Encyclopaedia of pests and natural enemies in field crops

AHDB

AGRICULTURE & HORTICULTURE DEVELOPMENT BOARD

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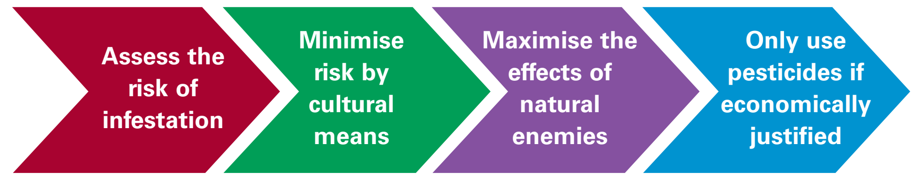
Introduction

Integrated pest management

Managing pests while encouraging and supporting beneficial insects is an essential part of an integrated pest management strategy and is a key component of sustainable crop production.

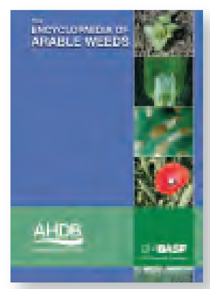
The number of available insecticides is declining, so it is increasingly important to use them only when absolutely necessary to safeguard their longevity and minimise the risk of the development of resistance. The Sustainable Use Directive (2009/128/EC) lists a number of provisions aimed at achieving the sustainable use of pesticides, including the promotion of low input regimes, such as integrated pest management.

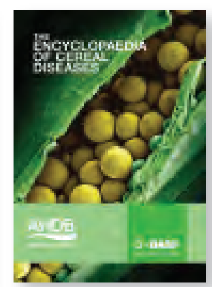
Effective pest control:



This publication

Building on the success of the Encyclopaedia of arable weeds and the Encyclopaedia of cereal diseases, the three crop divisions (Cereals & Oilseeds, Potatoes and Horticulture) of the Agriculture and Horticulture Development Board have worked together on this new encyclopaedia providing information on the identification and management of pests and natural enemies. The latest information has been provided by experts from ADAS, Game and Wildlife Conservation Trust, Warwick Crop Centre, PGRO and BBRO.





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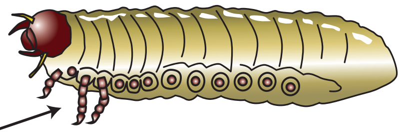
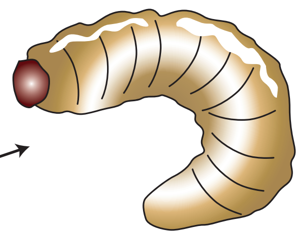
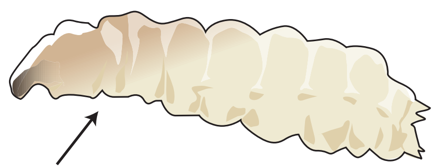
Beetle



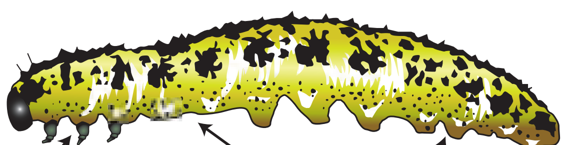
Weevil



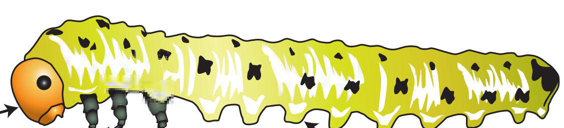
Fly



Moth/butterfly



Sawfly



Pest thresholds: quick reference

Integrated pest management involves using thresholds as the basis for control strategies:

– Identify the pest
– Look up pest thresholds
– Assess pest numbers on a field-by-field basis
– Reassess if treatment is delayed

Cereals

Wireworms (p. 33)	A seed treatment is justified if there are more than 750,000 wireworms per hectare
Summer aphids (p. 54 and p. 71)	Before GS61: half of tillers infested GS61 to two weeks before end of grain filling: two-thirds of tillers infested
Frit fly (p. 95)	More than 10% of plants damaged soon after full crop emergence
Gout fly (p. 97)	Winter crops at GS12: – Eggs found on more than half of plants
Leatherjackets (p. 99)	Spring cereals, prior to cultivation: – 50 leatherjackets per m^2 – 5 leatherjackets in 12 pipes – 5 leatherjackets per metre of row
Orange wheat blossom midge (p. 103)	Pheromone traps (at GS45): – 30 or more midges: General risk to crops in the following week – More than 120 midges: Very high risk. Treat wheat crops in surrounding fields at GS53–59 Crop monitoring (at GS53–59): – Feed crops: 1 midge per 3 ears – Milling/seed crops: 1 midge per 6 ears
Wheat bulb fly (p. 119)	A seed treatment may be necessary in all instances except where there are less than 100 eggs/m^2 in crops drilled in Nov–Dec. The risk, however, increases the later the drilling and the higher the egg count.
Slugs (p. 163)	Slugs per refuge trap, prior to cultivation: – Winter cereals: 4 – Spring cereals: 1

Oilseed rape

Cabbage seed weevil (p. 19)	Weevils per plant during flowering: – Northern UK: 0.5 – Elsewhere: 1
Cabbage stem flea beetle (p. 21)	Adult feeding thresholds: – >25% leaf area eaten at the cotyledon–2 leaf stage – >50% leaf area eaten at the 3–4 leaf stage – The crop is growing more slowly than it is being consumed Thresholds for control of larvae: Yellow water trap: – >96 beetles/trap (average) caught between early September and the end of October Plant dissection: – >5 larvae/plant – >50% of petioles damaged
Pollen beetle (p. 27)	Beetles per plant at the green to yellow bud stage: – If there are fewer than 30 plants/m^2: 25 – If there are 30–50 plants/m^2: 18 – If there are 50–70 plants/m^2: 11 – If there are more than 70 plants/m^2: 7
Mealy cabbage aphid (p. 59)	% of plants infested before petal fall: – Winter oilseed rape: more than 13% – Spring oilseed rape: more than 4%
Leatherjackets (p. 99)	Prior to cultivation: – More than 50 leatherjackets per m^2 – More than 5 leatherjackets in 12 pipes – More than 5 leatherjackets per metre of row
Slugs (p. 163)	Slugs per refuge trap, prior to cultivation: – In cereal crops: 4 – In cereal stubble: 1

Field beans

Bruchid beetle (p. 17)	Treatment should be applied when, during flowering: – Adults have been found in the crop – The temperature has reached 20°C on two consecutive days – Beans have developed the first pods on the lowest trusses
Pea and bean weevil (p. 25)	Spring field beans: – An average of 30 or more weevils on any one recording day
Black bean aphid (p. 45)	Early flowering until pod formation: – 10% of plants infested: Immediate treatment is justified – 5% of plants infested: Treatment can help prevent virus infection
Slugs (p. 163)	1 slug per refuge trap, prior to cultivation

Peas

Pea and bean weevil (p. 25)	Spring-sown peas: – An average of 30 or more weevils on any one recording day
Pea aphid (p. 61)	% plants infested, May to July: – Combining peas: 20% or more – Vining peas: 15% or more
Pea midge (p. 105)	If more than 500 midges are caught on one trap (placed by the third week of May), susceptible pea crops in the near vicinity should be examined
Pea moth (p. 141)	Dry harvested peas for human consumption: – 10 or more moths caught in traps (placed by the middle of May and examined at two-day intervals) on two consecutive occasions Vining peas: Traps are just used to determine if moths are present. Growers should be guided by the factory fieldsman as even very small infestations can lead to rejection
Silver Y moth (p. 143)	Vining peas: – Cumulative catch exceeds 50 moths by the first pod stage (GS204)
Slugs (p. 163)	1 slug per refuge trap, prior to cultivation

Pest thresholds: quick reference

Potatoes

Wireworms (p. 33)	The presence of even a single wireworm in twenty 10 cm diameter soil cores can represent a significant risk in the following crop
Potato cyst nematode (p. 155)	Eggs per gram of soil: – 1–10: Nematicide use recommended – 10–20: Nematicide treatment highly recommended – >20: Take into account all factors and, if appropriate, consider other ground

Sugar beet

Black bean aphid (p. 45)	Treatment is only justified on backward or stressed crops with more than 100 aphids per plant (averaged across the field)
Green aphids (p. 65)	Apply a foliar insecticide when one green wingless aphid per four plants is found. This increases to one green wingless aphid per plant once at the 12 leaf stage.
Beet leaf miner (p. 83)	Treat if the number of eggs and larvae exceed the square of the number of true leaves; for example, if a plant with four true leaves has a population of 16 or more eggs and larvae
Silver Y moth (p. 143)	The threshold is five caterpillars per plant
Beet cyst nematode (p. 151)	Thresholds vary widely across Europe. In the UK, latest results show an economic benefit from using BCN-tolerant varieties above two eggs and larvae per gram of soil
Free-living nematodes (p. 153)	Severe symptoms often occur in soils with *Trichodorus* populations of more than 1,000/litre of soil or *Longidorus* populations of more than 100/litre of soil
Slugs (p. 163)	1 slug per refuge trap, prior to cultivation

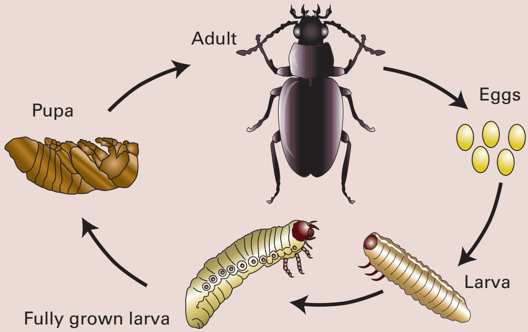
Pests:
Beetles

Contents – Pests: Beetles

Beetles (Coleoptera)

Beetles occur in all types of habitats and are among the commonest insects on farmland. A few beetle species are crop pests but the majority are harmless, while some are important predators of crop pests (see page 175).

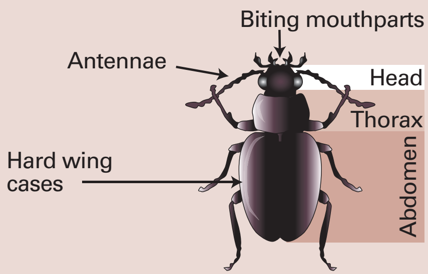
Life cycle



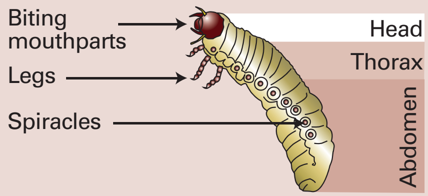
Beetle young (larvae) do not look anything like the adults. Their outer skin cannot grow and so must be shed in a series of moults as the beetle larva grows. The developmental stages between each moult are called 'instars'. When the larva is fully grown, it moults again, revealing a pupa. This is a non-feeding stage, inside which the larval body is broken down and reassembled in the adult form.

Defining features

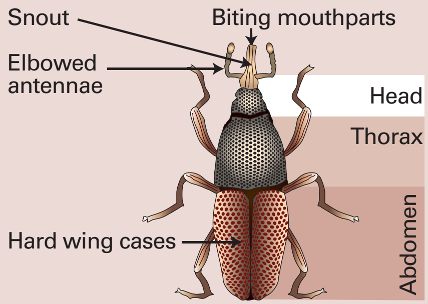
Adult beetles have a defined head and thorax and a distinct pair of hard wing cases covering the rest of their bodies, which meet in a line down the middle.



Beetle larvae have hardened, often dark, heads with biting mouthparts. They have three pairs of legs and spiracles (the openings of the respiratory system) along the sides of the body.



Weevils are a type of beetle. The adults have a snout with angular antennae. The larvae do not have legs (see page 11).



Crops affected

- Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- Peas
- ✔ Field beans
- Sugar beet
- Lettuce

Importance

In field beans, seeds damaged by the bruchid beetle reduce the value of the crop for human consumption, export trade or for seed.

In broad beans, the presence of the damage or the larvae makes them unacceptable for processing and may lead to rejection of the crop.

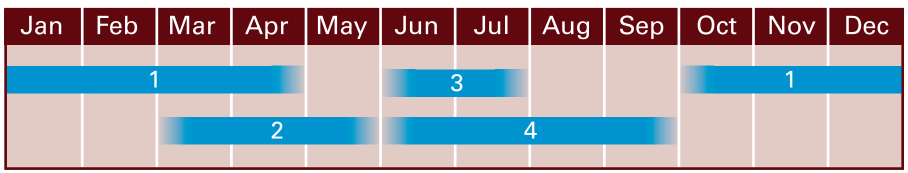
Risk factors

The pest is common in the south of the UK, up to Yorkshire.

Risk of economically damaging infestations is greater where the pest occurred in previous crops.

The adults fly into crops if the temperature is 15–20°C for several consecutive days.

Life cycle



1. Adults overwinter in hedgerows or other dense, shrubby habitats.
2. Adults fly into flowering bean crops when the temperature reaches 15–20°C.
3. Eggs are laid on pods after adults have fed on pollen for two weeks and the temperature has exceeded 20°C.
4. Larvae feed on the seeds before pupating within the seed. Pupation can occur in the field or in storage. Adults eat their way out of the seed.

In field beans, the larvae pupate at the same time as the seed matures and dries. Pupation and adult emergence often occur in storage, especially if the moisture content of the seed is high; however, this pest does not multiply in stored produce.

