Pedobiologia **41**, 110–114 (1997)
Gustav Fischer Verlag Jena

PROCEEDINGS OF IX INTERNATIONAL COLLOQUIUM ON APTERYGOTA, DUBLIN 1996

Population dynamics of epigeic Collembola in arable fields: the importance of hedgerow proximity and crop type

Tania Alvarez, Geoffrey K. Frampton and Dave Goulson

Department of Biology, University of Southampton, Southampton SO16 7PX, UK

Accepted: 17. January 1997

Summary. During spring 1996, the temporal and spatial dynamics of epigeic Collembola, in southern UK, were studied in fields planted with spring barley and vining peas. Composition of the fauna varied according to crop type and position within the field. Proximity of a hedgerow had a major impact upon population dynamics, with more species and a greater overall abundance near field edges. It was the major factor governing the abundance of *Isotomurus palustris* and *Bourletiella hortensis*, whereas crop type was most important in determining numbers of *Jeannenotia stachi*, *Sminthurus viridis*, *Sminthurinus elegans* and *Lepidocyrtus* spp. Temporal variation in species abundance was also clear: abundances of *J. stachi*, *B. hortensis*, *I. palustris* and *Lepidocyrtus* spp. decreased through the sampling period while those of *S. viridis* and *Isotoma viridis* increased. Overall, the management practices associated with the two crops were an important determinant of collembolan abundance but not of species composition.

Key words: Collembola, arable fields, population dynamics, cultivation, pesticide effects

Introduction

Long-term studies, such as the Boxworth Project (Vickerman 1992), which monitored the effects of different pesticide regimes, suggest that the spatial and temporal occurrence of species could determine their exposure and vulnerability to pesticide use. Results for predatory arthropods indicated that phenology and dispersal ability were major determinants of the severity and persistence of pesticide effects, with poorly-dispersive species, which overwintered in the field, being particularly vulnerable. Very little comparable information exists for epigeic Collembola. The aim of this work was to investigate, for two spring-sown crops, spring barley and vining peas: (i) the species composition of the collembolan fauna in relation to distance from the field boundary; (ii) whether certain species overwintered in the field; (iii) the temporal and spatial occurrence of population peaks; (iv) whether differences in population dynamics and community composition existed between the two crop types; and (v) whether specific species are particularly vulnerable to particular pesticide applications due to their ecology.

Materials and Methods

Site description

The study fields belonged to The Manydown Company, Wootton St Lawrence, Hampshire, UK (OS 595 525). The eight fields, located on well-drained calcareous soils, ranged in size from 50 to 100 ha, and were selected in spring 1996 to be homogenous in terms of soil type and cropping history. All the fields had at least one side of continuous mature hedgerow. Four fields were planted with spring barley cv. Chariot, on 16–17 March. Vining peas (cvs. Vada and Sherborne) were planted in the remaining four fields on 1–4 May. Fields were subject to current farm practice management and had the following chemical inputs (H = herbicide; F = fungicide): Spring barley received bromoxynil + ioxynil (H), mecoprop (H), metsulfuron-methyl (H), carbendazim (F) on 14 May and flusilazole (F) on 26 May. Vining peas received glyphosate (H), simazine and trietazine (H), terbuthylazine + terbutryn (H) between 26–29 March.

