THE M.A.F.F. "SCARAB" PROJECT: LONG-TERM CONSEQUENCES FOR FARMLAND ARTHROPODS OF PESTICIDE USE IN THE U.K.

G.K. FRAMPTON, T. ÇILGI and S.D. WRATTEN

Department of Biology, University of Southampton,
Bassett Crescent East, Southampton, SO9 3TU, U.K.

SUMMARY

The effects of contrasting average and reduced pesticide inputs on farmland arthropods in a range of arable crops are being investigated in a major long-term M.A.F.F. project sited at three Experimental Husbandry Farms in England.

Aspects of the project's design are discussed and preliminary results of arthropod monitoring are presented.

Effects of the insecticides chlorpyrifos and deltamethrin on Coleoptera, particularly *Bembidion* spp. (Carabidae), were detected early on in the project and have persisted despite the relatively small sizes of the treatment areas used.

INTRODUCTION

Experience from the Ministry of Agriculture, Fisheries and Food "Boxworth Project" indicated several groups of farmland invertebrates were particularly susceptible to the effects of intensive pesticide use in winter wheat, whereas some species appeared to benefit (Greig-Smith, Frampton & Hardy, 1992). Effects on populations of some Carabidae and Collembola were particularly severe, with the virtual elimination of *Bembidion obtusum* Serville (Coleoptera: Carabidae) and the lucerne flea, *Sminthurus viridis* (L.) (Collembola: Sminthuridae) from the high pesticide input treatment area at Boxworth Experimental Husbandry Farm (Burn, 1992; Vickerman, 1992).

In view of the severity of some of the adverse effects of intensive pesticide use on arthropods at Boxworth, it was considered important by those coordinating the Project to establish whether such effects might occur in other crops and at other locations in England. Also, the fact that single applications of some routinely-used broad-spectrum insecticides, such as dimethoate, are capable of adversely affecting arthropod populations (e.g. Vickerman & Sunderland, 1977; Vickerman *et al.*,1987) suggested that lower pesticide inputs than those used at Boxworth might be damaging in the long-term to arthropods on farmland.

Two long-term projects were set up in 1989 to extend the information obtained from Boxworth to other crops at different locations in England (Cooper, 1990). These are "SCARAB" (Seeking Confirmation About Results At Boxworth) and "TALISMAN" (Towards A Low Input System Minimising Agrochemicals and Nitrogen). SCARAB aims to establish, for a variety of arable crops at different locations, the ecological consequences for arthropods of reducing pesticide use further than at Boxworth. TALISMAN is concerned primarily with assessing the economic consequences of reducing pesticide and nitrogen inputs and has invertebrate monitoring as a secondary objective.

This paper summarizes the layout of SCARAB and presents some of the results obtained during the first three years of the Project. For further information on TALISMAN see Cooper (1990) and Lane (1991).