Adult bruchid beetle with bean seeds

Bruchid beetle (*Bruchus rufimanus*)

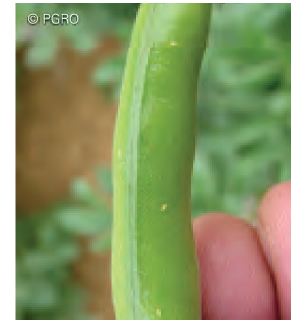
Identification and symptoms

The adult beetle is 3.5–4.5 mm long and oval. It is black or dark brown, with small, grey flecks along the wing cases. The base of the antennae and the front legs are a reddish colour. The wing case does not extend to cover the abdomen completely and the hind legs appear longer than the first two pairs of legs.

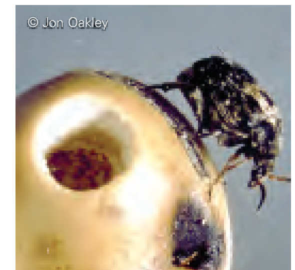
Yellowish, cigar-shaped eggs, around 0.5 mm long, are laid singly or in small groups on young seed pods. Pods that are 2–5 cm long and on the lower third of the plant seem to be preferred for egg laying.

The white fleshy larvae have a light brown head and three pairs of legs on the forward three segments. Upon hatching, they bore directly into the pod to the seeds and at maturity are 3–4 mm long.

In field beans, damage is characterised by a circular emergence hole in the seed where the adult beetle has bitten its way through the seed coat. In broad beans, the entry hole of the newly hatched larvae can be seen as a small hole or cut in the seed coat of the shelled bean, which may darken after vining. Cutting the beans open may reveal the immature larvae.



Bruchid beetle eggs



Bruchid beetle and damage

Monitoring

Crops should be examined for adults during flowering. This can be done by tapping the flowering stems into the hand or a shallow tray.

Thresholds

Treatment should be applied when adults have been found in the crop, the temperature has reached 20°C on two consecutive days and beans have developed the first pods on the lowest trusses.

Bruchid beetle spray forecasts are available from Syngenta:
www.syngenta.co.uk/bruchidcast

Non-chemical control

The parasitic wasp, *Triaspis luteipes*, attacks the beetle larvae. Small emergence holes in the seeds may be due to this natural enemy.

Insecticide resistance

None known.

Crops affected

- Cereals
- ✔ Oilseeds
- Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

Importance

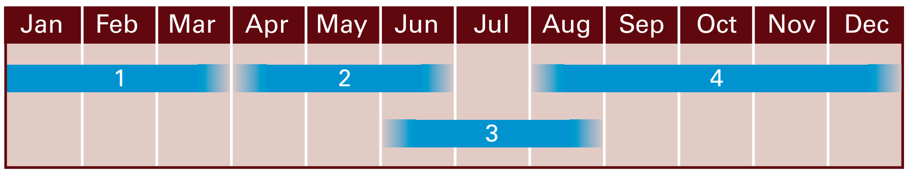
Cabbage seed weevils lay their eggs within the pods and the larvae feed on the developing seed.

Exit holes in the pods, created by seed weevil larvae returning to the soil to pupate, provide access for brassica pod midge adults to lay their eggs (see page 87). Yield losses from pod midge are potentially greater than direct losses from seed weevil.

Risk factors

Crops in the north of the UK tend to be at a greater risk.

Life cycle



1. Adults overwinter in woods and hedgerows.
2. Adults migrate into crops during flowering and lay eggs in pods.
3. Larvae feed within the pod before burrowing out to pupate in the soil.
4. Adults emerge in August and hibernate in non-crop situations. If further brassica crops are present, they may continue to feed before hibernating.

Cabbage seed weevil

Identification and symptoms

The adult is a small (2–3 mm) lead-grey to black weevil with a long snout.

Eggs are laid singly in young pods.

Larvae are plump, white, with a definite brown head capsule and no legs. At maturity, the larvae bore an exit hole in the pod and fall to the soil to pupate.

A brown scar, usually resulting in a kink in the pod, indicates where the pod has been punctured for egg laying. The larva feeds within the pod, usually consuming approximately 25% of the total seeds. A neat, circular hole indicates where the larva has escaped the pod to pupate.

Monitoring

Check the crop during flowering for the presence of the weevil. They are readily visible on flowering racemes on sunny days.

Thresholds

Northern UK: 0.5 per plant

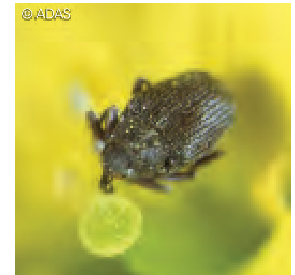
Elsewhere: 1 per plant

Non-chemical control

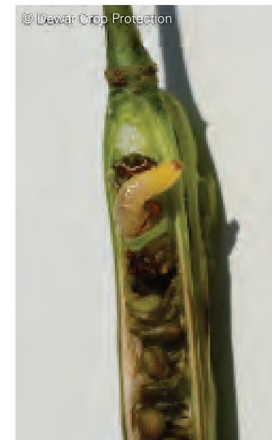
There are a number of parasitoid species that attack this pest, including parasitoids of egg, larval and adult stages. Encouraging their presence can help control.

Insecticide resistance

None known.



Cabbage seed weevil on oilseed rape flower



Cabbage seed weevil larva on oilseed rape

Crops affected	
	Cereals
✔	Oilseeds
✔	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

Importance

Cabbage stem flea beetle is a major pest of oilseed rape. Originally a problem in East Anglia, it now covers England and Wales and is spreading in Scotland.

Large numbers of adults feeding in the autumn can kill plants, occasionally resulting in total crop failure. Larval feeding in the stems and petioles reduces vigour and can cause severe damage, which may lead to stunting or plant death.

Larvae may feed within the stems of vegetable brassicas, such as spring cabbage and kale, during autumn and winter but it is an incidental pest.

Risk factors

Air temperatures above 16°C are more favourable for adult cabbage stem flea beetle migration. A warm autumn will favour egg laying and early hatch of larvae, coinciding with smaller, more vulnerable plants. Crops drilled into dry and cloddy seedbeds can be slower to emerge, with reduced vigour.

Life cycle

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
					1	1	2	3 / 4	4	4	4
5	5	6	6	7					5	5	5

1. Adults emerge and feed on foliage.
2. Adults 'rest' in moist, sheltered places.
3. Adults migrate into crops, feed on leaves and mate.
4. Adults lay eggs and feed on leaves until temperatures drop.
5. Eggs hatch and larvae feed if temperatures are 3°C or warmer.
6. Larvae feed on main stem behind the growing point.
7. Larvae drop to the soil and pupate.

Identification and symptoms

Adults are 3–5 mm long, metallic blue-black or light brown and are often seen crawling over trailer loads of seed at harvest. They have long antennae, large hind legs and jump when disturbed. The larvae are white with numerous, very small, dark spots on the back, a black head and tail and three pairs of dark legs. When fully grown, they can reach 6 mm in length.

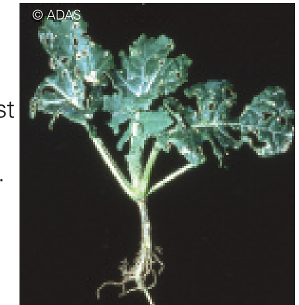
Cabbage stem flea beetle creating shot-holing symptoms

Adult feeding can be seen as characteristic shot-holing of the leaves. Plants infested with larvae lose vigour, becoming stunted, and die if the infestation is severe.

Cabbage stem flea beetle (*Psylliodes chrysocephala*)

Monitoring

For early warning signs, check for large numbers of cabbage stem flea beetle in previously harvested seed and shot-holing on volunteer oilseed rape. Monitor for pest damage as soon as crops begin to emerge. The amount of leaf area eaten can determine the need for treatment.



Adult cabbage stem flea beetle damage on oilseed rape

To predict larval populations, set two yellow water traps on the headland and two in the field along a wheeling in early September. Fill them with water and a drop of detergent. Empty and reset the traps weekly, recording the number of cabbage stem flea beetles and adding it to the previous total for that trap. Remove the traps at the end of October. Use the total numbers of beetles caught in each trap over the whole monitoring period to calculate an average number of beetles/trap.

Cabbage stem flea beetle larva

Plant dissection involves taking a random sample of 25 plants from the field in late October/early November. Samples are best dissected by an accredited laboratory.

Thresholds

Assessing the need to spray adults in oilseed rape:

- >25% leaf area eaten at the cotyledon–2 leaf stage
- >50% leaf area eaten at the 3–4 leaf stage
- The crop is growing more slowly than it is being consumed

Assessing the need to spray larvae in oilseed rape:

- >96 beetles/trap (average) caught over the monitoring period
- >5 larvae/plant, when dissected
- >50% of petioles damaged

Non-chemical control

Carabid beetles (*Trechus quadristriatus*) feed on cabbage stem flea beetle eggs and young larvae before they enter oilseed rape plants and the larval parasitoid (*Tersilochus microgaster*) parasitises larvae in the spring. All parasitoids may be vulnerable to pyrethroid insecticides. Minimum tillage has potential for conserving carabids and parasitoids.

Two entomopathogenic fungi (*Beauveria bassiana* and *Metarhizium anisopliae*) are known to infect cabbage stem flea beetles but their impact on the field populations is not known.

Insecticide resistance

Resistance to pyrethroids has been confirmed in the UK.

Cabbage stem weevil (*Ceutorhynchus quadridens*)

Crops affected	
	Cereals
✔	Oilseeds
✔	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

Importance

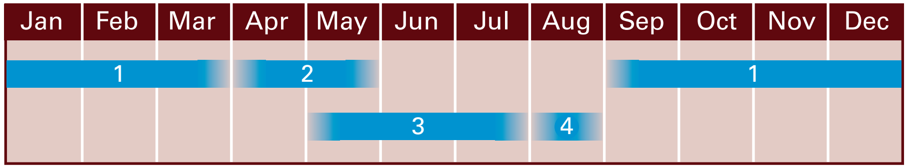
Cabbage stem weevil is frequently recorded in oilseed rape, occasionally causing economic damage.

It can infest vegetable brassicas and may cause cosmetic damage to high value crops, such as cauliflower. Damage can be caused by feeding adults as well as larvae. It is currently an occasional and minor pest of vegetable brassicas.

Risk factors

Spring crops in the southern counties are at particular risk. It is considered a minor pest in winter crops.

Life cycle

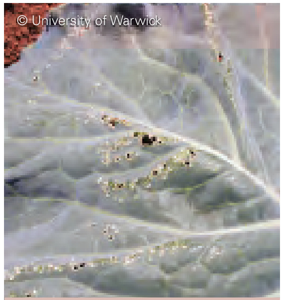


1. Adults overwinter in sheltered locations.
2. Adults migrate into the crop, laying eggs under the leaf surface.
3. Eggs hatch and larvae tunnel into the stem. At maturity, they bore an exit hole and pupate in the soil.
4. Adults emerge and feed for a short time.

Cabbage stem weevil

Cabbage stem weevil (*Ceutorhynchus quadridens*)

Identification and symptoms



Damage by cabbage stem weevil

Adults are small (3 mm long) with a long snout, reddish legs and antennae. They have a fine layer of yellow-white scales on the back that give them a mealy appearance and a white spot in the middle of the back.

Clusters of eggs are laid under the leaf surface in a blister. On hatching, larvae bore into the main stem to feed. They are creamy white with a brown head and no legs and grow to 4–5 mm long. At maturity, they bore an exit hole in the lower stem and drop to the soil to pupate.

Plants invaded by this weevil show few external signs of damage. Blisters near the main vein on lower leaves and leaf stalks in early summer indicate where eggs have been laid. Larval feeding and tunnelling can result in premature leaf drop and discolouration to the stem. Some stunting and loss of vigour can occur, especially in spring rape. In late summer, exit holes in the stem should be visible.

Monitoring

Crops can be checked in early summer for adults migrating in from overwintering sites. It is possible to trap adults in yellow water traps which may indicate when females are laying eggs. These numbers are reported in the Pest Blog.

Thresholds

None established.

Non-chemical control

Early drilling can minimise the risk of damage, as established plants will show a greater tolerance to the feeding.

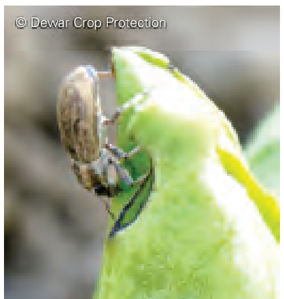
Natural enemies include spiders, ground beetles, rove beetles, predatory flies, and parasitoids of egg, larval and adult stages.

Insecticide resistance

None known.

Crops affected

- Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- ✔ Peas
- ✔ Field beans
- Sugar beet
- Lettuce



Pea and bean weevil feeding

Importance

The pea and bean weevil can cause yield reductions in field and broad beans and in combining, vining and fresh market peas. Adult feeding does not normally cause significant damage but larval feeding within the root nodules can affect yield. The larvae are difficult to target and pressure from this pest has increased in recent years.

Adults can transmit the broad bean stain virus (BBSV) and the broad bean true mosaic virus (BBTMV), which can affect product quality and result in large yield reductions if the infection occurs early.

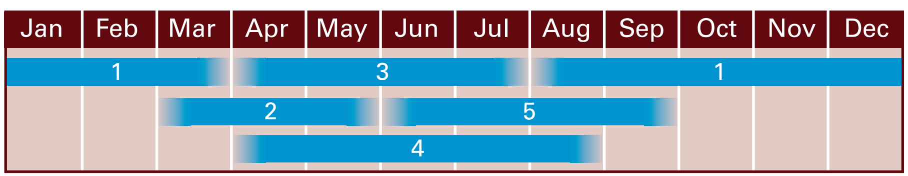
Risk factors

Crops are at increased risk if leguminous plants, such as clover and lucerne, neighbour the field or there are uncultivated grasses at field edges, especially if the field or fields nearby were previously cropped with peas or beans.