Sampling

To investigate the presence of Collembola in fields in the early spring prior to sowing, ten trays of soil (each 1500 cm^3) were taken from the centre of two of the designated pea fields on 16 March. These were stored for 2 weeks at 4 °C in darkness, before being incubated under controlled laboratory conditions (12–18 °C; light : dark 12 : 12; watered every 2 days or as needed) for 2 months and the emerging Collembola captured with small pitfall traps placed within the trays.
Suction sampling began in all eight fields on 18 March. Four sampling points were placed 20 m apart and 2 m into the field, along the edge adjoining the hedgerow and over 40 m from the nearest other edges. Four sampling points were similarly located a further 50 m into each field. Suction samples were taken at each point using a leaf blower ('Little Wonder') adapted as described in Stewart & Wright (1995). Each sample was taken by holding the suction tube (diameter 17 cm, height 1 m) for 10 seconds in 5 random positions within 1 m^2 at each site. The sampling area was thus 0.454 m^2. Samples were taken every 2 weeks (weather permitting) between 10 : 30 and 14 : 00 BST. They were frozen for storage and cleaned using flotation in water. They were then stored in 80 % methylated spirit, and examined under a binocular microscope; specimens difficult to identify were examined further using a compound light microscope. *Lepidocyrtus violaceus* Lubb. and *L. cyaneus* Tullberg, were not distinguished due to their problematic identification.
The abundances of Collembola in the edge and middle, and under the two different crops, were compared using Repeated Measures ANOVA. Differences between Shannon-Wiener equitability indices on each date were tested using 2-tailed t-tests. Figures given for population levels are in the form 'mean ± s.d.'. Population differences between individual fields were only significant for *Isotoma notabilis* Schäffer; hence for other species it was considered valid to treat the fields as replicates of the crop and position treatments.

Results

Temporal patterns of abundance over spring

The commonest species encountered in the period March to the end of May were: *Sminthurinus elegans* Fitch, *Sminthurus viridis* L., *Jeannenotia stachi* Jeannenot, *Bourletiella hortensis* Fitch, *Isotoma viridis* Bourl., *Lepidocyrtus* spp., *Isotomurus palustris* Müll., *I. notabilis*, and *Entomobrya multifasciata* Tullb. All were found in both crops and at both field locations. The total abundance of Collembola changed significantly over time ($F_{4,52} = 11.8$, $P < 0.001$) and was dominated throughout by the symphypleonids ($F_{1,27} = 11.9$, $P = 0.002$). Three patterns of abundance emerged over time (Table 1).
Catches of all species declined in the pea fields due to soil disturbance when these were sown, the cultivation being detrimental to epigeic populations (Fromm et al. 1993). A concurrent but smaller decrease in the spring barley catches of *S. elegans*, *I. viridis*, *I. palustris* and *B. hortensis* may have been attributable to the application of fungicides (Frampton 1994). *S. viridis* and *E. multifasciata* were unaffected by the chemical applications.

Table 1. Temporal distribution of Collembola in the spring. Values denote initial and final mean catches ± s.d.

Population trends	*Species*
Decreased abundance over spring in all fields and both positions:	*J. stachi* 17.5 ± 28, 1.5 ± 3, P = 0.003; n = 4 *B. hortensis* 4.9 ± 11, 2.9 ± 4, P < 0.001; n = 4 *Lepidocyrtus* spp 12.5 ± 12, 3.6 ± 8, P < 0.001; n = 4 *I. palustris* 4.5 ± 6, 1.0 ± 1, P < 0.001; n = 4
Increased abundance over spring in all fields and both positions:	*S. viridis* 0.2 ± 0.5, 20.3 ± 36, P < 0.001; n = 4 *I. viridis* 0.96 ± 2, 5.9 ± 10, P < 0.001; n = 4
Rare throughout spring; increase in abundance slight and restricted to the field edges:	*S. elegans* 0.22 ± 0.7, 1.2 ± 2, P < 0.001; n = 4 *E. multifasciata* 0.08 ± 0.3, 4.9 ± 20, P < 0.001; n = 4

Location of overwintering sites for different species

Unlike those recently drilled for barley, the fields due to be drilled with peas were left as undisturbed bare soil over winter. They therefore provided an opportunity to identify those species present in the soil prior to sowing, and hence those most likely to have overwintered there. *J. stachi*, *B. hortensis* and *Lepidocyrtus* spp were present as adults in suction samples taken on 18 March. Laboratory incubation of the soil also suggested that *I. viridis*, *I. palustris* and *Lepidocyrtus* could have overwintered as adults, whilst *S. elegans* and *S. viridis* probably overwintered as eggs as initial captures were predominantly of newly emerged nymphs (Table 2). *S. viridis* is known to overwinter as eggs (Maclagan 1932).