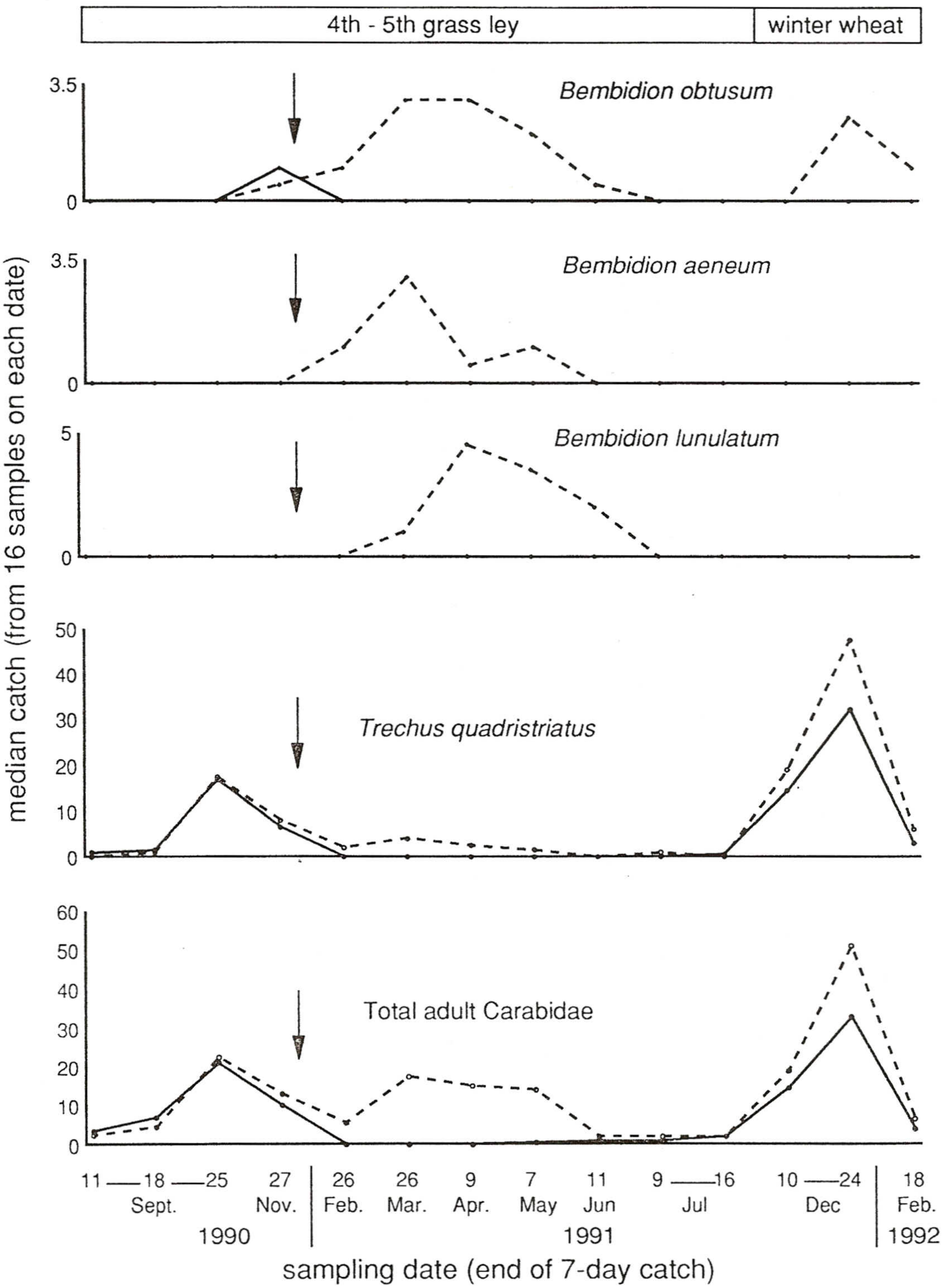
LAYOUT OF SCARAB

A comparison of the designs of the SCARAB and Boxworth projects is given in Table 1.

Table 1. Contrasting features of SCARAB and Boxworth Project designs.

		SCARAB	Boxworth
Number of sites (farms) in England		3	1
Crops grown		winter wheat winter barley spring wheat spring barley spring beans sugar beet potatoes oilseed rape grass	winter wheat (plus oilseed rape break crop)
Treatment units		half-fields	groups of fields
Area of treatment units	max.	17ha	53ha
	min.	4ha	23ha
Maximum pesticide input		average for the crop and flexible in response to yearly censuses	prophylactic and largely inflexible
Minimum pesticide input		supervised but no insecticides	supervised

Figure 1. Pitfall-trap catches of Carabidae in the Current Farm Practice (——) and Reduced Input Approach (- - -) halves of "Field 5". A chlorpyrifos spray (indicated by arrows) was applied only to the Current Farm Practice part of the field on 28 January 1991.



