

Earwig-friendly spray programmes in apple and pear crops



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Introduction

There are seven species of earwig (Order Dermaptera) in Britain. The earwig most commonly found in apple and pear orchards is the common European earwig, *Forficula auricularia*. This species is an important generalist predator in the trees, regulating populations of several damaging pest species, including aphids, mussel scale, codling moth and pear sucker.

The use and timing of plant protection product (PPP) applications probably contributes to the large differences in earwig populations found between orchards. Some products can be harmful to earwigs and there are occasions during the season when it is unavoidable to use them for the control of other damaging fruit pests.

Growers can employ strategies to avoid the use of certain harmful products at key times of the season, while also using management techniques to protect and enhance earwig populations. This guide will help growers to develop these strategies and help to construct earwig-friendly spray programmes.



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Key messages

A number of plant protection products (PPPs) can be harmful to earwigs in orchards. This guide will help growers to judge which products to use and when to apply them to protect their orchards, while preserving earwig populations (Figure 1).



Figure 1. Earwigs are an invaluable resource in orchards so every effort needs to be channelled into enhancing their populations

- Be aware of the numbers of earwigs present in each orchard
- Monitor numbers of earwigs and other natural enemies as part of your weekly recording of pest numbers
- Before spraying a product, consider whether it is necessary and its potential impact on earwig numbers
- Consider the target pest, choice and timing of specific PPPs using the table in this guide (page 13)
- Aim to build up earwig numbers in orchards
- Increase the complexity and plant diversity of the orchard, to provide earwigs with shelter and food
- Consider using floral alleyway sowings and earwig refuges tied into the trees
- Give thought to the timing of soil tillage – earwigs nest during the spring in the soil

Biology and life cycle of earwigs

Dispersal

Earwig populations are slow to build up in orchards for several reasons. They have only one generation per year and are relatively slow to disperse compared with other winged natural enemies. Dispersal by walking is slow – estimated to be between

only 8–29 metres in a month. Although they can fly, they very rarely do so. Earwigs are active at night (Figure 2) and rarely encountered in the daytime unless disturbed from a shelter. It is presumed that they hide during the day (Figure 3) to avoid predators, particularly birds.



Figure 2. Adult earwig emerging from its daytime hiding place after dark



Figure 3. Adult earwigs seek any hiding place they can find during the day – here seen sheltering in a plastic tree tie

Biology and life cycle of earwigs

Life cycle

In September, male and female earwigs mate and spend the autumn and winter in a chamber (2.5–10 cm deep) made in the soil of the orchard (Figure 4). From mid-winter to early spring, the male leaves the nest and the female lays 50 to 90 eggs. At night in the spring, males and females can be found in the orchard trees (Figure 5), but numbers of males decline by May. The female tends the eggs and then forages and regurgitates food to the first stage nymphs (Figure 6). Overwintered females

die before mid-summer. Second and third instar nymphs move into the tree canopy from May onwards (Figure 7). Adults emerge from fourth instar nymphs in July and August. A full representation of the earwig life cycle is depicted in Figure 8.

The number of earwig broods (sometimes a second brood is laid), their dispersal ability and the stage of earwig development in the orchard trees, may have consequences for spray application timings and other management practices throughout the season.



Figure 4. Adult female earwig and her eggs in a typical soil chamber created in the soil during the autumn and winter



Figure 6. Adult female tending her eggs in the nest



Figure 5. Adult male earwigs can be found feeding in orchards at night in the spring