Effects of position in the field on composition and abundance of fauna

There were significantly more species of Collembola found at the edge as opposed to the middle of all the experimental fields ($F_{1,22} = 43.13$, $P < 0.001$; Fig. 1). However, Shannon-Wiener equitability indices did not show any consistent pattern of species composition and abundance.

Isotomurus palustris and *E. multifasciata* tended to be more numerous at the field edge than in the middle (Table 3), as did *I. viridis* and *B. hortensis*. However, *S. elegans*, *S. viridis*, *Lepidocyrtus* spp, and *J. stachi* showed no significant differences between the two locations.

Table 2. Species found in / emerging from soil incubated under laboratory conditions. Where two clear size classes were evident, it was possible to identify adults (A) and nymphs (N)

Time incubated:	*I. palustris*	*S. elegans*	*S. viridis*	*I. viridis*	*L. cyaneus*	*B. hortensis*
1 week	4 A	5 N	44 N	25 A & N	50 A	1 A
2 weeks	2 A	19 N	54 N	14 A & N	10 A	6 A & N
3 weeks	0	4 N	4 N	1 N	5 A	6 N
4 weeks	0	10 N & A	11 N	2 N	1 A	9 N
5 weeks	0	52 N & A	26 N	1 N	8 A & N	55 N
6 weeks	0	224 N & A	2 N	1 N	0	0
7 weeks	0	260 N & A	0	13 N	6 N	5 N
8 weeks	2 N	355 N & A	0	59 N	4 N	1 N

Table 3. Influence of position and crop type upon the abundance of Collembola over spring. Values denote mean catch ± s.d.

Consistent effects of position upon abundance	*Consistent effects of crop type upon abundance*
E. multifasciata (edge 2.3 ± 12, >middle 0.3 ± 1), p = 0.004	*E. multifasciata* (barley 2.2 ± 12, >peas 0.6 ± 1), p = 0.016
I. viridis (edge 7.2 ± 10, >middle 3.0 ± 5), p = 0.024	*I. viridis* (peas 7.3 ± 9, > barley 2.4 ± 3), p< 0.001
B. hortensis (edge 15.9 ± 37, >middle 2.0 ± 4), p < 0.001	*Lepidocyrtus* spp. (peas 10.5 ± 17, > barley 4.1 ± 6), p = 0.021
I. palustris (edge 3.1 ± 5, >middle 1.0 ± 2), p = 0.001	*J. stachi* (peas 11.9 ± 25, > barley 1.4 ± 2), p = 0.042
	S. viridis (barley 20.8 ± 31, >peas 9.1 ± 19), p = 0.028
	S. elegans (peas 3.9 ± 11, >barley 2.6 ± 5), p = 0.029

The effects of different crop types

Initially the total collembolan catch in the designated pea fields (edge: 143 ± 25; middle 63 ± 12) was much higher than in the barley (edge 18 ± 2; middle 8 ± 1). This was probably due to the lack of soil disturbance. However, by the end of May the situation had been reversed (peas edge 35 ± 26, middle 8 ± 12 ; barley edge 98 ± 17, middle 41 ± 10). For certain species crop type had the major effect upon their abundance (Table 3), whilst for others both crop and position were important. Overall, despite differences in the catch of species, there were no clear differences in species composition between peas and barley.