Crop rotations

SCARAB comprises seven fields on three M.A.F.F. Experimental Husbandry Farms in Warwickshire, Nottinghamshire and North Yorkshire. Cropping in each field follows a six-year arable rotation which is typical of the farm's location, with a different rotation at each farm (Cooper, 1990).

Pesticide regimes

During the first ("baseline") year of the Project (1989-1990) all fields received an average "Current Farm Practice" input of pesticides appropriate to the particular crop. From the autumn of 1990 onwards, one half of each field was switched to a supervised "Reduced Input Approach" whilst the other half continued to receive the appropriate Current Farm Practice input. These contrasting pesticide regimes within SCARAB fields are planned to continue for six years, up to harvest in 1996. The contrasting treatments in each field are not separated by a physical barrier.

The Current Farm Practice regime is able to represent the average pesticide use for a given crop because it is based upon recent M.A.F.F. censuses of pesticide use. For this reason the Current Farm Practice regime can be more flexible from year to year than was the fixed programme of prophylactic inputs at Boxworth (Table 1). Thus, unlike the situation at Boxworth (where the high-input regime was considered by many to be unrealistic at the end of the Project), the SCARAB Current Farm Practice regime should reflect realistic agricultural inputs, even if these change during the course of the Project. In the Reduced Input Approach regime, pesticide applications are made, as in the Supervised regime at Boxworth, only when pest, weed or disease thresholds dictate the need. However, unlike the situation at Boxworth (Table 1), the Reduced Input Approach aims to avoid the use of insecticides altogether.

Cultivations, fertiliser applications and cropping affect whole fields so as not to confound their influence on arthropod populations with the effects of the pesticide regimes.

Figure 2. Pitfall-trap catches of *Bembidion lunulatum* in the Current Farm Practice (—) and Reduced Input Approach (- - -) halves of "Field 1".

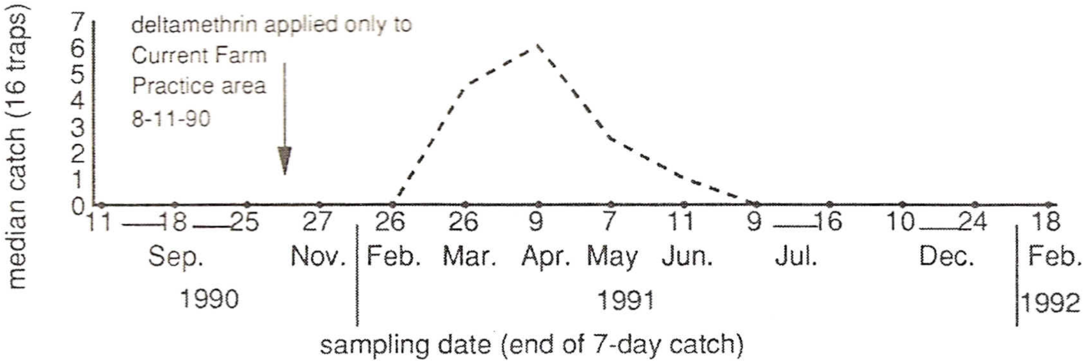


Figure 3. Pitfall-trap catches of *Helophorus spp.* in the Current Farm Practice (—) and Reduced Input Approach (- - -) halves of "Field 5".

