Off-target effects of pesticides - are we targetting the right indicator species for risk assessment ?

G. FRAMPTON

Biodiversity and Ecology Division, School of Biological Sciences, University of Southampton, Bassett Crescent East, Southampton, SO16 7PX, U.K.

Introduction

Predatory Carabidae, Staphylinidae and Araneae are sensitive to some pesticides and recommended for use in laboratory and field regulatory pesticide testing procedures (Barrett *et al.* 1994). These predators have been the focus of most (>80%) orthodox pesticide field trials monitoring arthropods during the last two decades (data from a survey of 28 published studies). In contrast, Collembola, also known over two decades ago to be sensitive to some pesticides (e.g. Edwards & Thompson, *inter alia*), have been monitored in fewer than 30% of field trials in the last twenty years and are not currently recommended for regulatory testing to evaluate off-target pesticide effects. This paper focuses on epigeic (surface-dwelling) Collembola which are abundant, easily sampled, preyed upon by many other arthropods and potentially at risk of exposure to sprayed chemicals.

Methods

The Ministry of Agriculture, Fisheries and Food (MAFF) SCARAB project, "Seeking Confirmation About Results At Boxworth", compared the effects on arthropods of conventional (current farm practice, CFP) and lower pesticide inputs (reduced input approach, RIA) over six years (1990-96) in seven fields (8-34 ha) divided among three arable rotations. The background and aims of the work are described in Cooper (1990). SCARAB used a split-field design to allow comparisons of the two pesticide regimes which were applied as half-field treatments. Insecticides were used routinely in the conventional but avoided completely in the reduced-input regime. Sampling of arthropods under each regime was done by 'D-vac' suction sampling and pitfall trapping over the six years of the comparison. A full analysis of the project's results has not been completed yet, but preliminary results, and information on the design of the project, are given in Hancock *et al.* (1995).

To provide additional information on the side-effects of specific insecticides, a separate one-season replicated-field experiment was conducted in 1994 in four contiguous fields of winter wheat cv. Hereward (each *c.* 2.9 ha). In terms of cropping, pesticides and cultivations the fields had previously been farmed as a single unit during 1992-1994; three of the fields had been farmed identically for at least 20 years prior to the experiment. Chlorpyrifos, cypermethrin and pirimicarb were applied by tractor-sprayer to four randomized plots within each field on 24 June 1994 (growth stage 61 to 69), against aphids (cypermethrin, pirimicarb) and wheat blossom midge (chlorpyrifos) according to label recommendations of the products Spannit® (chlorpyrifos 480 g.a.i. ha^{-1}), Ambush® (cypermethrin 25 g.a.i. ha^{-1}) and Aphox® (pirimicarb 140 g.a.i. ha^{-1}). The plots (each *c.* 0.7 ha) had minimum width 36m and were not separated physically. Routine fungicide and herbicide applications were made simultaneously to all plots as required during the season. Five 'Ryobi' (Macleod *et al.* 1994) suction samples were taken from the centre of each plot on several occasions before and after the insecticide applications. Results of arthropod monitoring presented here refer to samples 35 days pre- and 10 days post-treatment. Repeated measures analysis of variance with main factors field and treatment and the within-samples factor time was used to compare pre-to-post treatment changes in insecticide-sprayed populations with respect to changes in unsprayed control populations. Full details of applications, spray equipment and weather are given in a report of bioassay work conducted in one of the fields (Wiles & Frampton, 1996).

Results

SCARAB project

Although a full analysis of the SCARAB project data has not been completed, large population reductions were evident in one of the study fields after use of organophosphorus insecticides under the conventional input regime. Population recovery (conventional catch ≥ reduced-input catch) after a chlorpyrifos application was more rapid in predatory arthropods than Collembola (Fig. 1). A wider spectrum of Collembola than predator species was affected by the chlorpyrifos spray (Fig. 2).

Replicated-field study

There was a consistent negative effect of chlorpyrifos and a positive effect of cypermethrin and, to a lesser extent, pirimicarb, on Collembola (Table 1). A notable feature of the results is the occurrence of significant ($P<0.05$) field by treatment interactions, indicating that some effects were not consistent between fields. In such cases, confidence intervals for the ANOVA parameter estimates for contrasts were examined to determine whether pesticide effects were consistent in three of the four fields (Table 1). For Collembola, the similarity of the species composition in chlorpyrifos-sprayed and control (unsprayed) treatments clearly decreased in all fields after spraying but the pattern for Carabidae was inconsistent between fields (Fig. 3).

Fig. 1. Range of recovery times (from recovery of first species to recovery of all affected species) after chlorpyrifos use (grass, 1991, SCARAB project Field 5).