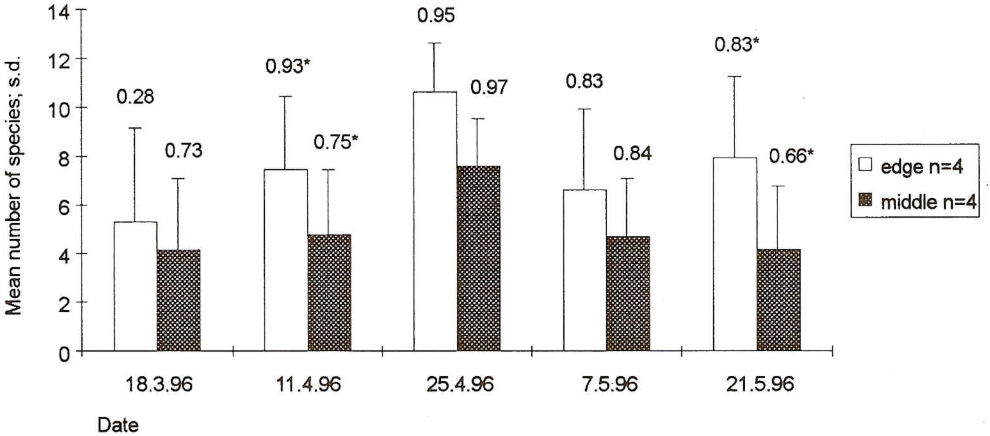

Fig. 1. Number of species present at the edge and middle of the fields at Manydown Farm. The Shannon-Wiener diversity index is indicated by the numbers and significant differences are shown as * ($P < 0.05$)

Discussion

The population dynamics of Collembola in arable fields during spring are of potential interest as springtails are an important prey source for polyphagous predators. Overwintering predator populations may be present earlier in the year than pests, and Collembola could be important as an alternative food source at this time. This study has shown that many of the species of Collembola abundant in early spring are susceptible to the effects of crop management.
The behaviour of populations during the winter is extremely important when considering pesticide effects (Vickerman 1992). The species which were common prior to crop emergence, namely *J. stachi*, *Lepidocyrtus* spp, *I. palustris*, *I. viridis* and *B. hortensis* could experience maximum exposure to pesticide applications as there was no shelter provided by a crop canopy. The source of population recruitment could also affect the ability to recover from pesticide applications and soil disturbance. Species which were able to regenerate in the middle of fields could recover faster than those which recolonise from other nearby populations, but would also be at greater risk of initial and residual exposure. Evidence that *E. multifasciata* may have colonised these fields from hedgerows is that: a) no individuals were found overwintering in the field either as adults or eggs; b) a potential source of colonists was present near hedgerows; and c) the field populations increased over time. Populations of other species may have regenerated *in situ*, particularly those which were present as eggs.
The differences in population trends between the two crop types could be attributed to several factors. Firstly, the different management practices required for two different types of crops, particularly the different sowing dates. Secondly, the different canopy types; and thirdly, the different use of pesticides. However, since the different canopy types were not encountered at these early stages, for most of this experiment the major differences were between a cereal providing vegetation cover, and bare ground. By the end of May barley covered 90 % of the ground (growth stage 27/28) whilst the peas' final ground cover was only 5–10 % (g.s. 103).
The results presented here form part of an ongoing study and, although they demonstrate that a considerable amount of information can be obtained from a simple and short-term monitoring programme, it is still desirable to study the population dynamics over a whole season, and under a mature canopy. Ideally this type of experiment should also be repeated over several years so as to have a greater confidence in the variation within the factors involved. Such information is essential to elucidate the mechanisms of exposure to, and recovery from, current pesticide use.

References

Frampton, G. K. (1994) Sampling to detect effects of pesticides on epigeic Collembola (springtails). Asp. Appl. Biol. **37**, 121–130.

Fromm, H., Winter, K., Filser, J., Hantschel, R., Beese, F. (1993) The influence of soil type and cultivation system on the spatial distributions of the soil fauna and microorganisms and their interactions. Geoderma **60**, 109–118.

Maclagan, D. S. (1932) An ecological study of the 'Lucerne Flea' (*Sminthurus viridis*, Linn.) I. Bull. of Ent. Res. **23**, 101–145.

Stewart, A. J. A., Wright, A. F. (1995) A new inexpensive suction apparatus for sampling arthropods in grassland. Ecol. Entomol. **20**, 98–102.

Vickerman, G. P. (1992) The effects of different pesticide regimes on the invertebrate fauna of winter wheat. In: Pesticides, cereal farming and the environment: the Boxworth project. Eds. Greig-Smith, P. W., Frampton, G. K., Hardy, A. R., HMSO, London. pp. 82–110.