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BOXWORTH AND SCARAB: APPROACHES TO THE LONG-TERM STUDY
OF SIDE EFFECTS OF PESTICIDE USE ON INVERTEBRATES

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SUMMARY

In England the Boxworth Project was conducted in the 1980s to examine the effects of intensive pesticide use on wildlife on a farm under winter wheat. The project identified vulnerable groups of arthropods and raised a number of questions about pesticide use which are now being addressed by follow-up studies. One of these, SCARAB (Seeking Confirmation About Results At Boxworth), is comparing the effects on invertebrates of 1990s average and reduced pesticide inputs. This paper considers the design of the two projects and compares preliminary results from SCARAB with those from Boxworth in relation to differences in pesticide use.

Key-words: pesticides, crops, arthropods, long-term, side-effects

RÉSUMÉ

'BOXWORTH' ET 'SCARAB': APPROCHES À L'ÉTUDE À LONGUE DATE DES EFFETS SECONDAIRES DE PESTICIDES SUR INVERTÉBRÉS TERRESTRES

En Angleterre, le projet 'Boxworth' a eu lieu dans la décennie depuis 1980 et a examiné les effets de l'emploi intensif de pesticides sur la faune de blé d'hiver d'une ferme. Le projet a identifié des groupes vulnérables des arthropodes et a produit quelques questions qui concernent l'emploi de pesticides qu'on s'adresse maintenant dans études de continuation. Une de ces études, le projet 'SCARAB', compare les effets d'emploi moyen et réduit de pesticides. Ce rapport-ci considère le dessein des deux projets et compare les résultats préliminaires de 'SCARAB' avec ceux de 'Boxworth' relatif à les différences entre leur emploi de pesticides.

Mots-clefs: pesticides, récoltes, arthropodes, effets secondaires, étude à longue date.

INTRODUCTION

In the 1980s the UK Ministry of Agriculture, Fisheries and Food (MAFF)-funded Boxworth Project showed that populations of beneficial arthropods in winter wheat were adversely affected by prophylactic, intensive use of pesticides (Vickerman, 1992). Results from the project indicated that poorly dispersive species which overwinter on the ground surface in cereal fields were particularly vulnerable (Burn, 1992). The Boxworth Project was conducted at a MAFF Research Centre in eastern England and compared the effects of intensive and managed pesticide inputs over five years. When the project ended in 1988 it had raised three important questions: (1) would the adverse effects on arthropods in wheat occur in other crops ?; (2) were the effects in eastern England typical of other geographical locations and soil types ?; (3) could such effects occur with typical 1990s current pesticide inputs ?.

Two long-term studies were set up in 1989 to extend the information obtained from the Boxworth Project (Cooper, 1990). One of these is the "SCARAB" (Seeking Confirmation About Results At Boxworth) project. SCARAB aims to answer the above questions raised by the Boxworth Project by comparing effects on arthropods of current average and reduced input pesticide use in a variety of crops over a six-year period. This paper compares the designs of Boxworth and SCARAB and some initial results from SCARAB with those obtained from Boxworth.

DESIGNS OF BOXWORTH AND SCARAB

A full account of the design of the Boxworth Project and the basis for the choice of design is given in Greig-Smith, Frampton & Hardy (1992). Major aspects of the design of Boxworth and SCARAB are compared in Table I.

Basis of the SCARAB design

The Boxworth Project was set up to investigate effects of intensive pesticide use on a variety of wildlife including birds and small mammals, so the experimental units were necessarily large and comprised groups of contiguous fields. In contrast, SCARAB was designed specifically for comparing the effects of two pesticide regimes on invertebrates. Half-field treatment units are used in SCARAB to overcome the problem of between-fields variation in invertebrate populations. Experience from the Boxworth Project showed that although the pesticide regimes were not replicated

spatially, it was possible to detect major effects of intensive pesticide use via long-term changes in populations of arthropods such as Carabidae, Araneae and Collembola (Fig. 2) (Burn, 1992; Vickerman, 1992). Because SCARAB is also seeking to identify effects of pesticide use by examining long-term population changes, rather than short-term effects of individual pesticide applications, its design has sacrificed replication of the treatment regimes. This has allowed the project to include a wider range of geographical locations, crops and soil types than would otherwise have been possible (Table I).

Table I. Design aspects of Boxworth and SCARAB projects.

