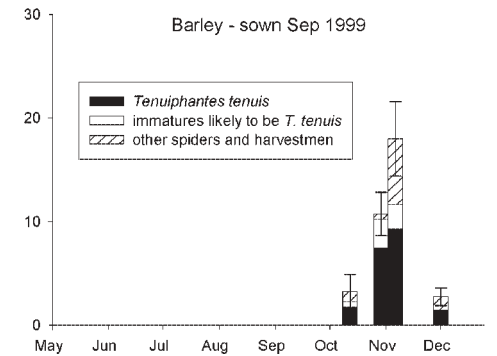
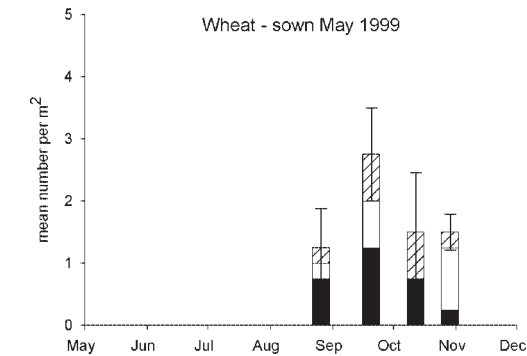
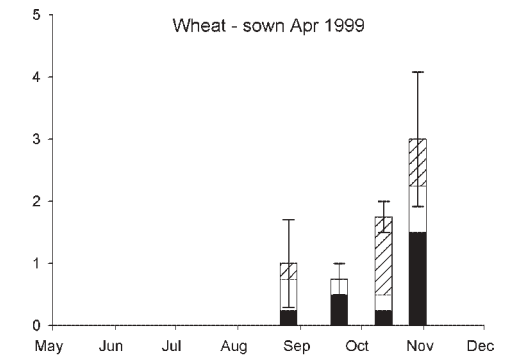
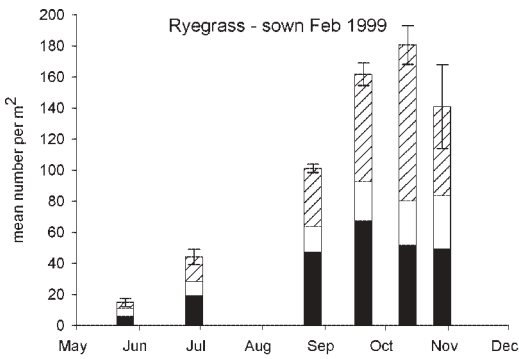
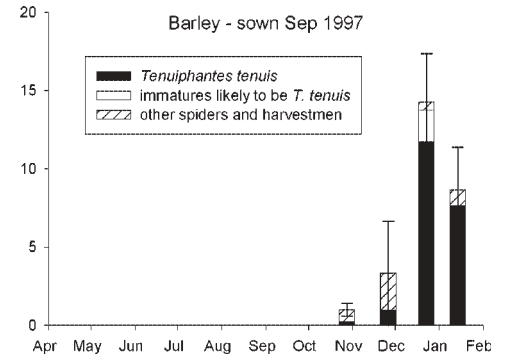
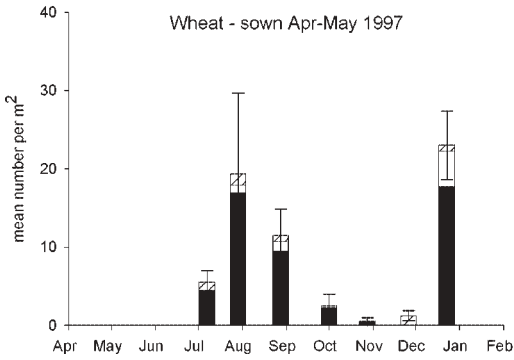
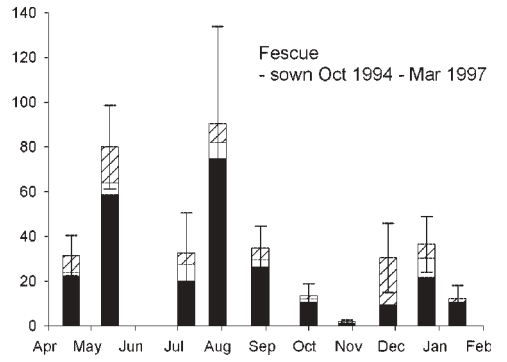
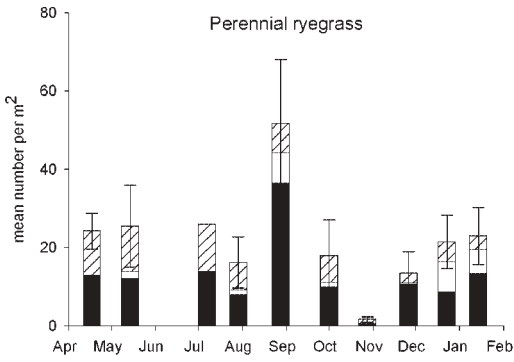
**Fig. 4** (*Opposite above*) Mean estimated densities ( $\pm$ SE) of spiders and harvestmen in grazed perennial ryegrass, fescue seed crops, and wheat and barley crops at the Geraldine site in 1997. Estimate based on only one, 1 m<sup>2</sup> replicate for perennial ryegrass on 7 July. Note: the y-axes scales differ.