Figure 7. Earwig nymph foraging for food at night

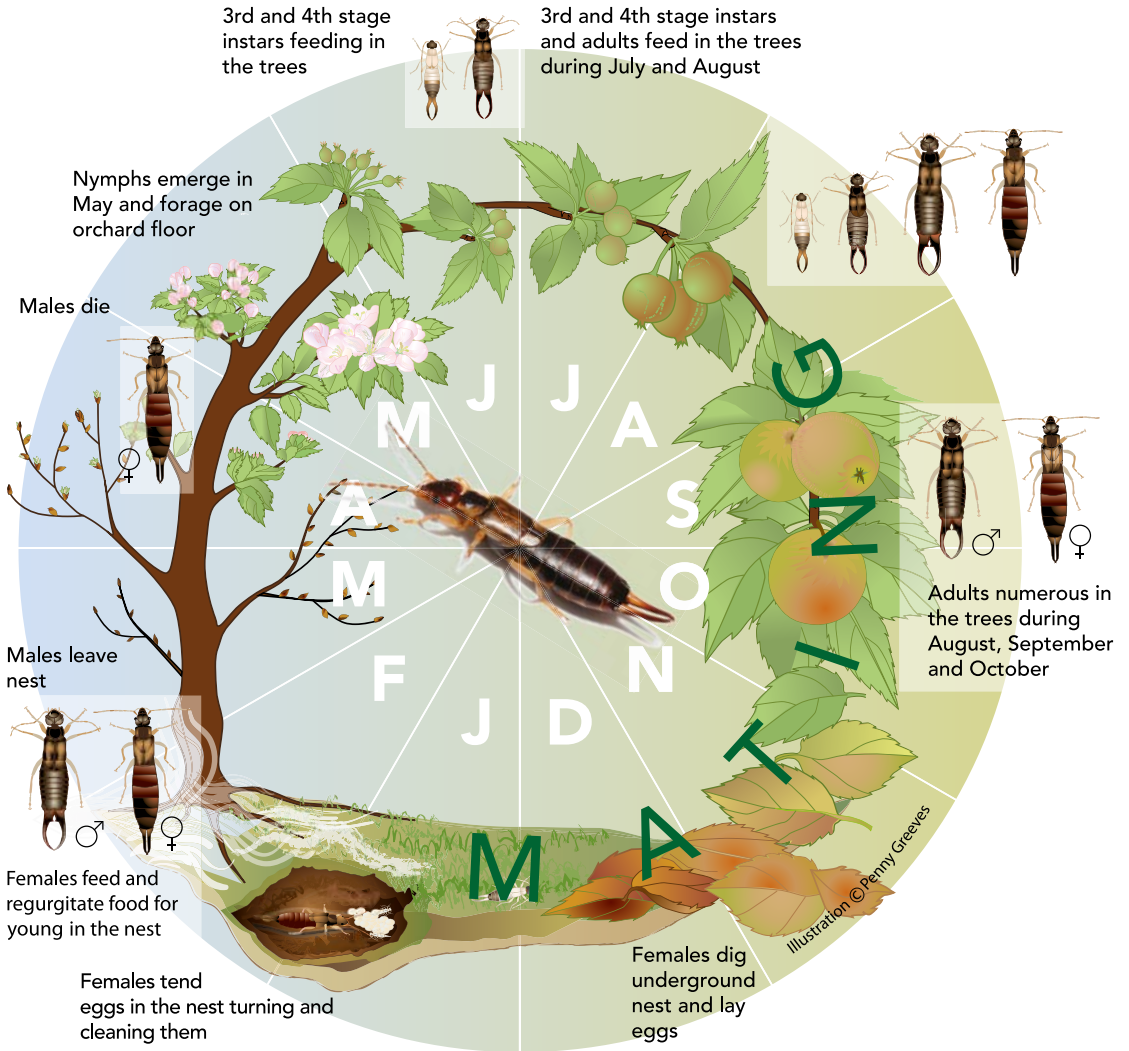


Figure 8. Annual life cycle of the European earwig in an apple orchard

Benefits of earwigs in commercial orchards

Earwigs are omnivorous and feed on other arthropods, plants, microscopic algae, pollen and fungi (Figure 9), and are even cannibalistic.

They are important predators of many orchard pests, including scale insects, psyllids, woolly apple aphid, leaf midges and codling moth.