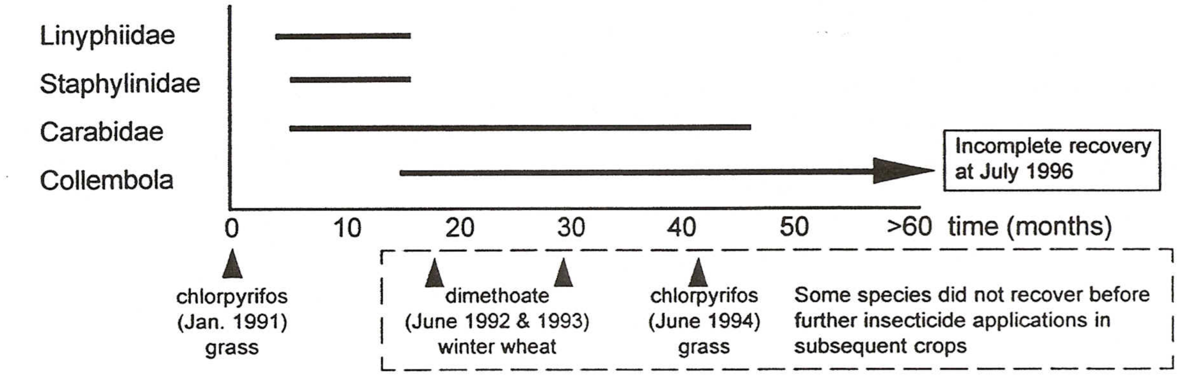

Fig. 2. Number of species exhibiting >90% population reduction after chlorpyrifos use (SCARAB project Field 5).

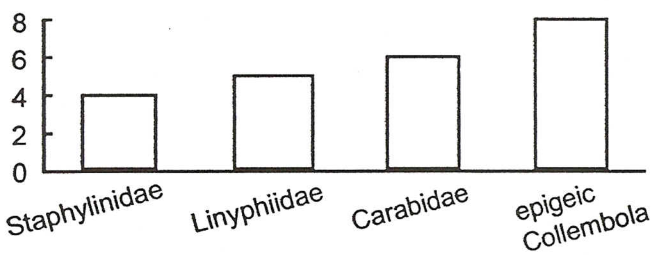

Fig. 3. Sorenson quantitative index of similarity of control and chlorpyriphos-sprayed communities:

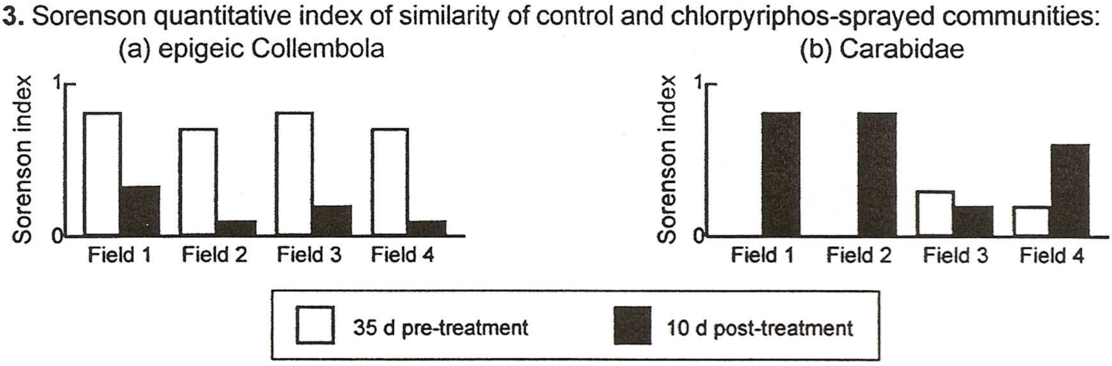

Table 1. Number of Collembola species showing significant (P<0.05) population changes with respect to control (unsprayed) populations (source: replicated field experiment).

	population change	chlorpyrifos	cypermethrin	pirimicarb
All 4 fields	decrease	5	0	0
	increase	0	3	2
3 fields only	decrease	4	0	0
	increase	0	2	0

(repeated measures ANOVA: field, insecticide, time; see text)

Discussion

A potential criticism of the data presented here from the SCARAB project (Figs 1 & 2) is that it is from one of several study fields and might be unrepresentative of the situation in arable farming in general. The answer will be known when a full multivariate analysis of the SCARAB project data is completed in 1997. Meanwhile, the data suggest that epigeic Collembola could be more reliable than predators as indicators of organophosphorus insecticide use. However, the results of the replicated-field study show that epigeic Collembola would not be suitable as indicators of adverse off-target effects of cypermethrin or pirimicarb; clearly the choice of indicator taxa must take into account differential susceptibilities of taxa to different chemicals. A plausible explanation for the favourable effect of cypermethrin on Collembola (Table 1) could be that the chemical depleted the predatory spider population, indirectly affecting collembolan prey.This explanation requires verification.

Ecotoxicologists face a number of problems in the environmental impact assessment of pesticide use on arthropods, including the selection of representative species and representative ecological scenarios from which data can be extrapolated to the wider environment. Results from the replicated-field study showed that the epigeic collembolan community as a whole could be a sensitive indicator of the use of chlorpyrifos (Fig. 3). However, a number of species exhibited responses to pesticides that were not consistent in all fields (e.g. where effects were consistent in only three fields - Table 1), calling into question the value of selecting any one species, or any one field, as ecological units for extrapolation.

A question that needs to be resolved is why are adverse effects of pesticides more pronounced in Collembola than in populations of their predators ? One reason could be that predators, being polyphagous, can switch prey types. Another, with implications for the interpretation of pesticide field experiment results, is that the high mobility of predators could preclude the detection of pesticide effects at the relatively small spatial scales usually used.

Monitoring pesticide effects at the community level using multi-field experiments would appear to be more reliable than using individual indicator taxa at a within-field scale. Epigeic collembolan communities seem to be suitable for this approach.

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References

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