**Fig. 5** (*Opposite below*) Mean estimated densities ( $\pm$ SE) of spiders and harvestmen in ryegrass, wheat and barley at the Lincoln site in 1999. Note: the y-axes scales differ.

## RESULTS

Twenty spiders (Order Araneae) and one harvestman (Order Opiliones) were identified from the grass and cereal samples (Table 1). Thirteen were endemic species. Species richness was higher (9–16 species) in grasses than in cereals (2–10 species) at both sites. The highest species richness (16 species) was recorded in fescue at the Geraldine site in 1997. Species richness was greater overall at the Geraldine site. The lowest observed species richness (two species) was recorded in barley at Lincoln in 1996. Figures 2–5 show the mean population densities of

spiders in all grasses and cereals sampled. All samples contained at least one spider or harvestman per square metre. Spider population densities were highest during spring at both sites. Ungrazed ryegrass had the highest numbers of spiders and harvestmen with a maximum mean density ( $\pm$ SE) of  $180.8 \pm 12.5$  m<sup>-2</sup>. Densities were also high in fescue seed crops at Geraldine (Fig. 2, 4). Densities in cereal crops were consistently lower than in grass. The highest mean density in wheat was  $23 \pm 4.4$  m<sup>-2</sup> and in barley  $18 \pm 3.6$  m<sup>-2</sup>. There were fewer spiders in grazed ryegrass at Geraldine than in fescue crops (Fig. 2, 4). Barley was sampled on only one date



**Table 1** The spider fauna from ground suction samples in arable crops and grasses. Data are pooled from separate samples in each year. \* = introduced species; all others are endemic except "immature Linyphiidae not Mynogleninae" and unidentified immatures, which were unknown. R = ryegrass, P = prairie grass, C = cocksfoot, W = wheat, B = barley, F = fescue, W1 = wheat sown in April, W2 = wheat sown in May.

Species	Total numbers of specimens collected																		% of all Total specimens			
	Lincoln 1996						Geraldine 1996						Geraldine 1997							Lincoln 1999		
	R	P	C	W	B		R	F	W	B		R	F	W	B		R	W1		W2	B	
<b>LINYPHIIDAE</b>																						
<i>Tenuiphantes tenuis</i> (Blackwall)*	565	385	485	16	0	0	170	584	8	30	0	467	932	179	74	0	969	10	12	71	4957	56.27
<i>Erigone wiltoni</i> Lockett*	23	2	28	1	1	0	26	17	1	5	0	78	22	2	2	0	7	1	2	0	218	2.48
<i>Erigone prominens</i> Bösenberg & Strand*	2	1	0	0	0	0	9	17	0	1	0	5	3	1	0	0	7	0	1	2	49	0.56
<i>Erigone</i> sp. imm.*	1	2	1	0	0	0	18	28	3	0	0	10	2	2	0	0	5	1	0	1	74	0.84
<i>Araeoncus humilis</i> (Blackwall)*	1	0	0	0	0	0	1	7	0	0	0	5	2	1	0	0	0	0	0	0	17	0.19
<i>Diplopecta communis</i> Millidge	2	1	0	0	0	0	4	23	0	0	0	18	9	0	0	0	8	0	0	0	65	0.74
<i>Microtononyx subitanus</i> (O. P.-Cambridge)*	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	3	0	0	0	5	0.06
<i>Osteartius melanopygius</i> (O. P.-Cambridge)*	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0.02
<i>Diplocephalus cristatus</i> (Blackwall)*	0	0	0	0	0	0	0	0	1	0	0	0	4	0	0	0	0	0	0	0	5	0.06
<i>Laeetia minor</i> Millidge	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.02
Immature Linyphiidae not Mynogleninae	276	173	218	2	0	0	18	97	4	6	0	104	121	27	8	0	472	7	8	20	1561	17.72
<i>Haplisis fucatinia</i> (Urquhart)	3	1	2	0	0	0	8	0	0	0	0	14	4	0	0	0	0	0	0	0	32	0.36
<i>Haplisis inexacta</i> (Blest)	0	0	0	0	0	0	0	0	0	0	0	3	2	0	0	0	0	0	0	0	5	0.06
<i>Haplisis exigua</i> Blest & Vink	0	0	0	0	0	0	1	0	0	0	0	6	2	0	0	0	0	0	0	0	9	0.10
<i>Haplisis</i> sp.	0	0	0	0	0	0	1	2	0	0	0	3	6	0	0	0	0	0	0	0	12	0.14
Immature Mynogleninae	0	0	1	0	0	0	9	1	0	0	0	31	17	1	0	0	1	0	0	0	61	0.69
<b>LYCOSIDAE</b>																						
<i>Anoteropsis hilaris</i> (L. Koch)	2	3	0	1	0	0	28	41	0	2	0	50	81	2	2	0	18	1	0	3	234	2.66
<b>THERIDIIDAE</b>																						
<i>Argyrodes</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.01
Unidentified species a	0	0	0	0	0	0	2	7	1	0	0	0	2	0	1	0	2	1	0	0	16	0.18
Unidentified species b	1	1	5	0	0	0	1	6	0	0	0	4	6	1	0	0	0	0	0	0	25	0.28
Unidentified species c	1	1	3	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	8	0.09
<b>SALTICIDAE</b>																						
Unidentified species a	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	3	0.03
Unidentified species b	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.01
Immature	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.01