Excluding earwigs from trees infested with woolly apple aphid or psyllid leads to a proliferation of the pests. Data collected in AHDB Project TF 223 has consistently shown that, where earwigs are numerous in pear orchards, there is rarely a build-up of pear sucker or its resulting honeydew.

Building up earwig populations in orchards through careful orchard management and selective use of plant protection products will increase natural control of many major orchard pests, and allow occasional sprays of more earwig-harmful products to be made when they are needed, to control early spring or sporadic pests.



Figure 10. Earwigs are important predators of aphids



Figure 9. Earwig foraging on fungal growth at night

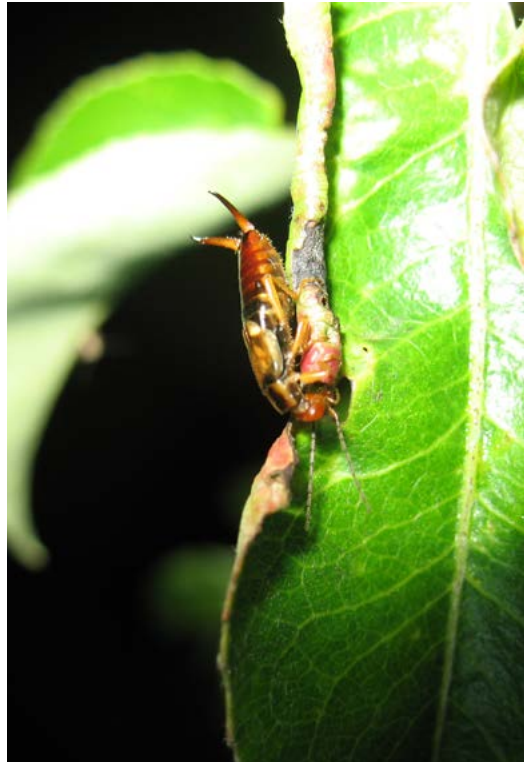


Figure 11. Earwigs also feed on leaf midge larvae

Monitoring for earwigs

Because earwigs are nocturnal, their numbers can be underestimated in orchards. Although they may not be directly exposed to product spray applications made in the daytime, they may be exposed to chemical residues while moving around and feeding at night.

It is important to know if orchards have adequate earwig numbers when deciding whether a spray application is required. One study from the Netherlands reported that four earwigs per tree was adequate for controlling aphids, although this may depend on canopy size and the severity of the pest population.

Earwigs can be monitored in three ways:

- Corrugated card filled plastic bottle refuges can be tied into trees (Figure 12) and then checked in the daytime for the presence of sheltering earwigs
- Tree branches can be tap sampled at night (with the aid of a head torch) or in the day over a white tray (Figure 13)
- Search for earwigs on a warm evening just after dusk, using a head torch to identify activity on the tree bark, fruit and foliage (Figure 14 – overleaf)



Figure 12. Corrugated card bottle refuges allow earwigs to hide from predatory birds by day whilst allowing growers to monitor for their presence during daylight hours



Figure 13. Tap sampling over a white tray can be used during the day to detect the presence of earwigs

Monitoring for earwigs

Monitor weekly, recording the number of earwigs and other natural enemies (Figure 15). This will help to build up a picture of biological control activity in the orchard allowing you to decide whether populations are sufficient to gain control of certain pests or whether a control spray is necessary.