	Boxworth	SCARAB
Number of sites	one farm	three farms
Soil type	chalky clay	clay (site 1) sandy loam (site 2) silty clay loam (site 3)
Crops	winter wheat only	range of arable crops
Duration of study	7 years (1981-1988)	7 years (1989-1996)
Baseline monitoring	2 years (1981-1983)	1 year (1989-1990)
Treatment contrasts	5 years (1983-1988)	6 years (1990-1996)
Treatment units	groups of contiguous fields	half-fields
Treated areas	22-53 ha	4-16 ha

Boxworth and SCARAB pesticide regimes

The pesticide regimes employed in the Boxworth and SCARAB projects are summarised in Table II and compared in Fig. 1. The Full Insurance regime at Boxworth represented the behaviour of intensive winter wheat producers in eastern England in the late 1970s (Greig-Smith & Hardy, 1992) and thus involved high average annual pesticide inputs (Fig. 1). This regime was operated in a similar way throughout the five-year treatment phase of the Boxworth Project and so was insensitive to year-to-year changes in pesticide use in winter wheat in England. In contrast, the Current Farm

Practice (CFP) and Reduced Input Approach (RIA) regimes of SCARAB are based on current pesticide use as indicated by the previous year's Pesticide Usage Survey Report. Thus, the average (CFP) inputs to SCARAB should remain typical of actual practice throughout the project. The CFP inputs in SCARAB are considerably lower than those of the Boxworth Full Insurance regime but similar to the Boxworth Supervised approach (Fig. 1). These differences in pesticide use between the two projects should be borne in mind when comparing the effects of the different pesticide regimes on non-target invertebrates.

Table II. Pesticide regimes used in the Boxworth and SCARAB projects.

Boxworth

Full Insurance - prophylactic use of pesticides representing intensive inputs to winter wheat which occurred in the late 1970s.

Supervised - managed use of pesticides in response to pest, disease or weed thresholds.

Integrated - managed use of pesticides plus use of cultural techniques where possible to further reduce pesticide inputs.

SCARAB

Current Farm Practice (CFP) - average use of pesticides appropriate to the crop, based on the Pesticide Usage Survey for the previous year (flexible in response to year-to-year changes indicated by the surveys).

Reduced Input Approach (RIA) - managed use of herbicides and fungicides in response to weed or disease thresholds, avoiding insecticide use.

Baseline periods in Boxworth and SCARAB

The so-called 'baseline' years of the projects (Table I) were periods during which all treatment units received similar pesticide inputs to allow spatial variation in invertebrate populations to be monitored in the absence of differing pesticide inputs. At Boxworth the baseline pesticide inputs approximated the Supervised regime and in SCARAB the Current Farm Practice (CFP) regime (Fig. 1 & Table 2).

An important difference between Boxworth and SCARAB concerns changes

that occurred with the switch from the baseline to the treatment phases of these projects: at Boxworth the Full Insurance area experienced an *increase* in pesticide inputs relative to the baseline years, whereas in the Reduced Input Approach (RIA) areas of SCARAB there was a *decrease* in inputs. As SCARAB has several crops, each with appropriate contrasting RIA and CFP regimes, there was field-to-field variation in the time at which the baseline period ended (indicated by the first differential applications of pesticides to the RIA and CFP areas: Figs 3 & 4). However, in all SCARAB fields the minimum baseline period was at least one year (Table I).

RESULTS OF BOXWORTH AND SCARAB

During the five-year treatment phase of the Boxworth Project populations of some arthropods exhibited adverse effects of the Full Insurance regime. Declines in some species, such as *Bembidion obtusum* (Carabidae) (Burn, 1992) and the lucerne flea *Sminthurus viridis* (Collembola) (Fig. 2 & Vickerman, 1992) occurred soon after the treatment phase of the project began in 1983 so these changes coincided with the switch from the baseline to the treatment phase of the Project. This indicated early adverse effects of the Full Insurance pesticide regime and demonstrated the value of comparing pesticide regimes temporally as well as spatially.

Despite very obvious differences between the spatial scales and pesticide inputs of Boxworth and SCARAB, some preliminary results from SCARAB mirror those from Boxworth. In particular, severe and persistent depletions in populations of *B. obtusum* (Frampton & Çilgi, 1992) and Collembola (Fig. 3) coincided with the use of an organophosphorus insecticide (chlorpyrifos) as part of the CFP regime in one of the fields in January 1991. At Boxworth, Linyphiidae were adversely affected by the Full Insurance regime, with more pronounced effects over winter as a consequence of the use of autumn synthetic pyrethroid sprays (Vickerman, 1992). Similar over winter declines in Linyphiidae in the CFP areas of some SCARAB fields occurred following autumn use of synthetic pyrethroids in SCARAB (Fig. 4).