prey populations (to be examined in a later publication) and the lack of habitat diversity in cereal crops. Spider abundance was increased by habitat diversification in 63% of the studies reviewed by Sunderland & Samu (2000). Kendall et al. (1991) found that reduced tillage in winter cereals increased the density of linyphiid spiders and other predatory arthropods. Both Topping & Sunderland (1994a) and Feber et al. (1998) found that spider population density and species richness were increased by partial weeding in winter wheat. De Barro (1992) found that lycosid and linyphiid spiders were an important factor in controlling cereal aphid (*Rhopalosiphum padi* (L.)) numbers in irrigated perennial grass pasture. Aphids comprise a major part of the prey of harvestmen (e.g., Leathwick & Winterbourne 1984) and spiders in cereal fields (e.g., Sunderland et al. 1986, 1987; Nyffeler & Benz 1988a,b) and the spiders and harvestmen found in New Zealand crops and pasture may contribute to reductions in pest populations.

Spider population densities and species richness were also higher in ungrazed ryegrass and fescue than in grazed grasses (Fig. 2–5; Table 1). Similar effects have been observed in the United Kingdom where heavy grazing greatly reduced linyphiid spider population density in grass (Thomas & Jepson 1997). Topping & Lövei (1997) also found that grazing had a negative effect on spider population densities in pastures in the lower North Island of New Zealand.

Spider numbers decreased in November 1996 at Lincoln (Fig. 3) and decreased sharply in November 1997 at Geraldine (Fig. 4). These population decreases did not appear to be due to insecticide application, as the Lincoln (grasses and cereals) and Geraldine (grasses) sites were not sprayed during the sampling period. The lower spider populations observed may have been due to the hot, dry north-west winds that are common in Canterbury in spring, which dry the crops and may reduce prey populations such as aphids (e.g., Farrell & Stufkens 1988).

Topping & Lövei (1997) recorded spider densities of 1.8–6.6 m<sup>-2</sup> in wheat and 5.0–130.0 m<sup>-2</sup> in North Island pasture. Topping & Lövei (1997) sampled only in late November, and the densities they recorded were similar to the range of population densities found in November in the present study (see Fig. 2–5). McLachlan & Wratten (2003) recorded a mean population density of 53.0 spiders per square metre throughout the year for all Canterbury pastures sampled with a minimum of 6.8 m<sup>-2</sup> and a maximum of 77 m<sup>-2</sup>, which fall within the range found in the present study.

We recorded between 2 and 10 spider and harvestmen species in cereals and 9–16 species in grasses (see Table 1). Topping & Lövei (1997) also recorded higher species richness in pasture (16 species) as compared with wheat (two species). Similar species richness and composition to those found in the present study were reported in North Island and Canterbury pasture (Topping & Lövei 1997; McLachlan & Wratten 2003). The most common species sampled in the present study was *T. tenuis*, which was probably introduced from Europe (Millidge 1988). This species was also reported as the most abundant spider species in North Island pasture (Topping & Lövei 1997) and Canterbury pasture (McLachlan & Wratten 2003). *Tenuiphantes tenuis* is also common in agroecosystems in England and other European countries (Sunderland et al. 1986; Topping & Sunderland 1994b; Sunderland 1996; Topping & Lövei 1997). Sunderland (1996) reviewed the population ecology of *T. tenuis* and stated that it had considerable biological control potential for cereal pests.