Figure 14. Earwigs come to life after dark and this can be a very useful time to make an assessment of earwig activity in an orchard

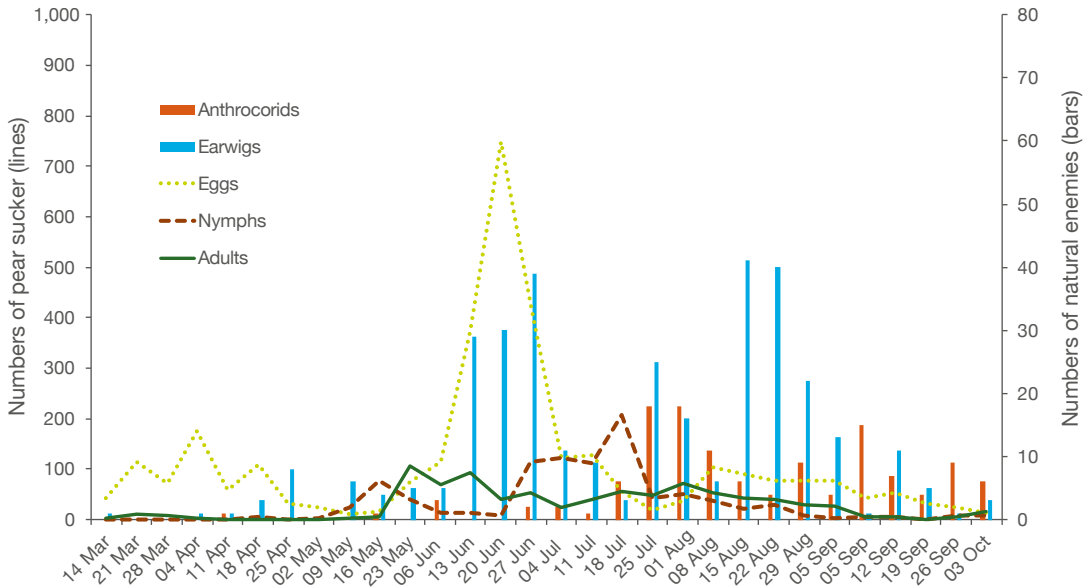


Figure 15. Weekly recording and plot of pear sucker (eggs, nymphs and adults) and associated earwigs and anthrocorids (natural enemies) used to track whether an application of control spray product is necessary

Enhancing earwig populations in orchards

Given that it takes time for earwig populations to increase, newly planted orchards tend to be deficient in earwigs for the first few seasons. They have a combination of disturbed soil and low bark and canopy complexity. In addition, the plant number and diversity in the alleyways may be sparse (Figure 16).



Figure 16. Earwig populations are generally low in orchards in their early years due to recently disturbed soil, lack of tree canopy and low plant diversity

In the early life of a new orchard, growers need to enhance earwig populations by providing cover to hide in during the day and a source of food/prey for the earwigs to feed on at night. Firstly, a more complex mix of grass and wild flower species should be sown in the alleyways to provide a mix of food including pollen and alternative insect prey (Figure 17).

Secondly, growers should provide refuges in the tree canopy that will allow the earwigs to hide by day and forage on food in the trees after nightfall. Refuges can be home-made and consist of old drinks bottles with the bottoms cut off and filled with corrugated

card (Figure 18) or straw. Bundles of bamboo canes can also be used, by placing them horizontally in the canopy. Ideally, one refuge would be placed in each tree.

There is evidence that regular soil tillage can reduce the number of earwig nymphs in spring and summer by 50 per cent.

Organic growers who till the soil for weed control should consider the timing of their operations to avoid the spring period when female earwigs may be tending eggs and young earwigs in the soil.



Figure 17. Mixing wild flowers with grasses in the orchard alleyway will help to provide a mix of pollen and alternative insects for earwigs to feed on



Figure 18. The use of corrugated card in refuge bottles provides perfect hiding spaces for earwigs

Protecting earwigs from spray products

There is much variation in earwig numbers between orchards. Influences may be varied but, increasingly, PPPs are thought to play a role. Products applied in the spring may affect brooding females, while applications between May and October coincide with earwig nymph development and pair bonding adults.

The effects of PPPs on earwigs

PPP's may be harmless, directly toxic and/or have sublethal effects on earwigs. Sublethal effects include reduced reproduction, growth or altered behaviour. Behavioural effects may leave earwigs vulnerable to predation (eg birds and small mammals) or affect their predation ability.