Migration occurs in early spring and often when the maximum air temperature exceeds 15°C. Any crops that are newly emerged at this point are particularly susceptible to damage from adult feeding.

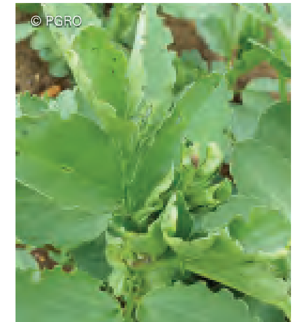
Crops grown in nitrogen-poor soil or exposed to drought conditions are most susceptible to larval feeding damage.

Life cycle



1. Adults emerge and overwinter in grasses and leguminous crops, such as clover and lucerne.
2. Adults migrate into crops when temperatures rise above 15°C for short periods.
3. Eggs are laid and are washed into soil at the crop base.
4. Eggs hatch and larvae enter root nodules to feed.
5. Larvae pupate in soil.

Identification and symptoms



Pea and bean weevil damage

Adults are 4–5 mm long and light brown with faint creamy yellow stripes along the length of the wing cases. They have a short 'snout' with the 'elbowed' antennae typical of weevils.

Eggs are oval and white when laid but darken as they mature. They are laid on or around crops and are washed into the soil around the stem bases.

Hatching larvae are legless and white with a brown head. When fully grown, they are 4–5 mm long and move out of the root nodules to form a pupa about 5 cm below the soil surface.

Adult feeding damage is evident as notching around the leaf margins and is usually first noticeable at field edges. Larval damage is difficult to detect. BBSV and BBTMV cause leaf malformation with light and dark green mottling and yellowish blotching.

Monitoring

A monitoring system that detects adult weevils migrating into the crop in early spring has been developed by Rothamsted Research, in collaboration with PGRO and ADAS.

The system comprises five cone traps containing pheromone lures, which are sited on a single grassy verge or headland of a field that had contained peas or beans the previous year. The traps should be placed by mid-February and monitored three times a week until a threshold catch is reached or until the latest sown crops have emerged (whichever is the sooner).

The system identifies when weevil numbers are low and crops do not require treatment, identifies periods of peak activity to allow optimal timing of treatments and informs the selection of drilling time to avoid periods of serious damage.

Thresholds

Spring-sown peas and spring field beans: An average of 30 or more weevils on any one recording day.

The crop may be at risk if the threshold is reached when the crop has just emerged or is due to emerge in the next ten days.

Non-chemical control

Avoid cropping in areas that have previously had large pea and bean weevil populations. Natural enemies include spiders, ground beetles, rove beetles, predatory flies and parasitoids.

Insecticide resistance

Resistance to pyrethroids has been confirmed in the UK.

Crops affected

Crops affected	
	Cereals
✔	Oilseeds
✔	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

Importance

In oilseed rape, the damage-susceptible stage is green to yellow bud. Adult and larval feeding can lead to bud abortion and reduced pod set. Damage rarely results in reduced yields for winter crops but spring crops can be more vulnerable as the susceptible stage often coincides with beetle migration. Oilseed rape usually compensates for early damage by producing more seeds on lower racemes.

Adults are occasional pests of cauliflower and broccoli, feeding on the curds or florets in mid-summer when new adults emerge from oilseed rape crops and move into other areas to feed.

Risk factors

Dry and warm weather (above 15°C) increases risk.

Backward crops and those suffering from pigeon damage are at greater risk.

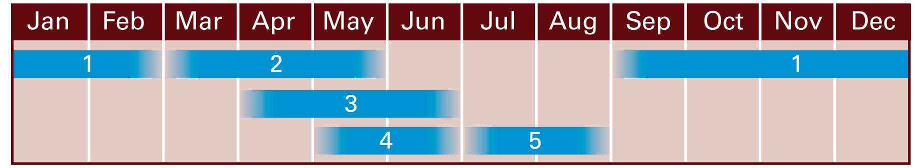
In vegetable brassicas, the risk of infestation is higher if horticultural crops are close to fields of oilseed rape.

Pollen beetles on oilseed rape

Pollen beetles on oilseed rape

Pollen beetle (*Meligethes* spp.)

Life cycle



1. Adults overwinter in sheltered spots.
2. Adults migrate into oilseed rape crops when temperatures exceed 15°C. They feed on pollen inside buds or in open flowers.
3. Eggs are laid in buds.
4. Larvae feed on pollen before pupating.
5. Adults emerge and feed on a variety of plants.

Once the crop starts flowering, the beetles move to the open flowers, becoming pollinators rather than pests.

Blind stalks on oilseed rape due to pollen beetle damage

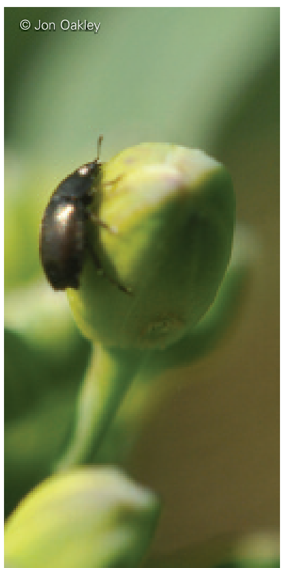
Identification and symptoms

The adults are small (approx. 2.5 mm), metallic greenish-black and have clubbed antennae.

Females bite slits in the base of oilseed rape buds and lay their eggs inside.

The larvae are creamy white, with a black head, three pairs of legs and dark brown spots and short bristles along the back. They grow to 3–4 mm long.

Pollen beetles damaging oilseed rape bud



Pollen beetle on oilseed rape bud

Monitoring

The Bayer Pollen Beetle Predictor forecasts pollen beetle migration into winter oilseed rape crops and the AHDB Horticulture Pest Bulletin website forecasts pollen beetle migration into vegetable brassica crops, helping growers to target crop walking.

In oilseed rape, estimate plant population per m^2 by counting the number of plants within a square foot and multiplying by 11. This is easiest at the 5–6 leaf stage. Use the plant population to determine the threshold. Count adults on the plant during the green bud stage.

Thresholds

Oilseed rape

Thresholds are based on the maximum number of buds each beetle can destroy and the number of excess flowers produced. Low plant populations tend to produce more branches and more flowers.

Threshold number of beetles per plant at the green to yellow bud stage:

- If there are fewer than 30 plants/m^2: 25
- If there are 30–50 plants/m^2: 18
- If there are 50–70 plants/m^2: 11
- If there are more than 70 plants/m^2: 7

Vegetable brassicas

None established.

Non-chemical control

Pollen beetle larvae are attacked by parasitic wasps during flowering. Insecticides can considerably decrease parasitism. Parasitism can be enhanced by planting oilseed rape crops close to where the crop was grown in the previous year and through trap cropping with turnip rape which can often reduce populations of pollen beetle to below threshold.

Minimum tillage following oilseed rape will also enhance survival of parasitoids.

Other natural enemies include spiders, ground beetles and rove beetles.

Insecticide resistance

Pollen beetle resistance to pyrethroid insecticides is now widespread throughout the UK. A strategy for contending with pyrethroid resistance needs to cover all spring and early summer insecticide applications, regardless of their intended target.

Investigate any control failures to further establish resistance levels. Consider neonicotinoids, indoxacarb or pymetrozine as alternatives to pyrethroids.

To limit the spread of resistance and any impacts on non-target pollinators, pyrethroid sprays should only be used when thresholds have been exceeded and during the green to yellow bud stage.

Pollen beetle damage to spring rape

Pollen beetle damage to cauliflower

Crops affected

- Cereals
- ✔ Oilseeds
- Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

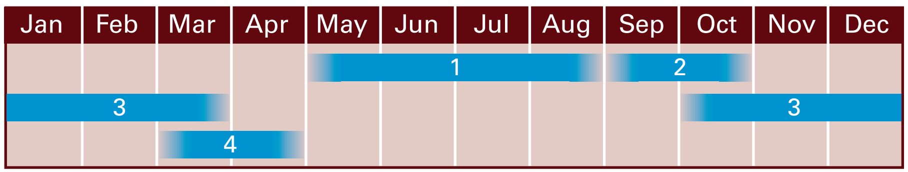
Importance

Rape winter stem weevil is an occasional pest of oilseed rape. It first came to attention in 1982, when a number of severe infestations were experienced in the east and south east. The main damage is caused by the larvae feeding within stems; adult feeding in the autumn is not considered important.

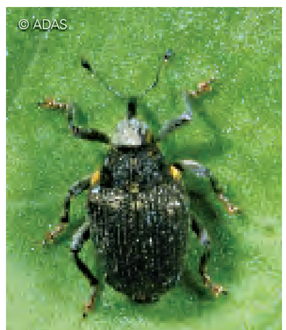
Risk factors

Initially limited to Lincolnshire and Cambridgeshire, the pest has now spread to other areas. Attacks are often worse near wooded areas.

Life cycle



1. Adults emerge from the soil and disperse to woods and hedges, where they enter a resting phase.
2. Adults invade autumn-sown oilseed rape crops, feeding on leaves.
3. Eggs are laid in punctures and crevices in the leaf stalk and plant crown. Hatching larvae bore into the stem to feed.
4. Fully fed larvae descend to the soil to pupate.



Adult rape winter stem weevil

Rape winter stem weevil (*Ceutorhynchus pictarsis*)

Identification and symptoms

Adults are 2.5–4 mm long, metallic black beetles, with elongated snouts, branched antennae and reddish-brown leg tips.

Eggs are laid in leaf petioles and other crevices on the plant.

Hatching larvae are white, plump and legless, with an orange-brown head end. After hatching, they burrow into the leaf petiole and from there into the stem and down to the crown of the plant, where numerous larvae can congregate in clusters. At maturity, they can reach 5 mm in length, at which point they leave the plant and drop to the soil to pupate.

The impact of larval feeding can vary widely, depending on the number of eggs laid on the plant. The larvae can destroy the terminal shoot, with the result that some plants may die during the winter while others survive by developing secondary shoots, producing a stunted plant with a rosette-like appearance. Attacked crops tend to be irregular and patchy with uneven flowering and ripening.

Monitoring

As adults are difficult to spot and larvae are challenging to find, monitoring this pest can be difficult. Where crops have previously been attacked, it is worthwhile inspecting the crop for young larvae from late October.

Thresholds

None established.

Non-chemical control

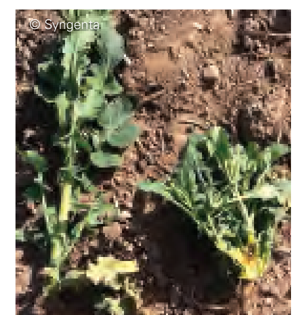
Natural enemies include spiders, ground beetles, rove beetles and several parasitoid species.

Insecticide resistance

None known.

Adult rape winter stem weevil

Rape winter stem weevil larva



Rape winter stem weevil damage

Crops affected

- ✔ Cereals
- Oilseeds
- Vegetable brassicas
- ✔ Potatoes
- ✔ Carrots
- ✔ Alliums
- ✔ Peas
- ✔ Field beans
- ✔ Sugar beet
- ✔ Lettuce

Wireworm

Wireworms

Importance

Wireworms are the soil-inhabiting larvae of click beetles (Elateridae). They are typically found in grassland but can attack a wide range of crops.

Wireworm feeding on potatoes can cause significant reductions in tuber marketability, even at low populations. This can make the difference between a crop worth >£100/tonne and one ploughed in at a significant loss.

In cereals, wireworms can affect all winter cereal or winter cereal/grass ley rotations and have become a serious pest since the withdrawal of organochlorine insecticides. Heavy infestations can cause yield losses of up to 0.6 t/ha.

Young sugar beet seedlings are susceptible to wireworms. Injury shows as small wounds that soon blacken on the stem below soil level. The wound is small but is usually enough to make the seedling wilt and die.

Leeks are also prone to damage and heavy infestations can cause entire crops to be lost.

The larvae burrow into the roots of crops, such as carrot, and damage vegetable seedlings.

Risk factors

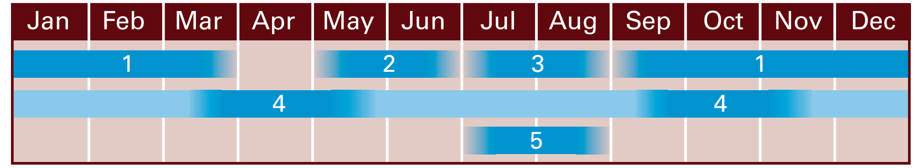
A pre-planting assessment of the risk of wireworm infestation is essential to developing a management strategy, as available chemicals can only be used at planting.

Crops sown within two years of ploughing out permanent pasture are at highest risk; however, any rotation with predominant winter cropping, particularly with grass weeds, is at risk.

An increased risk has also been associated with south-facing sloping fields, heavy alluvial soils and minimum tillage cereal crops. Late-lifted potatoes are also at greater risk of wireworm damage.

Life cycle

Adult click beetles live for about a year. Larvae feed for five years before pupating. Numbers increase over the years; largest populations occur in old permanent pastures. Wireworms feed in ploughed-down turf for about six months before moving to the surface to damage the next two crops.



1. Adults overwinter below soil surface.
2. Females lay eggs just below the soil surface.
3. Eggs hatch.
4. Larvae (wireworms) feed.
5. Larvae pupate.

Identification and symptoms

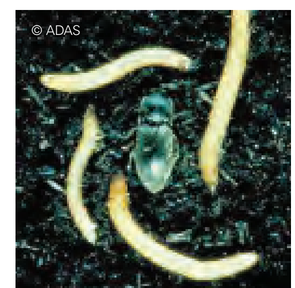
There are three key species: *Agriotes lineatus*, *A. obscurus* and *A. sputator*. The larvae of the three species are indistinguishable by conventional means.