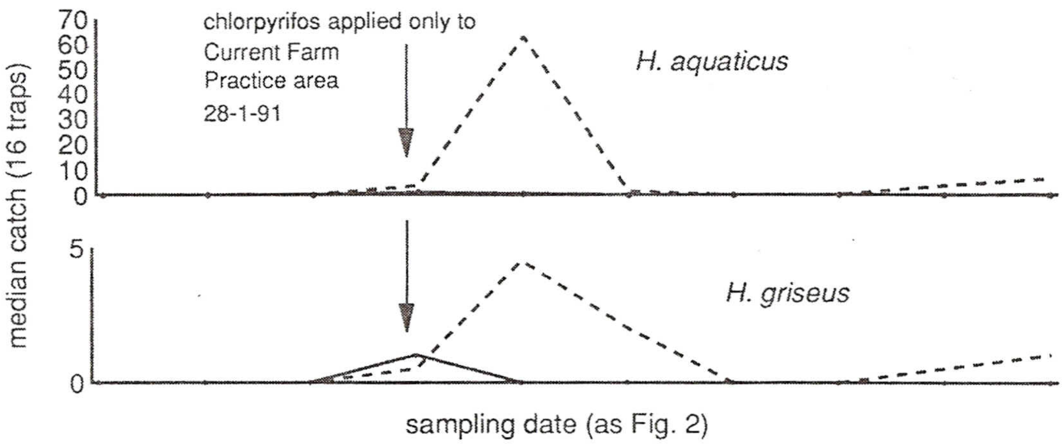
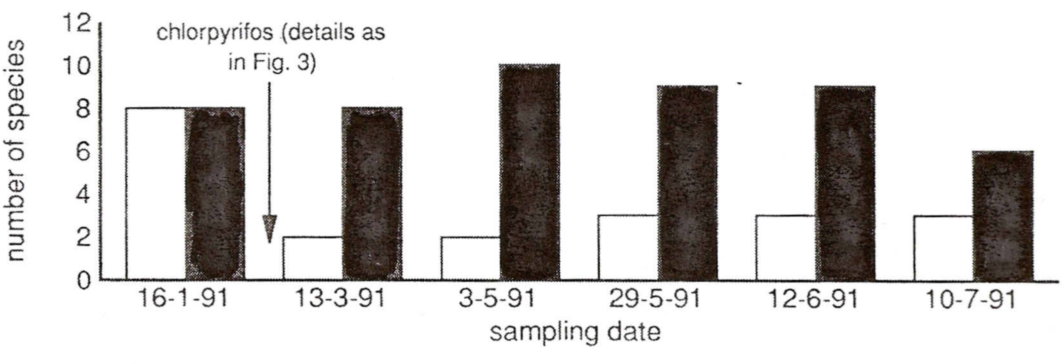


Figure 4. Number of Collembola species trapped by suction sampling in the Current Farm Practice (□) and Reduced Input Approach (■) halves of "Field 5".



Arthropod monitoring

Routine pitfall-trap and suction (D-vac) samples have been collected from matched locations in both treatment halves of each SCARAB field since June 1990 and sampling will continue until the Project ends in 1996. Details of the sampling programme are given in Ogilvy (1992). In addition, some soil arthropods will be monitored in selected fields from spring 1993 using soil cores.

RESULTS

The results presented here cover the period from June 1990 up to February 1992. In this period, seven of the fields received herbicides and insecticides and five received fungicides. A total of nine insecticide applications was made to SCARAB fields as part of their Current Farm Practice regime. No insecticide applications were made to the Reduced Input Approach half of any field. Details of the insecticides used and their application rates are given in Frampton & Çilgi (1993).

Routine arthropod monitoring using pitfall traps (Figs 1 to 3) and suction samples (Fig. 4) revealed marked differences in arthropod populations between the Current Farm Practice and Reduced Input Approach treatments which coincided with the use of insecticide sprays in two of the fields.

Pitfall-trap catches of the Carabidae *Bembidion aeneum* Germar, *B.lunulatum* (Fourcroy) and *B.obtusum* (Fig. 1) and the Hydrophilidae *Helophorus aquaticus* (L.) and *H. griseus* Herbst (Fig. 3) were restricted almost entirely to traps in the Reduced Input Approach area of "Field 5" after a chlorpyrifos spray to control leatherjackets was applied to the Current Farm Practice half of the field in January 1991.There was no evidence for any recovery in catches of these Coleoptera even twelve months after the chlorpyrifos spray (Figs 1 and 3), when the following winter wheat crop had reached Zadoks Growth Stage 23. The most abundant of the Carabidae in "Field 5" in late summer/autumn and winter was *Trechus quadristriatus* (Schrank) (Fig. 1). Following the chlorpyrifos spray, catches of this species in the sprayed half of the field were zero for up to four months whereas in the unsprayed area insects were trapped in low numbers. In contrast to the responses of *Bembidion* and *Helophorus*, this species showed a clear recovery in the numbers trapped in the sprayed half of the field five months after the spray, although subsequently a greater number was trapped over winter in the unsprayed area (Fig. 1).