Topping & Lövei (1997) recorded high numbers of an unidentified lycosid species, likely to be *A. hilaris*, in North Island pasture. This spider was one of the more numerous species in pasture in Nelson (Martin 1983) and Canterbury (McLachlan & Wratten 2003). *Anoteropsis hilaris* has also been reported in high numbers in carrot fields (Sivasubramaniam et al. 1997) and bean crops (Hodge & Vink 2000). In both these studies, lycosids were as numerous as *T. tenuis*. However, both studies used pitfall trapping to sample spiders and, therefore, their results were a combination of activity and population density. Most lycosids are active, cursorial hunters and are more likely to be caught by pitfall traps. In contrast, many linyphiids are web builders and are less likely to be caught by pitfall traps. Topping & Sunderland (1992) found that pitfall traps underestimated the numerical species composition of linyphiids and overestimated the numerical species composition of lycosids. Some linyphiid species, including *T. tenuis*, had behaviours that enabled them to either avoid or escape from pitfall traps (Topping 1993). Suction sampling, however, also has biases. Although the type of suction sampler used in the present study has been found to be more efficient and accurate for sampling than other suction samplers (Macleod et al. 1994), pitfall traps and sweep netting (Samu & Sárospataki 1995), it can overestimate absolute spider population density (see Samu et al. 1997). Conversely, Macleod

et al. (1994) found that in some cases as few as 50% of the lycosids present were sampled by a ground suction sampler similar to that used in this study. Lycosid specimens have been observed in the field clinging to the bases of grasses immediately after a suction sampler has been applied to the area (C. J. Vink unpubl. data). Sunderland & Topping (1995) also showed that the efficiency of collecting spiders from wheat with a suction sampler varied, often catching less than 70% of spiders present.

*Erigone wiltoni* was also amongst the more abundant spider species found in New Zealand pasture by Martin (1983), Topping & Lövei (1997), and McLachlan & Wratten (2003). Sivasubramaniam et al. (1997) also recorded high numbers of *Erigone* spp. in Canterbury carrot fields. The introduced linyphiid *Eperigone fradeorum* (Berland), which was recorded in North Island pasture by Topping & Lövei (1997) and Nelson pasture by Martin (1983 [misidentified as *Epirigone tridentata* (Emerton)]), was not recorded in the present study or by McLachlan & Wratten (2003). *Eperigone fradeorum* appears to be uncommon in the middle and lower South Island and has only been recorded once south of 42°S (Millidge 1988).

*Anoteropsis hiliaris* was the only abundant endemic spider species found in this and other studies of arable crops, pasture, and other agroecosystems in New Zealand (Martin 1983; Sivasubramaniam et al. 1997; Topping & Lövei 1997; Hodge & Vink 2000; McLachlan & Wratten 2003). Other New Zealand endemics were found (see Table 1) but never in high numbers. New Zealand's large spider fauna consists mostly (>95%) of endemic species, but most are found in native forest (Forster & Forster 1999). *Anoteropsis hiliaris* is one of the few New Zealand endemic spider species found in natural grasslands (Vink 2002). *Anoteropsis hiliaris* and many of the introduced species, whose natural habitats are similar to agroecosystems, dominate New Zealand's arable crops and introduced grasslands as most endemic species are unable to compete with them.

The introduced harvestman *P. opilio* is found in a variety of agroecosystems in New Zealand (e.g., Ashby 1974; Wratten & Pearson 1982; Martin 1983; Leathwick & Winterbourn 1984; Berry et al. 1996; Sivasubramaniam et al. 1997; Hodge & Vink 2000). Martin (1983), Leathwick & Winterbourn (1984), Sivasubramaniam et al. (1997), and Hodge & Vink (2000) recorded high numbers of *P. opilio* in pasture, lucerne, carrots, and beans, respectively. Berry et al. (1996) used a ground suction sampler in carrot crops

and found *P. opilio* densities of up to 3 m<sup>-2</sup>, which is within the range of densities found in our study.

The present study is the first to compare spider population density over time in a range of arable crops and grasses in New Zealand. We found that numbers increased after winter and decreased again towards the end of spring. The introduced linyphiid *T. tenuis* was the numerically dominant spider species, but the spiders *E. wiltoni* and *A. hiliaris*, and the harvestman *P. opilio* were also common. This study has shown that spider species richness and densities are much higher in grasses than in cereals. Factors that increase spider and harvestmen densities in New Zealand cereal fields and their impact on pest populations need to be investigated experimentally.

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