The preliminary results of SCARAB which are summarised here suggest that considerably lower pesticide inputs than those used at Boxworth can have adverse effects on arthropods. However, the majority of such effects detected so far in SCARAB coincided with the use of broad-spectrum organophosphorus insecticides in winter or synthetic pyrethroids in autumn. This supports the assertion, based on studies which have shown persistent adverse effects of organophosphorus (Vickerman & Sunderland, 1977) and

synthetic pyrethroid insecticides (Pullen, Jepson & Sotherton, 1992), that the population changes at Boxworth may have been caused by few of the total pesticide applications. Whereas Boxworth had a relatively inflexible prophylactic high-input regime, pesticide use in SCARAB reflects actual current usage in the UK. SCARAB can include, for example, the increasing use of synthetic pyrethroid applications in summer and it remains to be seen whether these will exacerbate the over winter effects on Linyphiidae.

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Figure 1. Mean number of annual pesticide applications per field (excluding seed treatments) to winter wheat in the three Boxworth and two SCARAB pesticide regimes.

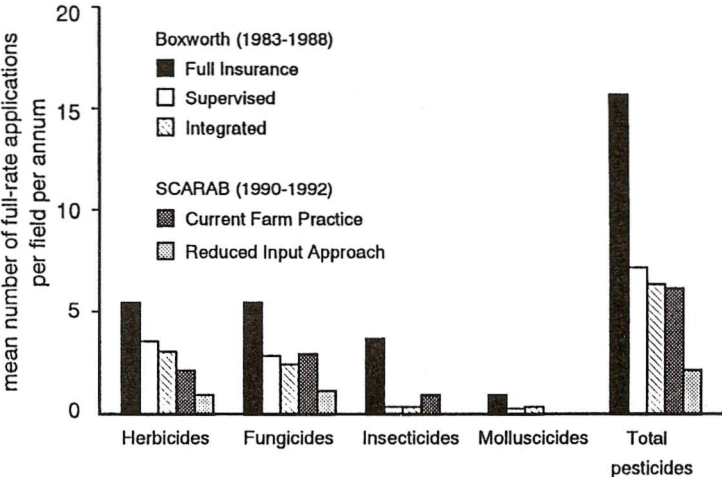


Figure 2. Numbers of the lucerne flea *Sminthurus viridis* (Collembola) in May suction samples from winter wheat under three pesticide regimes at Boxworth, 1986-1988 (source: Boxworth Project unpublished Annual Reports, 1986-1988).

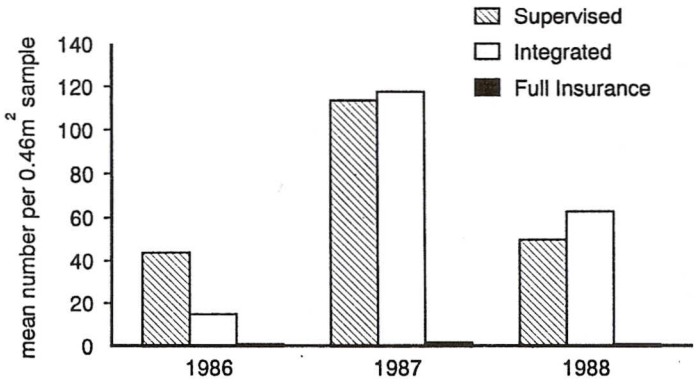


Figure 3. Collembola in suction samples from the RIA and CFP areas of SCARAB Field 5. Fungicides and herbicides were applied at full rate to the CFP area of the field and half rate to the RIA area; insecticides were applied only to the CFP area. (Means are derived from log-transformed data).

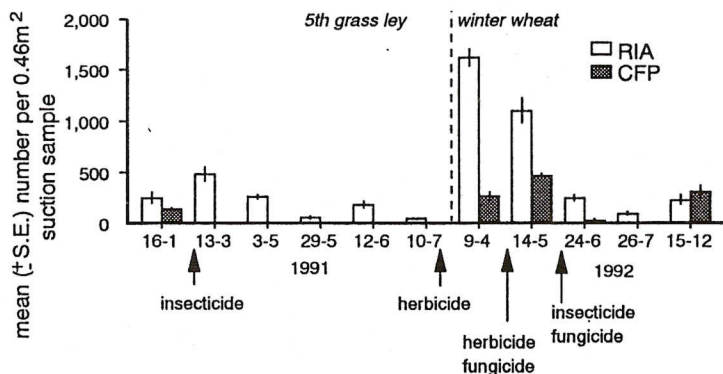


Figure 4. Geometric mean (± S.E.) of log-transformed Linyphiidae catch per pitfall trap (figures on ordinate) in the RIA and CFP areas of SCARAB Field 1. Details of fungicide, herbicide and insecticide applications to RIA and CFP areas are as given in the legend to Fig. 3.