AHDB funded two projects at NIAB EMR to investigate the effects of commonly used insecticides on earwigs in orchards (TF 196) and to develop earwig-safe spray programmes (TF 220). The first of these investigated the effects of commonly used orchard insecticides on the nymph, adult female and adult male earwigs in the laboratory and in the field. Data was

combined with other published records to formulate a table on product safety and appropriate timing (Table 1). It should be noted that different methodologies may contribute to discrepancy in some of the findings and there is little or no data on the effects of fungicides and herbicides on earwig populations.

In Project TF 196, spiroticlofen (Envidor), spinosad (Tracer), acetamiprid (Gazelle) and methoxyfenozide (Runner) had little or no effect on earwig mortality. However, sublethal effects were observed. Spiroticlofen (Envidor), spinosad (Tracer), thiacloprid (Calypso), acetamiprid (Gazelle) and methoxyfenozide (Runner) reduced the growth of nymphs in laboratory tests. Spinosad (Tracer) and thiacloprid (Calypso) also changed the behaviour of the earwigs, sometimes inducing immobility.

In behavioural studies in Project TF 220, earwig nymphs avoided feeding on bean leaves sprayed with thiacloprid (Calypso), but spiroticlofen (Envidor) appeared to stimulate adult earwig feeding (Figure 19).



Figure 19. Earwigs were introduced to bean leaves which had previously been sprayed with crop protection products, to assess the effect on their behaviour

Table 1. Safety of plant protection products to earwigs in apples and pears. Actives listed were approved on apple and pear at the time of publishing – August 2018)

Active (Typical product)	Target pest	Adults Feb–Apr and Sep–Oct	Nymphs May–Aug
acetamiprid (Gazelle SG)	Aphids	Safe	Affects growth
Bacillus thuringiensis (Dipel DF, Lepinox Plus)	Caterpillars	Safe	Safe
chlorantraniliprole (Coragen)	Caterpillars	Safe	Safe
deltamethrin (Bandu, Decis)	Broad spectrum	Harmful	Harmful
diflubenzuron (Dimilin Flo)	Caterpillars	Harmful	*
fenoxycarb (Insegar WG)	Caterpillars	*	*
flonicamid (Mainman)	Aphids	Safe	Safe
indoxacarb (Steward)	Caterpillars	Harmful	Harmful
lambda-cyhalothrin** (Hallmark)	Broad spectrum	* Likely harmful	* Likely harmful
methoxyfenozide (Runner)	Caterpillars	Safe	Harmful
spinosad (Tracer)	Caterpillars	Harmful	Harmful
spirodiclofen (Envidor)	Mites, mussel scale, sucker	Safe	Harmful
spirotetramat (Batavia)	Aphids, midges, mites, mussel scale	Safe	*
tebufenpyrad (Masia)	Mites	*	*
thiacloprid (Calypso)	Aphids, midges, weevils	Safe	Harmful
thiamethoxam (Centric)	Aphids	*	*

Key

Harmful – where a significant lethal or sub lethal effect has been observed in laboratory and/or field trials

Safe – where no effect has been observed in laboratory and/or field trials

* no data available

** lambda-cyhalothrin has a 365-day harvest interval on apple

The table has been compiled using data gathered from AHDB Projects TF 196 and 220, along with data from scientific literature.

Protecting earwigs from spray products

In long-term laboratory studies (TF 220) where earwigs were exposed to products and then maintained overwinter through to egg laying, significant female earwig mortality occurred following previous exposure to spirotetramat (Envidor) and abamectin (Agrimec) – which is no longer approved. In addition, spirotetramat (Envidor) delayed egg laying the following spring by a month. The combined effects of autumn and spring earwig mortality and delayed egg laying, meant there were a third more eggs laid in the water only control compared to the spirotetramat (Envidor), thiacloprid (Calypso) and abamectin (Agrimec) treatments.

