# O.13 - Using population models to develop management tactics for *Tipula paludosa* in organic systems

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## Abstract

Leatherjackets, the larvae of *Tipula paludosa* Meig., are pests that are strongly associated with crops that follow grass. This makes organic systems that rely on grass/clover fertility building phases in a rotation particularly vulnerable to attack in comparison with conventional agriculture. There is currently no approved method of controlling leatherjackets in an organic vegetable crop and all available options necessitate some form of advance intervention. Avoidance is the most effective approach and this can take two forms – restricting pest population growth and not planting a crop when it is vulnerable to attack. Other possible techniques are to use cultivations to cause mortality to leatherjackets, or to apply a biopesticide. In this paper I explore this range of options using simulation models of leatherjacket population dynamics and field observations on the timing of instars in the population.

## Introduction

Leatherjackets, the larvae of the Dipteran *Tipula paludosa* Mg., are a soil-dwelling pest of several crops. They are an annual species with a relatively well synchronised adult emergence period peaking in late August/early September. Larvae hatch within 2-3 weeks and feed through the winter until late June when they enter a pre-pupation resting phase. They are susceptible to mechanical damage, suffering significant mortality from cultivations (Blackshaw 1988) and for this reason on-farm populations will only build up in grassland or other uncultivated areas. Since these are important fertility-building phases in organic rotations crops grown after them will be vulnerable. Examples of these include brassicas, lettuce and maize.

Other than noting that leatherjackets can be a pest there is little effective information available to organic vegetable growers. Organic growers have four options open to them: 1) avoidance through either not growing a vulnerable crop or delaying planting until feeding ceases, 2) additional cultivations to cause greater mortality, 3) application of biopesticides such as *Bacillus thuringiensis* or entomopathogenic nematodes, 4) do nothing and accept the crop losses. Although apparently trivial, the last option opens up the question of the cost-benefits of control options.

Whilst we do not yet have sufficient information to be able to calculate economic thresholds for leatherjackets in different vegetable crops it is clear they will be lower than those associated with cereals; leatherjackets kill individual seedlings and plant densities are lower in vegetable than cereal crops.

In this paper I will show how our recently increased understanding of leatherjacket population dynamics can be used to compare the management options open to organic vegetable growers using simulation modelling. I will further show how it is possible to introduce rational pest management decision-making – expressed as economic (action) thresholds – into organic agriculture.

## Materials and methods

#### Stadia timing and within generation mortality

The standard sample used in this study was 20 randomly selected soil cores of 10 cm diameter and 15 cm depth. These were processed using pressurised water and wet-sieving, with retained leatherjackets floated off in a saturated brine solution. Larvae were allocated to an instar on the basis of head capsule widths (Blackshaw & Moore 1984). Counts were aggregated per sample.

Samples were collected in the first week of the calendar month from four permanent grass fields in Northern Ireland from October 1981 to September 1986, providing monthly data over five complete generations. Exceptionally, there was no sample collected in January 1985; this was treated as missing data in subsequent analyses.

Monthly population counts were normalised by dividing each by the mean monthly count for the specific field/year combination, and curvilinear regression used to fit data to a curve describing population changes by week number since the 1 October over the season. The timing and duration of each instar was estimated from the observed data.

#### Model source and assumptions

All changes in population from one year to the next use the general simulation model developed by Blackshaw & Petrovskii (in press):

## Results and Discussion

By the time that crops are established in the spring populations will, generally, be in the fourth instar (Fig 1). It can be postulated that this stage has a relatively short feeding period, and if this can be substantiated it should be possible to more precisely define the period of seedling vulnerability. A further conclusion is that in these data mortality appears to be largely associated with the fourth instar.

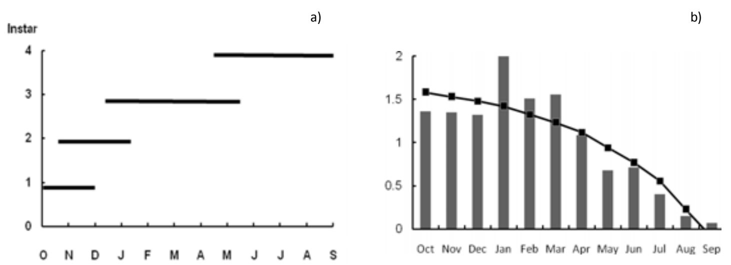


Fig 1. Timing of leatherjacket stadia (a) and changes in population levels over time (b) with bars showing observed normalised population counts and a fitted regression line.

Calculated economic thresholds are shown in Table 1. The resultant values can be compared with typical populations of 525,000 to 720,000 $ha^{-1}$ in long term grassland in the UK, and average populations in spring crops following grass of around 30,000 $ha^{-1}$ reported from surveys in Northern Ireland (Blackshaw 1988). Given the conservative nature of these thresholds (one leatherjacket = one plant lost) this strongly suggests that October applications of suitable biopesticides may be more economically viable than the initial cost might suggest.

Table 1 Economic thresholds for the application of entomopathogenic nematodes (EPN) or *B. thuringiensis* (*Bt*) to grass in the October preceding the planting of a vegetable crop.

| | EPN | *Bt* |
|---|---|---|
| Cauliflower | 62531 | 25523 |
| Lettuce | 103638 | 42301 |
| Sweetcorn | 61682 | 25176 |

In addition, we also know that the frequency distributions of leatherjacket populations in annual field surveys have relatively few large populations and a long tail of low counts (Blackshaw & Perry 1994). Despite the thresholds for *B. thuringiensis* shown in Table 1 approximating to the mean spring crop survey value reported by Blackshaw (1988) there will still be many fields for which a biopesticide application is unnecessary. Thus it is a precursor of any advisory system that might recommend the application of control measures in grassland in October that the leatherjacket population can be estimated with an appropriate monitoring technique.

This presents another research challenge. Leatherjacket development (Fig 1a) shows that at this time larvae are mainly in the first and second stadia. These are the hardest stages to detect and they may also be more aggregated than later stages because of oviposition behaviour (see Fig 2), and hence more difficult to sample accurately.

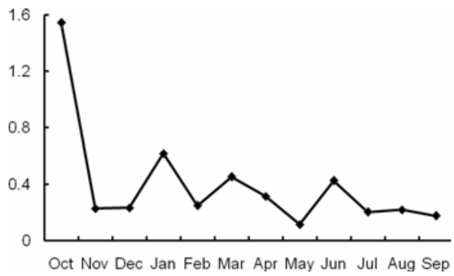


Fig 2. Variance: mean ratios of normalised monthly leatherjacket counts from four fields in Northern Ireland over five years by calendar month.

The eventual shape of advice on the management of leatherjackets in organic vegetable systems is becoming clear and relies on anticipating problems in the autumn prior to crop establishment. Fields that have been in grass/clover for only one year are unlikely to harbour damaging populations. Fields that have been in grass for two or more years should be monitored to estimate *T. paludosa* population levels in October. If sufficiently numerous then biopesticide control measures can be implemented or, alternatively, crop establishment should be delayed until July when larval feeding has finished. For low or undetectable populations no action may be necessary. The position over intermediate populations is less clear and it is possible that minor interventions such as additional cultivations may be sufficient to reduce damage to tolerable levels.

This work has also identified the research needs to deliver such an advisory package. These centre on estimating leatherjacket populations in the autumn and determining feeding behaviours of fourth instars in vegetable crops. Once these issues are resolved it should be possible to provide a complete decision support system for leatherjacket management in organic cropping systems.

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