Newly hatched wireworms are transparent, white and 1.3 mm long. They grow to up to 25 mm long and a shiny golden brown. They have a cylindrical body, tough skin, three pairs of legs at the head end and two dark spots at the tail. The head is dark brown, with powerful biting mouthparts. They develop very slowly, taking four to five years to reach maturity.

Adults (click beetles) have a dark brown to black elongated body (8–15 mm long and 2–3 mm wide), which is covered in fine whitish-grey hairs. The adults live for about a year.

Larvae leave ragged holes at the base of the stem in cereals, sugar beet and leeks, moving along rows to attack further shoots. Damage to potato tubers and carrots is visible as small, round holes on the surface leading to narrow tunnels.

Wireworm in potatoes



Wireworms and click beetle

Click beetle pheromone trap

Adult click beetle

Wireworm damage in onion

Monitoring

Bait and pheromone traps can be used to determine the presence or absence of wireworms and click beetles, respectively. There is no clear relationship between wireworm infestations and the numbers of click beetles caught in pheromone traps or wireworms caught in bait traps, they just indicate presence or absence.

Soil samples can be used to assess population size and provide a reasonably good estimation of subsequent damage in potato crops. Populations can be very patchy, however, so accurate estimations are difficult and wireworm populations are capable of causing significant damage even at the lower limit of detection in potato crops (60,000 per hectare).

For cereals, examining soil cores in the field for larger wireworms or in the laboratory for smaller ones is costly and rarely justified.

Thresholds

Potatoes: The presence of even a single wireworm in twenty 10 cm diameter soil cores (equivalent to approximately 60,000 per hectare) can represent a significant risk in the following crop.

Cereals: If wireworms exceed the threshold of 750,000 per hectare (as determined by soil extraction), use a seed treatment. Even where a seed treatment is used, damage can still occur under high pest pressure (1.25 million per hectare).

Other crops: None established.

Wireworm damage in onion

Non-chemical control

Consolidating seedbeds helps restrict movement of the pest and controlling grass weeds can reduce availability of food sources. Rolling a thin crop may also encourage tillering. In arable rotations, plough-based cultivation may help to reduce populations. A spring rotation in cereal crops can also be beneficial.

For potatoes, avoid wireworm-infested fields entirely and consider lifting the crop early if damage is expected.

The main natural enemies are fungi and parasitic wasps. Larval stages are attacked by ground beetles and adults are eaten by birds.

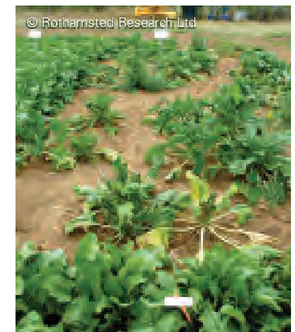
No commercial biological control agents are currently available for controlling wireworms, although some strains of the insect-pathogenic fungus *Metarhizium anisopliae* have shown encouraging results under experimental conditions.

The use of cruciferous plants as green cover crops or de-fatted mustard meals as soil amendments has been shown to reduce wireworm populations in Italy but the results have not yet been reproduced in the UK.

Insecticide resistance

None known.

Wireworm and damage to sugar beet seedling



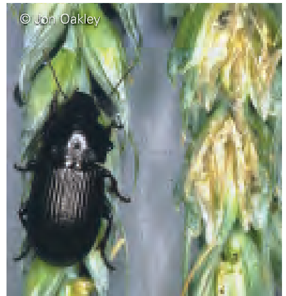
Wireworm damage in sugar beet

Wireworm damage in sugar beet (left: treated; right: untreated)

Cereal ground beetle (*Zabrus tenebrioides*)

	Crops affected
✔	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

The cereal ground beetle attacks crops in England, from Oxfordshire and Cambridgeshire southwards.



Cereal ground beetle

Larvae burrow into soil, pulling down and eating shoots from October to May. Adult beetles feed on cereal ears before harvest and on split grain and stubble re-growths.

Damage is worst in all-cereal rotations and with minimal cultivations. A non-cereal break crop or early ploughing will provide good control.

Cereal leaf beetle (*Oulema melanopa*)

	Crops affected
✔	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

The cereal leaf beetle is commonly seen in cereal crops, especially oats, across the country from mid-summer.

Cereal leaf beetle larva

Adults and larvae eat long thin strips from the leaves, occasionally leaving the lower epidermis intact.

They are very rarely of economic importance and predation usually keeps the population in check.

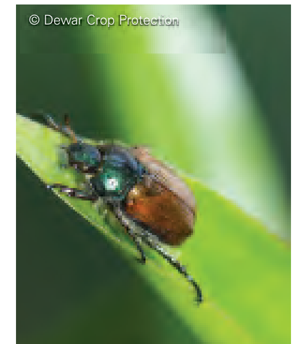
The larva has the unedifying habit of covering itself with its own excrement, and can easily attach itself to your trousers when walking through the crop.

Chafer grubs (*Melolontha melolontha*)

	Crops affected
	Cereals
	Oilseeds
	Vegetable brassicas
✔	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
✔	Sugar beet
	Lettuce

The most common species of chafer in the UK is the cockchafer or May bug, although garden chafers and Welsh chafers are also common. Adult beetles are large (2.5 cm long) with a reddish-brown body and black head. They fly in May to feed in woodlands and lay eggs in the soil in grassland or cereals during the summer. Larvae develop over the next three years and are most damaging in their second or third year. Attacks are localised and sporadic and control is not usually economically justified.

Chafer grub



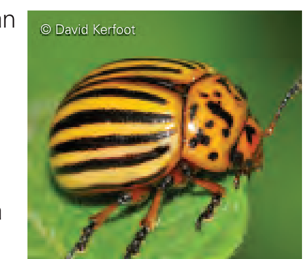
Adult garden chafer

Colorado beetle (*Leptinotarsa decemlineata*)

	Crops affected
	Cereals
	Oilseeds
	Vegetable brassicas
✔	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

The Colorado beetle is a serious pest of potatoes; however, it is not established in the UK and is **a notifiable quarantine pest.** It originated in North America but in 1922 it gained a foothold in France and has since spread to most European countries.

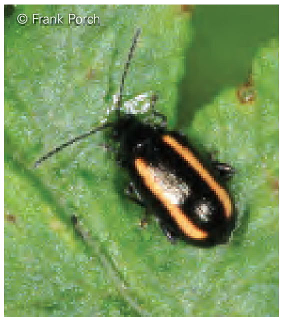
A single fertilised beetle can establish a breeding colony, so contact your local Defra Plant Health and Seeds Inspector if you find or suspect the presence of the beetle in a crop or import consignment.



Colorado beetle

Other flea beetles

	Crops affected
	Cereals
✔	Oilseeds
✔	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
✔	Sugar beet
	Lettuce



Striped flea beetle

Flea beetle damage to sugar beet

A number of flea beetles, including Wessex, striped and turnip flea beetles, cause occasional crop damage. *Phyllotreta* species can be very damaging pests of seedling crucifers, for example, swede and rocket.

The Wessex flea beetle is of increasing importance in southern England and is most likely to damage earlier-sown oilseed rape crops, especially if they are slow to grow away in September. Crops can be severely checked.

The striped and turnip flea beetles are principally pests of spring brassicas, of which later-sown crops are most susceptible; however, any crop may be at risk if growth is checked by sunny, dry weather.

Adult beet or mangold flea beetles can cause serious damage to the upper or lower surface of cotyledons, leaves and petioles of sugar beet. They overwinter in sheltered spots (field margins or hedges) and emerge in spring. Eggs are laid in late spring and larvae feed on roots before pupating but the damage is caused by adult feeding in the spring. They are most damaging when they are present in large numbers, in cold, dry, sunny weather, and when soil temperatures are low and plant growth is slow.

Linseed is also particularly susceptible to flea beetles.

All of these beetles are smaller than the cabbage stem flea beetle (page 21).

Pygmy beetle (*Atomaria linearis*)

	Crops affected
	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
✔	Sugar beet
	Lettuce

Pygmy beetle

A small, elongate beetle of 2 mm in length, the pygmy beetle can damage sugar beet seedlings. Damage after the six true leaf stage is rarely of economic significance.

Beetle bites on the root and hypocotyl cause small black pits, which may allow invasion by parasitic fungi. Severe damage can destroy the vascular tissue, causing the seedling to collapse. Cotyledons and leaves may also be eaten, leaving irregular-shaped holes.

The adults overwinter in the soil and survive on beet crowns left after harvest. In spring, they move to the soil surface and fly on warm, still days from May onwards to colonise new beet fields. In dry weather, the beetles move deep into the soil. In humid weather, they move to the soil surface and feed on the hypocotyl and leaves. Eggs are laid in late spring and summer and the larvae feed on roots of well grown plants, causing little damage.

Seedlings are most sensitive to damage from adults in fields where beet is grown in close rotation or where crops are infested early from adjacent fields with beet the previous year. Rotation is usually the most effective control.

Wheat shoot beetle (*Helophorus nubilus*)

	Crops affected
✔	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

Wheat shoot beetle

The wheat shoot beetle is an occasional pest of winter cereals following a grass rotation.

The larvae feed at the base of the shoot, causing the plant or central leaves to yellow and die.

Damage is usually seen from January to March but can be avoided by leaving a sufficient interval between ploughing grass and drilling the crop – a month should be sufficient under most conditions.

Further information

Alerts and bulletins

AHDB Horticulture Pest Bulletin: horticulture.ahdb.org.uk/latest-pest-bulletin
BruchidCast: www.syngenta.co.uk/bruchidcast
Pollen Beetle Predictor: cereals.ahdb.org.uk/pests

AHDB Horticulture Publications

Available at **horticulture.ahdb.org.uk**

Factsheet 35/12: Minor pests of Brassicas (2012)

Factsheet 25/11: Control of bruchid beetle on broad beans (2011)

Factsheet 22/10: Control of flea beetles and other key insect pests of leafy salad Brassica crops (2010)

AHDB Cereals & Oilseeds Publications

Available at **cereals.ahdb.org.uk/publications**

Information Sheet 55: Cabbage stem flea beetle (2016)

Information Sheet 18: Monitoring and control of pollen beetle in oilseed rape (2013)

Research Review 86: A review of pest management in cereals and oilseed rape in the UK (2016)

AHDB Cereals & Oilseeds neonicotinoid information: cereals.ahdb.org.uk/neonics

AHDB Potatoes Publications

Available at **potatoes.ahdb.org.uk/knowledge-hub**

Growers' advice – Wireworm factsheet (2011)

Information from other organisations

Fera Plant Pest Factsheet: Potato flea beetles (2011)

Fera Plant Pest Factsheet: Colorado beetle: Identification (2011)

Fera Plant Pest Factsheet: Colorado beetle (2006)

Pests:

Bugs and aphids

Contents – Pests: Bugs and aphids

Bugs (Hemiptera)

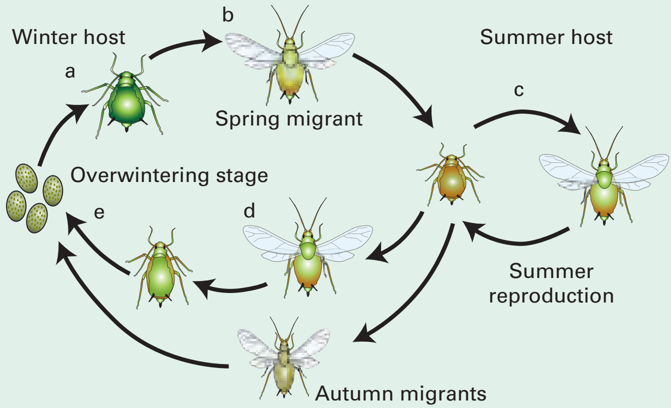
Bugs (Hemiptera) include true bugs (Heteroptera), aphids and white flies (Sternorrhyncha) and hoppers (Auchenorrhyncha). Many species are plant-feeding pests but there are also some natural enemy species (see page 181).

Life cycle

Bugs can have complicated life cycles and aphids are the best example of this. The life cycles of other bugs (for example, whiteflies and hoppers) retain the same basic features but are often simpler.

Most agronomically important aphid species have separate winter and summer hosts. In spring, when conditions are suitable, new individuals emerge and develop into fundatrices (a). These reproduce asexually and their offspring develop wings before migrating to summer hosts (b). Many more asexual generations are produced on the summer hosts (c).

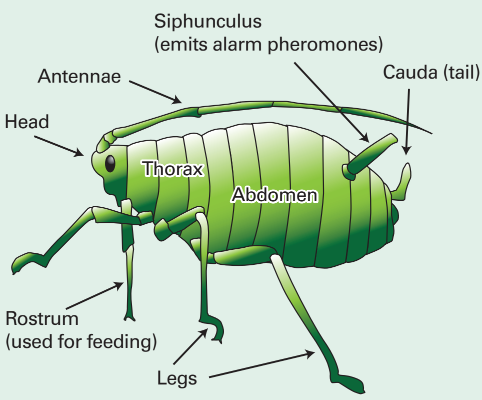
In the autumn, winged males and females are produced, which migrate back to the winter host (d). These then mate and overwinter, either as eggs (e) or active stages. Some aphid species are able to reproduce asexually all year.



Defining features

Bugs are characterised by their sucking mouthparts, comprising of a piercing, segmented rostrum and compact, often flattened bodies. The front pair of wings is usually leathery and the back pair is usually membranous.

Immature aphid and plant bug stages (nymphs) resemble smaller versions of the wingless adults, while whitefly nymphs resemble oval, flattened scales. Nymphs progress through a number of 'instar' stages before becoming adults.