In the final year of Project TF 196, grower conventional and earwig-compatible spray programmes were compared. While earwig numbers increased in orchards with the earwig-compatible spray programme, populations were significantly negatively affected by the conventional spray programmes (which included chlorpyrifos and methoxyfenozide – Runner).

Research has demonstrated that more selective PPPs are less harmful to earwigs, eg acetamiprid (Gazelle), chlorantraniliprole (Coragen), *Bacillus thuringiensis*, flonicamid (Mainman) and spirotetramat (Batavia).

In the AHDB projects, fewer earwig nymphs were found in trees treated with flonicamid (Mainman) or thiacloprid (Calypso). However, in trials with larger treated areas, Calypso did not reduce the numbers of earwigs in the trees, and applications of Calypso or Gazelle had no effect on the numbers of earwigs in apple trees when applied in the spring or mid-season.

In a pear orchard, sprays of thiacloprid (Calypso) applied pre-blossom, early summer (June), mid-summer (July) or

post-harvest (October) had no effect on the numbers of earwigs in the trees. However, an early summer foliar application of spirotetramat (Envidor) or abamectin (Agrimec) reduced the numbers of earwig nymphs in the trees. By July, when many earwigs are maturing to adults, spirotetramat (Envidor) had no discernible effect on the numbers of adult earwigs in pear trees.

The results of such field spray trials, however, can be confounded by interactions of the insecticide product on pest numbers in the trees and, hence, availability of food to earwigs. In addition, differences in canopy density and, hence, spray coverage, or earwig population levels in the orchards may also affect the impact of PPPs.

What can be learnt from this research?

The AHDB-funded projects have highlighted those products commonly used for pest control in apple and pear orchards, which are either safe to earwigs or which have an adverse effect on either adults or nymphs at different times of the season.

Table 1 (see page 13) summarises the effects on earwigs that were recorded in AHDB Projects TF 196 and TF 220 by applying a range of pest control products either in the laboratory or field or both. Other published data from the scientific literature is also included. Growers and agronomists should consult this table when constructing pest control spray programmes and aim to time applications to avoid disruption to earwig populations.

In conclusion, the research suggests that, where essential, an occasional application of a PPP is unlikely to have long-term effects on earwig populations, if:

- Earwig populations are already high in orchards
- Less harmful products are selected, based on the life stage of the earwig
- Refuges are provided where earwigs can avoid direct spray applications during the day
- Conservation biology is employed providing earwigs with suitable food sources/ habitats and consideration is given to the timing of soil tillage to encourage earwigs into newly established and more mature orchards

Growers and agronomists should determine whether a spray application is necessary by considering if numbers of the most effective natural enemies are sufficient to control the pest. If an application is necessary, consider the current stage of the earwig life cycle and whether a product can be selected that does little or no harm. This will allow earwig numbers to build in orchards and help with pest regulation, further reducing the need for insecticide applications.

The effect of long-term earwig compatible spray programmes is unknown. It is possible, for example, that sporadic pests (eg weevils and capsids), not controlled by the earwig compatible programmes, may become more abundant.



Further information

Useful AHDB project reports

- TF 181 Exploiting semiochemicals, conservation biocontrol and selective physical controls in integrated management of pear sucker (Defra Horticulture LINK HLO194)
- TF 185 Identifying prey preferences of earwigs in an apple orchard as a prerequisite for assessing their biocontrol potential.
- TF 196 Investigation of the effects of commonly used insecticides on earwigs, important predators in apple and pear.
- TF 220 Further development of earwig-safe spray programmes for apple and pear orchards.

Other useful AHDB publications

AHDB Factsheet 28/12. Developing integrated management controls for pear sucker

Online Apple Best Practice Guide – Chapters: Natural enemies and Integrated pest and disease management apples.ahdb.org.uk

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