The effect of the chlorpyrifos spray was also evident on Collembola. Populations of both sub-orders of these insects were seriously depleted in the sprayed relative to the unsprayed half of "Field 5" for at least five months after the spray (the current extent of available information) (Fig. 3 in Frampton & Çilgi, 1992a). After the chlorpyrifos application, several species disappeared from the sprayed area (Fig. 4). These included *Entomobrya multifasciata* (Tullberg) (Entomobryidae), *Isotoma viridis* Bourlet (Isotomidae), *Sminthurides signatus* (Krausbauer) and *Sminthurus viridis* (Sminthuridae) (Table 5 in Frampton & Çilgi, 1992b).

Following the chlorpyrifos spray in "Field 5" there were changes in pitfall-trap catches of Linyphiidae, especially *Erigone* spp., in the sprayed half of the field which indicated that these spiders had also been adversely affected by the insecticide (Frampton & Çilgi, 1992); none were trapped in the sprayed area until twelve months after the spray, suggesting that recolonisation was slow.

There was evidence that another insecticide, deltamethrin, which was used to control aphids (autumn BYDV vectors) in "Field 1" also adversely affected pitfall-trap catches of *Helophorus* spp., several species of Linyphiidae and *B. lunulatum* (Frampton & Çilgi, 1992b). However, only for *B.lunulatum* were these effects clearly persistent; there was no indication of any recovery of this genus in the sprayed half of the field up to fifteen months after the spray (Fig. 2).

DISCUSSION

SCARAB was set up to investigate the long-term consequences for arthropods of average and reduced pesticide inputs and this is reflected in its design, with relatively small adjacent areas of contrasting treatments (Table 1). Such small areas are considered to be inappropriate for short-term within-season studies of pesticide effects because redistribution of mobile arthropods between experimental areas is likely to obscure the effects of pesticides (Duffield & Moffatt, 1991). Even though the Project would therefore seem ill equipped to examine effects of single insecticide applications (which is not its objective), the preliminary results presented here clearly demonstrate that, for certain ecological groups of arthropods with poor powers of dispersal (e.g. Burn, 1992), persistent adverse effects of pesticides (up to 15 months) can be detected at a small spatial scale.

The SCARAB Project pesticide regimes are not replicated within individual years (Cooper, 1990), but the timing and long duration of the differences between treatments in Coleoptera and Collembola catches gives confidence that the differences were caused by insecticide applications (Frampton & Çilgi, 1992). Although the experimental scales of SCARAB and Boxworth are very different (Table 1), preliminary results from SCARAB mirror some of those obtained at Boxworth. In both studies, effects of pesticides on *B. obtusum* and the "lucerne flea" *Sminthurus viridis* were severe and persistent, with virtual elimination of these insects from the treated areas, whereas effects on *T. quadristriatus* were severe but transient (see Burn, 1992; Vickerman, 1992). More recently-acquired information on species not hitherto studied in detail at Boxworth (G.P.Vickerman, personal communication) indicates that, as has been shown in SCARAB (Figs 1 and 2), several other species of *Bembidion* may have been adversely affected by intensive use of pesticides at Boxworth.