Bird cherry–oat aphid (*Rhopalosiphum padi*)

Crops affected

- ✔ Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

Importance

The bird cherry–oat aphid is an important vector of barley yellow dwarf virus (BYDV), particularly in the south west of England, where many aphids remain in the asexual form. Even very small populations, which may go unnoticed, can cause economic damage by transmitting BYDV.

Rarely, direct feeding by this pest can also damage cereal crops. It can also infest sweetcorn.

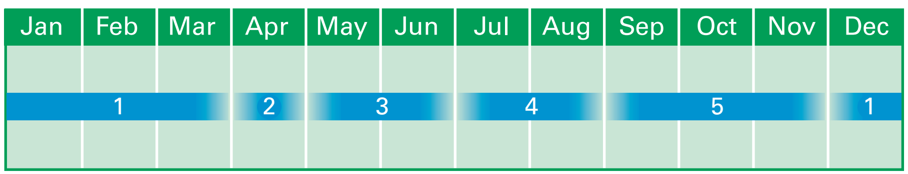
Risk factors

Winter crops: Crops sown early, particularly in a warm autumn, are most susceptible to bird cherry–oat aphid attack. These conditions allow aphids to breed rapidly. However, a crop should suffer little yield loss from new BYDV infection after GS31.

Spring crops: After mild winters, BYDV may be transmitted to late-sown crops by winged aphids.

All crops: BYDV is most damaging to plants infected in the early growth stages. The effects of BYDV may be exacerbated by other stress factors, including adverse weather conditions, soil acidity and other pests and diseases.

Life cycle



1. Eggs overwinter on bird cherry trees (*Prunus padus*).
2. Eggs hatch.
3. Winged forms migrate to cereals and grasses.
4. Multiple generations occur, infesting lower leaves and stems first.
5. Winged forms migrate back to bird cherry trees. In mild conditions, asexual forms can remain and feed in cereal crops.

The proportion of asexual forms of this species that overwinter as active stages on cereals and grasses varies with location. The proportion of sexual forms migrating in the autumn, seeking bird cherry trees, is higher the further north you go.

Bird cherry–oat aphid (*Rhopalosiphum padi*)

Identification and symptoms

The adult aphids are 1–2 mm long, broadly oval-shaped and green to dusky brown, with rust red patches at the rear. Winged adults are a similar size with a pale to dark green abdomen.

The initial symptoms of BYDV infection are normally seen as individual plants scattered through the crop with bright yellow upper leaves. Later, as infection spreads, larger areas of the crop become infected, appearing as patches of bright yellow and severely stunted plants.

Bird cherry–oat aphid

Barley yellow dwarf virus symptoms

Monitoring

Serious losses due to BYDV can be caused by very small numbers of bird cherry–oat aphids. AHDB Aphid News provides information on aphid migration and an indication of risk to crops.

Thresholds

No satisfactory thresholds for treatment exist. If aphids are present, it should be assumed that they are carrying BYDV.

Non-chemical control

Ground beetles, spiders and parasitoids are natural enemies that are active in autumn and winter, although the latter may only be so in mild winter weather. Minimum tillage, grass banks and field margins provide habitats for these natural enemies but can also harbour infective aphids. Beetle banks should be considered in large arable fields of 20 ha or more.

If high levels of aphid-infested grasses, especially annual meadow grass, are present in the stubble, a desiccant herbicide or ploughing may be beneficial to remove this green bridge. However, the risk of infestation by winged aphids in the autumn is lower following minimum tillage, and more so if the straw is left, compared to ploughing. Delaying sowing so that crops emerge after the end of the aphid migration (usually early November) will also reduce BYDV risk but this is not always practical.

If a spring barley crop follows a mild winter or is in a milder area, it may be worthwhile choosing a moderately resistant variety (see AHDB Recommended List).

Insecticide resistance

None known.

Crops affected	
	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
✔	Field beans
✔	Sugar beet
	Lettuce

Importance

The black bean aphid can cause significant damage to faba bean crops. Damage mainly occurs through the direct feeding of the pest, which can result in yield reductions if aphid populations grow large enough.

These aphids also transmit viruses, such as bean leaf roll virus (BLRV), pea enation mosaic virus (PEMV), bean yellow mosaic virus (BYMV) and beet yellows virus (BYV).

The production of honeydew during feeding encourages chocolate spot (caused by *Botrytis* spp.), which can reduce the yield of the crop.

On spinach and sugar beet, populations can develop rapidly on the undersides of leaves, which as a result become chlorotic and crinkled.

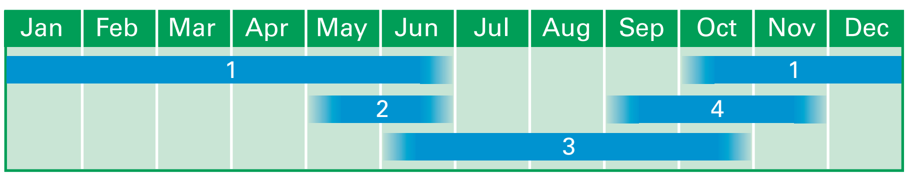
Risk factors

Late-sown spring crops are most at risk, as plants may be less well established and yet to flower.

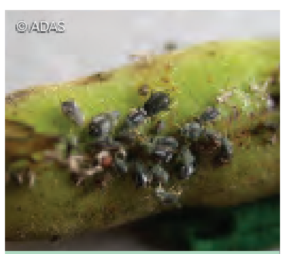
Control of early invading aphids is essential to prevent virus infection. Colonies can grow rapidly in the summer, especially if conditions are warm and humid.

There is a tendency for serious infestations to occur in alternate years, so severe attacks can be expected in a year following little or no infestation.

Life cycle



1. Eggs overwinter on spindle (*Euonymus europaeus*). In mild winters, active stages may overwinter on leguminous weeds or winter beans.
2. Winged forms appear and migrate into a wide range of summer crops.
3. Breeding continues throughout the summer, usually peaking in July/August. Further winged forms are produced in response to crowding, spreading within the crop and to other crops.
4. Winged forms migrate back to spindle to lay eggs.



Black bean aphids

Black bean aphid (*Aphis fabae*)

Identification and symptoms

The wingless adults are 1.5–3 mm long, black or olive green and often have distinct waxy stripes on the upper surface of the abdomen. Winged adults are very dark with faint black crossbars on the upper surface of the abdomen. Colonies are often noticeably attended by ants. A colony can become very large and dense, numbering in the hundreds, and develops from the top of the plant downwards onto the leaves and developing pods as it grows.

Direct feeding can damage flowers, retard or even prevent pod development and cause plants to lose vigour and wilt in dry conditions.

BLRV causes leaf yellowing, upward leaf-rolling and a decrease in pod numbers. Symptoms are often more obvious if the aphid invades the crop before flowering.

PEMV in beans causes vein clearing and the formation of translucent spots, which are apparent when infected leaves are held up to the light. Upper leaves become pointed and crinkled and may contain necrotic spots. Symptoms of an advanced infection are the cessation of terminal growth, the disappearance of axillary buds and impairment of flower set.

Following BYMV infections, leaves become crinkled and occasionally pointed, the plant becomes stunted and vein clearing may occur. Symptoms can be mistaken for PEMV but without the translucent spotting and streaking on the leaf surface.

Direct feeding damage on sugar beet can occur but is rarely worth controlling.

Monitoring

Inspect the crop regularly from early flowering until pod formation. Colonies tend to appear on the headlands first. This aphid is included in the AHDB Horticulture Pest Bulletin.

Thresholds

In beans, immediate treatment is justified when 10% of plants are infested. Treating the crop when 5% of plants are infested can help prevent virus infection.

In sugar beet, treatment is only justified on backward or stressed crops with more than 100 aphids per plant (averaged across the field and not just on headlands).

Non-chemical control

Natural enemies include parasitic wasps, ladybirds, hoverflies, lacewings and insect-pathogenic fungi. Providing habitats that encourage the presence of these may help control aphid numbers. They may not be effective in preventing virus transmission, as this can occur even at low aphid densities.

Insecticide resistance

None known.

Crops affected

- Cereals
- Oilseeds
- Vegetable brassicas
- ✔ Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

Importance

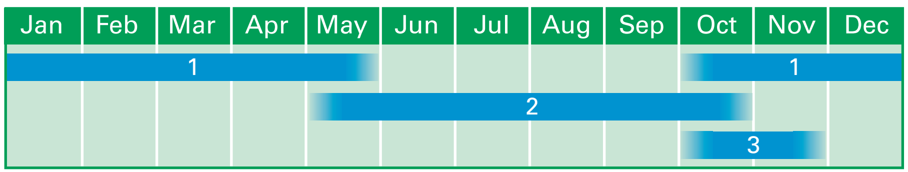
Buckthorn–potato aphid is a relatively minor pest of potato. Populations rarely grow large enough to cause economic damage through direct feeding.

This aphid can, however, transmit non-persistent viruses, such as potato virus Y (PVY) and potato virus A (PVA). It is thought to be a poor vector of the persistent virus, potato leaf roll virus (PLRV).

Risk factors

Control measures are usually unwarranted but populations can vary widely from year to year and warm conditions in late spring/early summer can promote large populations of the pest. Most direct damage is caused during tuber bulking in late July and August.

Life cycle



1. Eggs overwinter on buckthorn.
2. Winged adults move into crops in May/June and reproduce throughout the summer.
3. Winged adults migrate to buckthorn to lay eggs.

Buckthorn–potato aphids

Buckthorn–potato aphid (*Aphis nasturtii*)

Identification and symptoms

The wingless adult is relatively small (1–2 mm) and bright yellow-green.

Very heavy infestations can seriously damage the haulm and reduce yields.

PVY infections caused by aphids result in leaf drop streak, where lower leaves develop black streaks on their underside veins and eventually collapse, hanging off the stem by a thread. Younger leaves may develop necrotic spotting.

PVA infections usually cause mild mosaic symptoms.

Monitoring

Buckthorn–potato aphids are rarely caught in suction traps, so winged migration data is not available.

Thresholds

None established. Control measures are usually unwarranted.

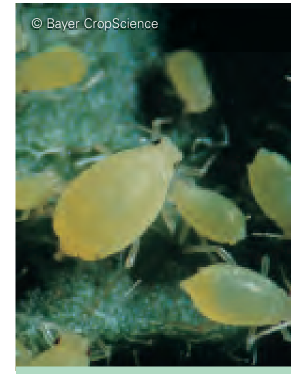
Non-chemical control

Natural enemies include parasitic wasps, ladybirds, hoverflies, lacewings and insect-pathogenic fungi. Providing habitats that encourage the presence of these may help control aphid numbers. They may not be effective in preventing virus transmission, as this can occur even at low aphid densities.

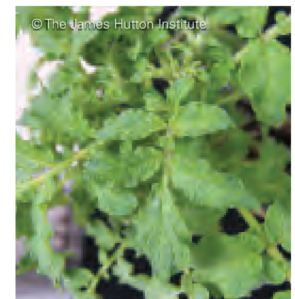
Using seed potato certified by the British Seed Potato Classification Scheme reduces the virus risk and its subsequent spread by aphids. Potato varieties differ in their susceptibility to aphid infestation and virus infection. Seek expert advice on which variety to choose if the crop is in a high-risk area.

Insecticide resistance

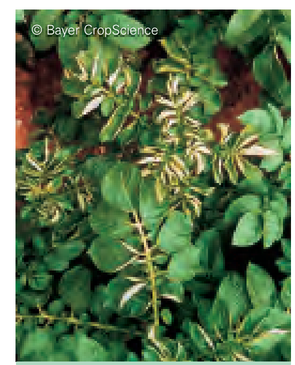
None known.



Buckthorn–potato aphids



Potato virus Y leaf symptoms



Buckthorn–potato aphid damage

Crops affected	
	Cereals
	Oilseeds
✔	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

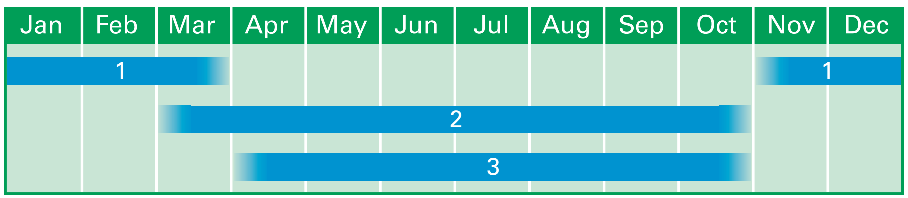
Importance

Cabbage whitefly is a major problem because the immature stages (scales) and waste products (mainly honeydew, which can lead to the development of mould) contaminate plants and reduce quality. The presence of adults and scales can cause contamination issues in produce that is packed.

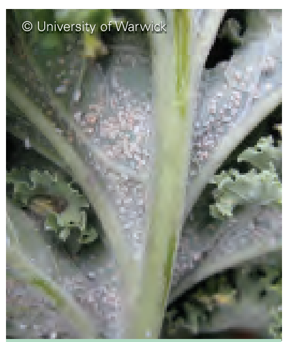
Risk factors

The cabbage whitefly has become an increasing problem in recent years. The reason for this is unknown but it is believed to be due to a combination of climate change, removal of certain active ingredients from use, insecticide resistance and later harvest times of crops. Kale and Brussels sprout appear to be 'preferred' hosts and suffer the most damage in terms of a reduction in plant quality.

Life cycle



1. Whiteflies overwinter mainly as adult females in sheltered locations.
2. Adults may migrate in substantial numbers when temperatures are above 8°C. As temperatures rise, females will begin to lay eggs on leaves.
3. For a short time after the egg hatches, the larva has limited mobility but cannot leave the leaf on which the egg was laid. Once the larva finds a suitable location for feeding, it spends the rest of its development attached to the leaf. After three moults, the larva develops into a pupa from which a new adult will emerge.



Cabbage whiteflies

Cabbage whiteflies are capable of multiple generations per year in the UK (two to five). The rate of development and the start of reproduction are determined by ambient temperature, so climate and weather conditions will dictate the maximum number of generations and the size of the population.

Identification and symptoms

The adults are small, white moth-like insects about 1.5 mm long with two pairs of black spots on the forewings. The eggs are pale, elongated cylinders less than 0.1 mm, laid in full or partial circles. The larvae are flat oval semi-transparent scales from 0.3–1 mm. The pupae are off-white to brown flattened scales, with eyes visible in the later stages.

All life stages are likely to be accompanied by circular deposits of pale wax, which can be used as a sign of adult presence, even when no insects are observed.

Monitoring

Adult whiteflies can be captured on blue or yellow sticky traps. However, within-crop monitoring is probably the most effective approach.

Thresholds

None established.

Non-chemical control

Natural suppression by whitefly predators is unlikely to provide substantial control in most crops. Specialist whitefly natural enemies include parasitoid wasps (*Encarsia inaron, Encarsia tricolor, Euderomphale chelidonii*), a ladybird (*Clitostethus arcuatus*) and a fly (*Acletoxenus formosus*). Generalist predators of aphids will also feed on whiteflies in the absence of their primary prey.

There may be some potential for inundative releases of parasitoids to provide control in crops. The potential for using biopesticides (eg fungal pathogens) to reduce whitefly populations has yet to be explored.

Crop covers have been shown to reduce whitefly infestations by up to 71% when applied season-long in trials on Brussels sprout in Germany (for organic production). Fine mesh netting (0.8 x 0.8 mm) reduced or delayed immigration, even with periodic cover removal for weeding. When combined with better knowledge of pest ecology and forecasting, there is potential to disrupt pest infestations through targeted short-term covering after planting out.

Studies have provided evidence of host plant resistance to whitefly in some brassicas; however, commercial kale and Brussels sprout varieties with specific resistance to cabbage whitefly are not available currently.

Insecticide resistance

Resistance to the pyrethroid, deltamethrin, was found in whitefly samples taken from crops in southern and central England in 2009–2011. Such resistance was shown to impair control in field trials. Whiteflies globally have been shown to rapidly develop resistance to a range of insecticides and effective products should be carefully managed to prevent this.

Currant–lettuce aphid (*Nasonovia ribisnigri*)

Crops affected
Cereals
Oilseeds
Vegetable brassicas
Potatoes
Carrots
Alliums
Peas
Field beans
Sugar beet
✔ Lettuce

Importance

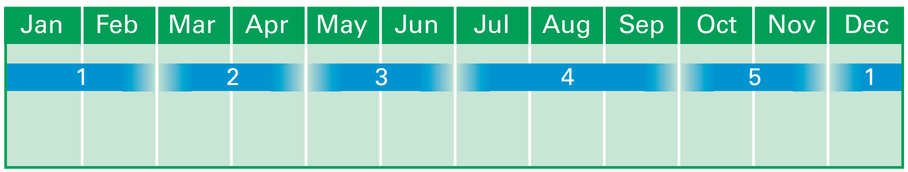
The currant–lettuce aphid is the most important foliage aphid on lettuce. Rapid development of colonies causes plants to become stunted and even small numbers can contaminate plants and affect marketability. In some cases, large populations on young plants may prevent 'hearting'.

This species does not usually transmit lettuce mosaic virus.

Risk factors

These aphids prefer to feed in the centre of the plant and can be extremely difficult to control once the lettuce plant has hearted.

Life cycle



1. The aphid usually overwinters as an egg on currant or gooseberry bushes.
2. Eggs hatch in March/April and the nymphs infest the tops of the young shoots.
3. Colonies are formed on the developing leaves and, in May/June, winged aphids migrate to lettuce and wild hosts.
4. Several generations are produced on the summer hosts.
5. During October/November, winged aphids migrate back to the winter hosts, where eggs are laid. In warm locations, the mobile stages can survive and slowly reproduce on wild hosts throughout the winter.

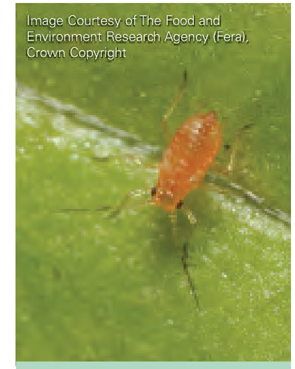
Currant–lettuce aphids on lettuce

Currant–lettuce aphid (*Nasonovia ribisnigri*)

Identification and symptoms

Adult wingless currant–lettuce aphids are 1–3 mm long, green to yellowish-green and sometimes reddish. They have a shiny abdomen with a dark green-black pattern on the upper surface. There are two long tubes (siphunculi) at the rear end, with pale bases and dark tips. The tail is pale, finger-shaped and about two-thirds the length of the siphunculi.

The winged form has black siphunculi and antennae, and a clear black pattern on the abdomen.



Currant–lettuce aphid nymph

Monitoring

A day-degree forecast for currant–lettuce aphid is available as part of the AHDB Horticulture Pest Bulletin.

Thresholds

None established.

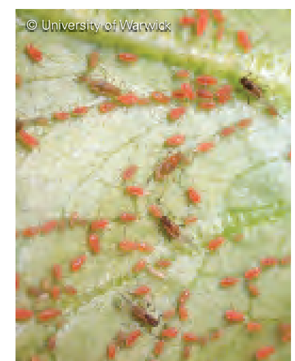
Winged currant–lettuce aphid

Non-chemical control

The mobile forms are attacked by a number of natural enemies, including ladybirds, hoverflies and lacewings. Young aphids may be parasitised by certain species of wasp, whose larvae eventually kill the aphid, which forms a hard gold-coloured 'shell' known as a 'mummy'.

To date, biological control with natural enemies has not been evaluated comprehensively in the UK but the efficacy of several biopesticides is being evaluated.

A range of cultivars of lettuce with complete resistance to currant–lettuce aphid have been available for a number of years. However, in recent years certain populations of currant–lettuce aphid have overcome this form of resistance.



Currant–lettuce aphids on lettuce

Insecticide resistance

Resistance to pirimicarb and pyrethroid insecticides was detected in certain UK field populations some years ago; however, the resistance does not appear to have had a major impact on levels of control in the field.

Grain aphid (*Sitobion avenae*)

Crops affected

- ✔ Cereals
- Oilseeds
- Vegetable brassicas
- ✔ Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

Grain aphids

Grain aphid

Importance

Grain aphid is important as the main vector of barley yellow dwarf virus (BYDV) in the east, middle and north of the UK, with losses up to 2.5 t/ha. Even very small populations, which may go unnoticed, can cause economic damage by transmitting BYDV.

Grain aphid is an efficient vector of potato virus Y. Migration during late June and early July poses the greatest risk of a high incidence of viruses within crops. They can occur in potato crops in extremely high numbers in summer, when they migrate from desiccating cereal crops into potato fields in search of food.

The aphid also causes direct injury through feeding.

Risk factors

BYDV: Risk of BYDV spread is significantly greater in mild winters through exposure to winged aphids migrating later into the season. Migrations can continue into November and infect later-sown crops. After mild winters, spring crops may be vulnerable to BYDV transmitted by winged aphids.

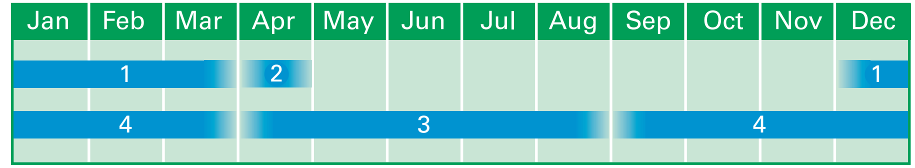
BYDV is most damaging to plants infected in the early growth stages.

Direct feeding damage (summer): All cereals are at risk of direct feeding damage, although winter barley is less affected due to its earlier senescence. This species may also infest sweetcorn. Drought-affected crops or those damaged by other pests and diseases suffer greater impacts, due to lower reserves of soluble stem carbohydrates.

Increased risk is also associated with dry, settled weather during early grain filling. Outbreaks tend to occur after colder winters, which reduce natural enemy populations more than populations of these cold-hardy aphids.

Grain aphid (*Sitobion avenae*)

Life cycle



1. **Adults can overwinter on crops and grasses, they do not have an alternate woody winter host.**
2. **Fresh migrations infest crops from April. During dry, settled weather numbers can increase rapidly. Crop senescence, rainfall and natural enemies all act to limit population growth.**
3. **Direct feeding is a risk from April until August.**
4. **BYDV is a risk from September until around March (pre-GS31).**

In autumn, most aphids probably come from grasses, especially perennial rye-grass. The virus may also be vectored from other cereal crops and volunteers.

Some grain aphids have a sexual life cycle. Eggs are laid in the autumn on grasses and cereals; these survive through the winter, hatching in spring.

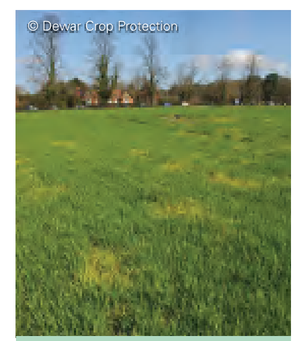
Grain aphids on ear

Identification and symptoms

The grain aphid is large, long-legged and yellowish-green, green or reddish-brown to nearly black.

BYDV: The initial symptoms of BYDV infection are normally seen as individual plants scattered through the crop with bright yellow upper leaves. Later, as infection spreads, larger areas of the crop become infected appearing as patches of bright yellow and severely stunted plants.

Direct feeding damage (summer): Only very severe infestations produce visible symptoms in crops. Infested leaves turn yellow and senesce prematurely. Indirect damage is caused by the secretion of honeydew during feeding, which provides a medium for sooty moulds and a sugar source for flies, including pest species.



BYDV symptoms

Grain aphids

Grain aphids

Monitoring

BYDV: AHDB Aphid News provides information on aphid migration and an indication of risk to crops from BYDV and direct feeding.

Direct feeding damage (summer): To monitor for direct feeding damage, check for aphids on the leaves initially at about the time the cereals are coming into ear. Individuals move up to the ears during grain filling and feed from the phloem supply to the grain.

Thresholds

BYDV: Serious losses due to BYDV can be caused by very few grain aphids

Direct feeding damage (summer):
Before GS61: Half of tillers infested

GS61 to two weeks before end of grain filling: Two-thirds of tillers infested from stem extension to flag-leaf emergence or if more than 66% of tillers are infested and numbers are increasing for the period from flowering to watery ripe.

Non-chemical control

If a spring barley crop follows a mild winter or is in a milder area, it may be worthwhile choosing a moderately resistant variety (see AHDB Recommended List).

Autumn/winter: Ground beetles, spiders and parasitoids are natural enemies that are active in autumn and winter, although the latter may only be so in mild winter weather. Spiders, especially web-building money spiders, are likely to be the most effective because they capture immigrating aphids and prevent their spread, are present in high numbers in the autumn and their webs continue to catch aphids after being abandoned. These spiders need some structures between which to build their webs and so can be more abundant on cloddy seeds beds or those with trash present. They are highly vulnerable to pyrethroid insecticides.

If high levels of aphid-infested grasses, especially annual meadow grass, are present in the stubble, a desiccant herbicide or ploughing may be beneficial to remove this green bridge. However, the risk of infestation by winged aphids in the autumn is lower following minimum tillage, and more so if the straw is left, compared to ploughing. Delaying sowing so that crops emerge after the end of the aphid migration (usually early November) will also reduce BYDV risk but this is not always practical.

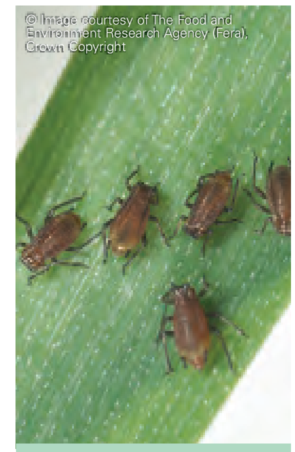
Spring/summer: Early in the aphid population growth phase, the generalist predators (spiders and beetles) provide background control, helping to prevent aphids from reaching economically damaging levels. Once aphid numbers build up, aphid-specific predators, such as hoverflies, ladybirds and lacewings, and parasitic wasps become more important.

Overall levels of natural enemies can be encouraged using minimum tillage that allows field-overwintering species to survive and provides structure for spiders. Grass banks and field margins provide overwintering habitats, alternative foraging sites and refuges in summer. While grasses can harbour infective aphids, they also help maintain populations of parasitic wasps, facilitating faster colonisation in spring. Beetle banks should be considered in large arable fields of 20 ha or more. Flower-rich habitats provide essential nectar resources for hoverflies and parasitic wasps, while also supporting alternative insect prey for many other natural enemies.

Insecticide resistance

Cases of knockdown resistance (kdr) to pyrethroids may impact on product performance, particularly when sprays are applied at reduced field rates. It is important that full recommended pyrethroid field rates are used. If control remains poor, a pyrethroid-based product should not be used again and growers should switch to an insecticide with an alternative mode of action.

Grain aphids



Grain aphids

Crops affected	
	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
✔	Lettuce

Importance

Infestations of the lettuce root aphid can reduce yield and marketability. Severe infestations can also lead to significant crop losses.

Risk factors

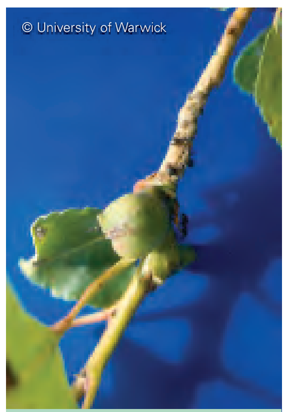
Symptoms are more severe in dry seasons because the aphids damage roots and reduce water uptake.