In addition to the information obtained from Boxworth and SCARAB there is good evidence that *Bembidion* species, especially *B. obtusum*, are particularly susceptible to the effects of some widely-used broad-spectrum pesticides such as dimethoate (Vickerman *et al.* 1987), chlorpyrifos (Asteraki, Hanks & Clements, 1992) and methiocarb (Purvis & Bannon, 1992). This susceptibility is probably due at least in part to the poor dispersal ability and phenology of these carabids such that pre-reproductive adults are exposed in the field to insecticide sprays and are subsequently unable to recolonise quickly (Burn, 1992). Whereas deltamethrin was less detrimental than dimethoate to most of the carabids sampled by Vickerman *et al.* (1987) in winter wheat, effects of deltamethrin on *B.obtusum*, in terms of an overall reduction in numbers, were at least as severe as those of dimethoate (Table 3 in Vickerman *et al.*, *loc. cit.*). Further evidence that deltamethrin may be hazardous to this genus of Carabidae is shown by the changes in trap catches of *B. lunulatum* which occurred after the SCARAB deltamethrin spray in "Field 1" (Fig. 2), although that particular spray event had no apparent adverse effect on *B. obtusum* (Frampton & Çilgi, 1992b).

The chlorpyrifos and deltamethrin sprays in SCARAB fields both had adverse effects on subsequent catches of *Helophorus* spp. in the sprayed areas of the SCARAB fields (Frampton & Çilgi, 1992b), but the effects were greater following the chlorpyrifos spray (Fig. 3). These insects are capable of flight and it is surprising that recolonisation of the relatively small (*c.* 4ha) sprayed area did not occur up to twelve months after the chlorpyrifos application (Fig. 3).

Up to February 1992 there was no evidence for any major effects on arthropods caused by applications of other insecticides to SCARAB fields. Reasons for this are discussed in Frampton & Çilgi (1993). During 1992, dimethoate was used as a summer aphicide in SCARAB fields for the first time and it remains to be seen whether this and other pesticides will cause further perturbations to arthropod populations, and whether the existing effects of chlorpyrifos and deltamethrin will persist.

The split-field design of SCARAB, with adjacent areas of contrasting pesticide inputs, has two potential limitations. These are:

(1) Recolonisation of the relatively small treated areas by mobile arthropods could mask effects of pesticides. Even though some persistent effects have already been detected in SCARAB fields, other effects on more mobile species might be missed. Potential reservoirs of recolonisers in SCARAB fields are the unsprayed half of the field, and the field boundary (hedgerow) and surrounding habitat (mostly other arable fields).

Within-field recolonisation is being monitored in SCARAB fields using transects of pitfall traps which extend from the Current Farm Practice half of fields into the

Reduced Input Approach half. Results of this monitoring will be presented in future.

Although the surrounding habitat could be important as a source for the recolonisation of small fields like those used in SCARAB, the relative importance of this compared to within-field recolonisation will depend on how the field's boundaries restrict the influx of arthropods from the surrounding habitat. Work carried out in southern Norway (Frampton, Çilgi, Fry & Wratten, in prep.) and in England (Mauremootoo & Wratten, this volume) shows that, compared to cereal fields, typical field boundaries can considerably slow the movement of large Carabidae, such as *Pterostichus melanarius* Illiger. The implications of these results for SCARAB are that pesticide effects in the fields are likely to be obscured more immediately by within-field recolonisation (currently being monitored) than by recolonisation from surrounding fields.

(2) Drift of pesticide spray from the sprayed (Current Farm Practice) half to the unsprayed (Reduced Input Approach) half of a SCARAB field could occur. If amounts of drift are sufficient to cause arthropod mortality, effects of the contrasting pesticide regimes could be obscured.

Drift of insecticides has been monitored routinely in SCARAB fields using a fluorescent dye tracer mixed with the insecticide in the spray tank (Çilgi & Frampton, 1992). Laboratory bioassays with Carabidae have been carried out to examine whether the levels of drift so far recorded in SCARAB fields would have caused carabid mortality in the unsprayed areas of the Project fields (Çilgi *et al.*, this volume).

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