Life cycle

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		2			3		5			1	
					4						

(Bars: 1 runs Jan–Feb; 2 runs Mar–May; 3 runs Jun–Jul; 5 runs Aug–Oct; 1 runs Nov–Dec; 4 runs Jun–Aug.)

1. The aphid overwinters as an egg on Lombardy and black poplar trees.
2. Eggs hatch into nymphs, which feed on developing petioles, which enlarge to form galls within which the nymphs live and mature to produce a further generation of aphids.
3. Winged aphids appear over a 4–5 week period in late June/July and migrate to lettuce and wild hosts.
4. They produce live young as soon as they arrive on the lettuce plants and the wingless progeny migrate to the roots, where numbers increase through the production of several wingless generations.
5. Winged aphids are formed and fly to poplar trees.



Lettuce root aphid gall on poplar

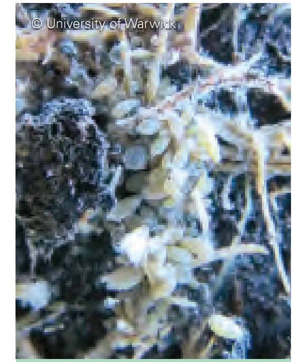
Lettuce root aphid (*Pemphigus bursarius*)

Identification and symptoms

Adult winged lettuce root aphids are 2 mm long and have a dark head bearing short antennae. The thorax is dark brown or black and the abdomen is brownish-orange with a slight powdering of wax.

Adult wingless lettuce root aphids have a yellow head with green-grey antennae that are much shorter than the body. The body is yellowish-white and often covered in large quantities of white-grey wax. There are no siphunculi.

The presence of lettuce root aphids is not apparent until plants start to wilt. Large infestations cause plants to wilt, dry up and turn yellow.



Lettuce root aphids

Monitoring

A day-degree forecast for lettuce root aphid is available as part of the AHDB Horticulture Pest Bulletin.

Thresholds

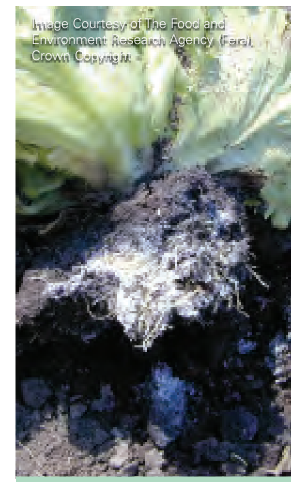
None established.

Non-chemical control

The effects of lettuce root aphid attacks are worse when plants are under water stress. Irrigation can be very beneficial for crops showing signs of damage.

It is recommended that Lombardy poplars should not be planted as windbreaks close to areas of lettuce cultivation.

Natural enemies, including ladybirds and hoverflies, attack the aphids in galls on poplar and also aphid colonies feeding on lettuce roots.



Lettuce root aphid damage

No attempts have been made to release biological control agents or to control lettuce root aphids with biopesticides.

Cultivars of lettuce with almost complete resistance to lettuce root aphid (Avoncrisp and Avondefiance) were developed in the UK but the material has not been used to develop more modern cultivars.

Insecticide resistance

None known.

Mealy cabbage aphid/Cabbage aphid (*Brevicoryne brassicae*)

Crops affected	
	Cereals
✔	Oilseeds
✔	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

Importance

The mealy cabbage aphid is a serious pest of vegetable brassicas, where infestation leads to distorted foliage and contamination of produce by aphids, wax, cast skins and honeydew. Severe infestations reduce yield and may even kill young plants. In vegetable brassicas, it is also an important vector of several viruses, including turnip mosaic virus (TuMV) and cauliflower mosaic virus (CaMV).

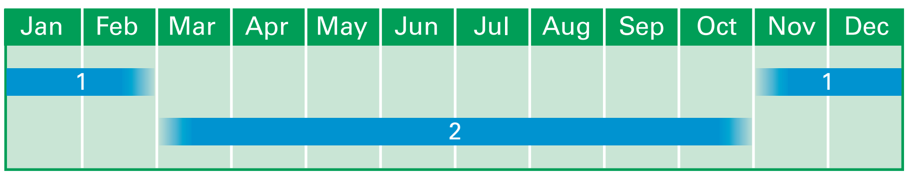
Mealy cabbage aphid is not usually a serious pest of oilseed rape.

Risk factors

Mild winters can allow infestations on winter oilseed rape to increase to damaging levels. Spring oilseed rape can become severely infested after mild winters.

Hot, dry summers can cause large populations to develop.

Life cycle



1. While this species can overwinter as eggs on brassica crops and wild hosts, it is thought that most overwinter as active stages on brassica crops and wild hosts.
2. The production of winged forms allows this species to move to new brassica crops, multiplying rapidly in hot, dry conditions.

Mealy cabbage aphids

Mealy cabbage aphid/Cabbage aphid (*Brevicoryne brassicae*)

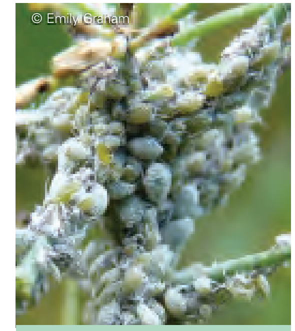
Identification and symptoms

Wingless aphids are bluish-grey, up to 2.6 mm long, with short transverse dark bars on the upper side of the thorax and abdomen, which is often covered in a thick layer of wax.

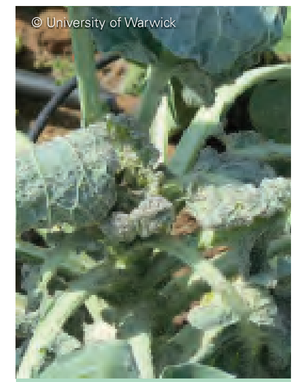
The first symptoms in vegetable brassicas are small bleached areas on the leaves. The leaves then turn yellowish and become crumpled. Young plants can be stunted and may die in unfavourable weather.

Early infestations in oilseed rape are found under leaves but later infestations move to developing flowers and pods, where they can produce dense colonies. Autumn feeding often causes leaf distortions, twisting of the mid-rib and chlorotic patches. The crop usually recovers in the spring. In spring oilseed rape, serious infestations can cause pod distortions and yield loss.

On all crops, TuMV and CaMV cause leaf mottling and vein clearing, stunting, and black mottling and streaking on stems.



Mealy cabbage aphids on oilseed rape



Mealy cabbage aphids on vegetable brassica crop

Monitoring

AHDB Aphid News and the AHDB Horticulture Pest Bulletin provide information on aphid migration.

Thresholds

Winter oilseed rape: >13% of plants infested before petal fall

Spring oilseed rape: >4% of plants infested before petal fall

Vegetable brassicas: None established

Non-chemical control

Natural enemies include parasitic wasps (eg *Diaeretiella rapae*), ladybirds, hoverflies, lacewings, a range of predatory flies, spiders, and insect-pathogenic fungi. Providing habitats that encourage the presence of these may help control aphid numbers. They may not be effective in preventing virus transmission, as this can occur even at low aphid densities.

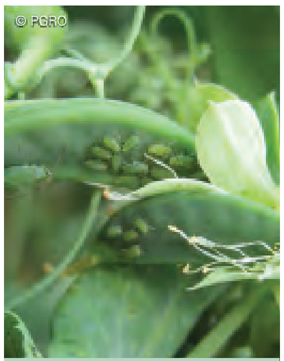
Biopesticides are being evaluated for control of this pest.

Insecticide resistance

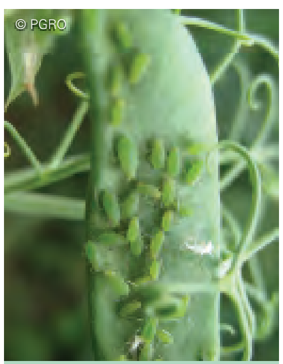
None known.

Crops affected

- Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- ✔ Peas
- ✔ Field beans
- Sugar beet
- Lettuce



Pea aphids



Pea aphids on a bean

Importance

Pea aphid is a major pest of peas and beans. Attacks by the pest can result in reduced yields by spoiling flowers, causing pod filling to fail and by generally reducing plant efficiency.

The pea aphid also transmits a number of viruses, including pea seed-borne mosaic virus (PSbMV), pea enation mosaic virus (PEMV) and bean leaf roll virus (BLRV). PSbMV affects quality in vining peas and the maintenance of disease-free seed stocks. PEMV can cause large yield reductions in severe cases.

Additionally, the honeydew produced by the pest can provide an ideal medium for the growth of saprophytic fungi. It is very sticky and may increase the cost of cleaning vining machinery.

Risk factors

Combining peas are particularly vulnerable to pea aphid damage up until the development of the fourth pod-bearing node but if infestation occurs after this point no appreciable reduction in yield will occur.

The presence of overwintering crops, such as clover and lucerne, in neighbouring fields can increase the risk of aphids migrating into the crop in May.

The most likely manner for PSbMV to become established is after the use of infected seed. The virus is transmitted by aphids in early spring.

Crops are most at risk from PEMV if it is transmitted before flowering occurs.

Life cycle

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2	2	3					6	1	1	1
				4	5	5					

1. Eggs overwinter on forage crops. Active stages may overwinter in mild years.
2. Eggs hatch.
3. Wingless generations reproduce on overwintering plants.
4. Winged forms migrate to pea and legume crops.
5. Aphids feed and reproduce rapidly on peas and legumes, with highest numbers usually seen between late June and early July.
6. Winged forms migrate to overwintering sites.

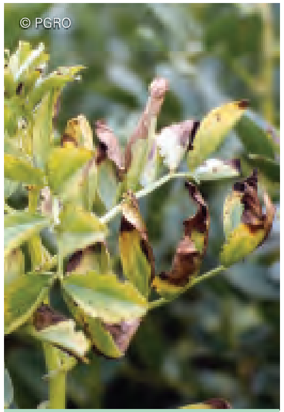
Eggs are only laid at the beginning of winter on forage crops, such as lucerne, trefoils and clover, where they remain until hatching in the spring. During the summer, pea aphids produce live young asexually, allowing populations to grow rapidly.

Pea seed-borne mosaic virus symptoms

Pea aphids

Pea aphids

Pea enation mosaic virus (PEMV) symptoms



Bean leaf roll virus (BLRV) symptoms

Identification and symptoms

The pea aphid is green with a pear-shaped body, long antennae and long legs. The winged females are 2.5–3 mm long and have deep red or black eyes and yellowish-green antennae, while wingless females are similar but with a smooth, shiny skin.

PSbMV causes vein-clearing, narrowing and downward rolling of leaflets and foreshortening of the apical internodes. Pods on the upper parts of the plants may become stunted and develop a glossy green appearance. A white blistering may also develop over the seed coats as the peas mature in the pod, giving the peas a 'tennis-ball' marking.

PEMV causes vein clearing and the formation of translucent spots, which are apparent when infected leaves are held up to the light. Development of stipules (the leaf-like structures at the base of leaves) is often retarded and they can remain narrow, while leaflets become crinkled and may contain necrotic spots.

The tops of the plants often become yellow and mottled with distorted leaves and pods may be severely malformed and fail to fill. At an advanced stage of infection, enations may appear. These are small, irregular, protruding ridges of plant tissue found on pods and the underside of leaves.

Further symptoms of an advanced infection are the cessation of terminal growth, the disappearance of axillary buds and impairment of flower set.

BLRV causes leaf yellowing, upward leaf-rolling and a decrease in the number of pods in field beans.

Monitoring

Check the crop for the pest from May to July. If there is a light or general distribution and humid weather, or if breeding colonies are evident, control measures are generally warranted.

AHDB Aphid News provides information on aphid migration.

Thresholds

Combining peas: 20% or more of plants infested at early flowering.

Vining peas: 15% or more of plants infested.

Field beans: None established.

It should be noted that virus transmission can occur even with low aphid numbers. It is recommended that, if crops are in high-risk areas for viruses, aphids should be controlled as soon as colonies appear, particularly if this occurs before flowering.

There is no need to treat combining peas if they have been infested after the development of the fourth pod-bearing node.

Non-chemical control

Avoid growing peas or beans in fields with nearby concentrations of clover or lucerne.

Predators, such as ladybirds and hoverfly larvae, may help control pest populations but the presence of hoverfly larvae can contaminate vining peas. Other natural enemies include spiders, fungal pathogens and parasitoids.

Virus transmission risk can be minimised by ensuring that seed stock is free of PSbMV.

Insecticide resistance

None known.

Crops affected	
	Cereals
✔	Oilseeds
✔	Vegetable brassicas
✔	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
✔	Sugar beet
✔	Lettuce

Peach–potato aphids

Peach–potato aphids

Importance

The peach–potato aphid is an important pest of potatoes, oilseed rape, vegetable brassicas, sugar beet and lettuce. Transmission of viruses can cause serious economic damage but only heavy infestations cause direct feeding damage.

This aphid is the most important vector of turnip yellows virus (TuYV), potato leaf roll virus (PLRV), potato virus A (PVA) and potato virus Y (PVY). It also transmits cauliflower mosaic virus (CaMV), beet yellows virus (BYV), beet chlorosis virus (BChV) and beet mild yellowing virus (BMYV). The average yield loss from TuYV in oilseed rape is 15% but it can be as high as 30%.

Risk factors

In potato and vegetable crops, infestations can be more severe if overwintered brassica crops (or other overwintering hosts) are in neighbouring fields. Sugar beet and oilseed rape can be a source of infestation for vegetable brassicas and lettuce.

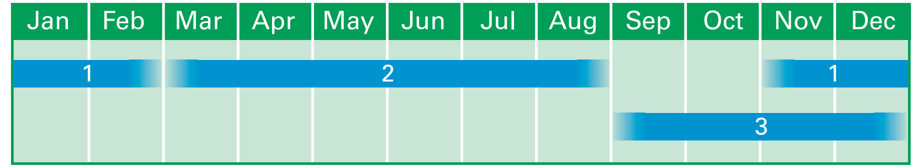
Greater numbers of overwintering adults will survive if winter conditions have been mild. This is likely to lead to a larger and earlier spring migration and a greater level of virus spread in early sown crops.

In years with a smaller spring migration and larger summer migration, late-sown crops are at higher risk from virus transmission. The spring migration is often reduced in northern parts of the UK, due to cooler winters.

In oilseed rape, early sown winter crops tend to be at greatest risk during warm autumns, while later-sown spring crops tend to be at greater risk after mild winters.

A close relationship has been found between temperatures in winter and early spring and the incidence of virus yellows in sugar beet at the end of August in the absence of seed treatment.

Life cycle



1. Asexual females overwinter in brassica and herbaceous crops and weeds. A small proportion of eggs overwinter on peach and nectarine trees. Cold weather reduces survival of mobile stages.
2. Adults migrate to, and infest, a range of summer crops, including potato. They can multiply extremely quickly, with populations usually peaking in early to mid-July. A further, smaller, peak occasionally occurs in late August/September.
3. In mild autumns, adults infest oilseed and vegetable brassicas, transferring viruses.

Identification and symptoms

The wingless peach–potato aphid is medium-sized and pale green to pink or almost black. The winged form is a similar size but has a black central abdominal patch on the upper surface with a pale underside.

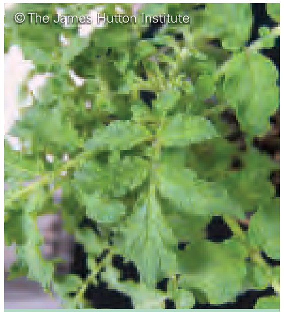
In oilseed rape, TuYV infection doesn't usually show until late spring/early summer, appearing as purple tingeing of leaf edges and pods, easily mistaken for frost damage, nutrient deficiency or other stresses.

In vegetable brassicas and lettuce, the peach–potato aphid is a contaminant, can transmit viruses and, in cases of severe infestation, may cause severe distortion of the plant.

In sugar beet, beet yellowing virus symptoms are characterised by diffuse chlorotic patches on mature leaves, which expand and coalesce. Leaves may be subject to infection by secondary pathogens, such as alternaria. Leaves also become thickened and brittle, snapping crisply when broken.

Different colours of peach–potato aphid

Turnip yellows virus symptoms



Potato virus Y leaf symptoms

In potato, PVY infections caused by aphids result in leaf drop streak, where lower leaves develop black streaks on their underside veins and eventually collapse, hanging off the stem by a thread. Younger leaves may develop necrotic spotting.

Aphid-vectored PLRV infections result in the margins of young leaflets rolling upwards and inwards, a pattern more pronounced at the leaflet base. Infected leaves may also develop a purple discolouration.

Symptoms of secondary (tuber-borne) infections of these viruses may differ from the primary infections described above.

PVA infections usually cause mild mosaic symptoms.

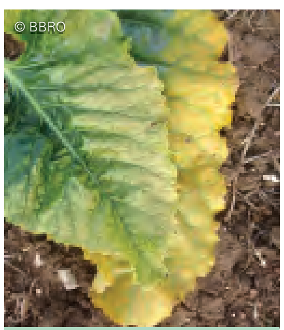
Potato leaf roll virus symptoms

Monitoring

AHDB Aphid News provides information on aphid migration.

There is a tool on the AHDB Potatoes website (**potato.ahdb.org.uk/online-toolbox**) where you can be alerted when the first peach–potato aphid is found in a chosen region and when numbers exceed a given threshold.

BBRO maintains a network of yellow water pans in the sugar beet growing areas and records the number of peach–potato aphids found weekly.



Symptoms of beet yellowing virus (top leaf) and beet mild yellowing virus (bottom leaf)

Thresholds

For sugar beet, apply a foliar insecticide when one green wingless aphid per four plants is found. This increases to one green wingless aphid per plant once at the 12 leaf stage.

Potato virus Y symptoms

No satisfactory thresholds exist for other crops. If aphids are present, they should be assumed to be carrying virus.

Non-chemical control

Natural enemies include parasitic wasps, ladybirds, predatory flies, spiders, ground beetles, rove beetles, lacewings and insect-pathogenic fungi. Providing habitats that encourage the presence of these may help control aphid numbers. They may not be effective in preventing virus transmission, as this can occur even at low aphid densities.

Using seed potato certified by the British Seed Potato Classification Scheme reduces the virus risk and its subsequent spread by aphids. Potato varieties differ in their susceptibility to aphid infestation and virus infection. Seek expert advice on which variety to choose if the crop is in a high-risk area.

Early sowing of sugar beet can mean it is less likely to be affected, as older leaves are less palatable to the aphids.

Insecticide resistance

There are three different mechanisms of insecticide resistance in peach–potato aphid in the UK. Neonicotinoid resistance has been discovered in southern mainland Europe but has not yet been detected in the UK.

Chemical group	Actives	Resistance
Organophosphates	Chlorpyrifos Dimethoate *(withdrawn from use)*	Mechanism: elevated carboxylesterase. Resistance has fallen substantially following a decline in the use of organophosphates against aphids.
Carbamates	Pirimicarb *(withdrawn from use except on peas and beans on which* M. persicae *is not a pest)*	Mechanism: modified acetylcholinesterase (MACE). Resistance is common and widespread, with more than 80% of peach–potato aphids now resistant.
Pyrethroids	Beta-cyfluthrin Lambda-cyhalothrin Alpha-cypermethrin Cypermethrin Zeta-cypermethrin Deltamethrin Esfenvalerate Tau-fluvalinate	Mechanism: knockdown resistance (kdr). Two forms exist: kdr and a more potent variant termed super-kdr. kdr resistance is currently rare; however, super-kdr resistance is common and widespread. The majority of peach–potato aphids in the UK at present carry both super-kdr resistance to pyrethroids and MACE resistance to pirimicarb.

Crops affected

- Cereals
- Oilseeds
- ✔ Vegetable brassicas
- ✔ Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- ✔ Sugar beet
- ✔ Lettuce

Importance

The potato aphid is widespread most years and rarely occurs in epidemics. It is usually the commonest aphid species found on potato and can persist late into autumn.

Yield reductions are caused as a result of sap-feeding and, especially, through the transmission of viruses, such as potato virus Y (PVY) and potato leaf roll virus (PLRV).

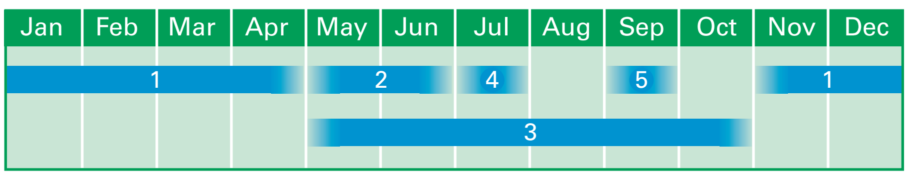
On potato, this aphid tends to multiply on the flowers and shoot tips and even moderate numbers can produce appreciable yield reductions.

Potato aphid may infest vegetable brassicas and lettuce but it is generally a contaminant rather than causing severe damage to plants. Sugar beet does not usually suffer from direct feeding damage but potato aphid can transmit beet mild yellowing virus (BMYV) and beet yellows virus (BYV), although less efficiently than peach–potato aphid.

Risk factors

Damage in potatoes is greatest when aphid numbers peak after mid-July. Risk of virus transmission in sugar beet is greater in crops (without insecticide seed treatments) that have fewer than 12 true leaves; older crops become unpalatable.

Life cycle



1. Wingless adults and immature stages overwinter on weeds, potato sprouts, rose and protected lettuce.
2. Winged forms migrate to summer crops.
3. Wingless forms feed and reproduce on the crop.
4. If heavy infestations occur, a further migration is common.
5. A small autumn migration may occur.

Adult potato aphid

Potato aphid (*Macrosiphum euphorbiae*)

Identification and symptoms

Adult potato aphids are large, relative to other aphid species, with wingless forms being 2.5–4 mm long. They have a pear-shaped green to pinkish-red body with a dark stripe running down the back. They have long legs, a cauda (a finger-shaped structure at the rear) and antennae at least as long as the body. Winged adults have a yellowish-brown head and green thorax.

When infestations on potato are heavy, the feeding can result in 'false top roll' symptoms (upper leaves roll). This can be distinguished from PLRV symptoms as it usually occurs earlier in the summer, has a patchy in-field distribution and is usually found with the aphids or their cast skins.

PVY infections caused by aphids result in leaf drop streak, where lower leaves develop black streaks on their underside veins and eventually collapse, hanging off the stem by a thread. Younger leaves may develop necrotic spotting.

Aphid-vectored PLRV infections result in the margins of young leaflets rolling upwards and inwards, particularly at the leaflet base. Infected leaves may develop a purple discolouration. Symptoms of secondary (tuber-borne) infections of these viruses may differ from the primary infections described above.

In sugar beet, beet yellowing virus symptoms are characterised by diffuse chlorotic patches on mature leaves, which expand and coalesce. Leaves may be subject to infection by secondary pathogens, such as alternaria. Leaves also become thickened and brittle, snapping crisply when broken.

Monitoring

AHDB Aphid News provides information on aphid migration. BBRO maintains a network of yellow water pans in the sugar beet growing areas and records the number of potato aphids found weekly.

Thresholds

Potatoes: None established. Treat if aphid numbers start to increase rapidly on varieties known to be susceptible to 'false top roll'.

Non-chemical control

Natural enemies include parasitic wasps, ladybirds, predatory flies, spiders, ground beetles, rove beetles, lacewings, and insect-pathogenic fungi. Providing habitats that encourage the presence of these may help control aphid numbers. They may not be effective in preventing virus transmission, as this can occur even at low aphid densities. Early sowing of sugar beet can mean it is less likely to be affected, as older leaves are less palatable to the aphids.

Insecticide resistance

None known.

Rose–grain aphid (*Metopolophium dirhodum*)

Crops affected

- ✔ Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

Importance

Where populations of this pest exceed threshold levels, their feeding can cause yield losses of up to 4 t/ha but 0.25–1 t/ha is more usual.

Rose–grain aphid is unimportant as a vector of barley yellow dwarf virus (BYDV) because it spends the winter as an egg on roses.

Risk factors

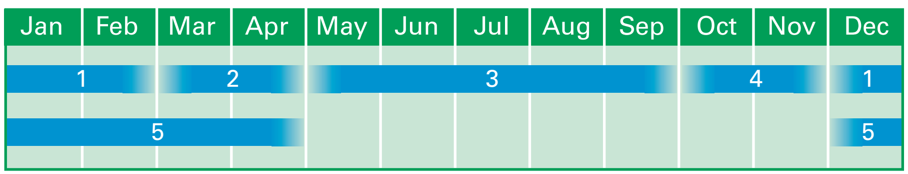
All cereals are at risk, although winter barley is less affected due to its earlier senescence.

Drought-affected crops or those damaged by other pests and diseases also suffer greater impact due to lower reserves of soluble stem carbohydrates.

Increased risk is also associated with dry, settled weather during early grain filling.

Rose–grain aphids tend to be a problem after hard winters when both grain aphids and their natural enemies are scarce. The rose–grain aphid is susceptible to all the natural enemies of the grain aphid. If the grain aphid and its natural enemies are present, it is more difficult for an infestation of rose–grain aphid to become established.

Life cycle



1. Eggs overwinter on wild and garden roses.
2. Winged forms migrate to crops.
3. Feeding on crops and grasses.
4. Very frost-hardy eggs laid on wild and garden roses.
5. Adults can overwinter on grasses.

Rose–grain aphid

Rose–grain aphid (*Metopolophium dirhodum*)

Identification and symptoms

The rose–grain aphid is medium-sized and light green or, rarely, pink. Green varieties have a dark, bright green stripe down the centre of their back. Rose–grain aphids are only ever found on the leaves and never on the ears.

Only very severe infestations produce visible symptoms in crops. Infested leaves turn yellow and senesce prematurely.

Monitoring

Check for aphids on the lower leaves at about the time the cereals are coming into ear. Individuals also collect on the top leaves in the later growth stages. They do not move to the ear.

Refer to AHDB Aphid News for information on migration.

Thresholds

Before GS61: Half of tillers infested

GS61 to two weeks before end of grain filling: Two-thirds of tillers infested from stem extension to flag-leaf emergence, or if more than 66% of tillers are infested and numbers are increasing for the period from flowering to watery ripe.

Non-chemical control

Agri-environment habitats comprised primarily of grasses, such as buffer strips, can also provide harbourages for aphids; on the other hand, these populations also help support their parasitoids through the winter. Wildflower strips with a more diverse grass mixture are less likely to harbour pests and will encourage parasitoids and hoverflies. Other natural enemies include lacewings, ground beetles, soldier beetles, rove beetles, ladybirds, spiders and fungal diseases.

Insecticide resistance

None known.

Rose–grain aphids

Rose–grain aphids

Rose–grain aphids

Crops affected

- Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- ✔ Carrots
- Alliums
- Peas
- Field beans
- ✔ Sugar beet
- ✔ Lettuce

Importance

The tarnished plant bug is a type of capsid bug. The adults and nymphs feed on leaves, buds and fruits of susceptible plants (carrot, celery, lettuce and other vegetables), seriously reducing marketability.

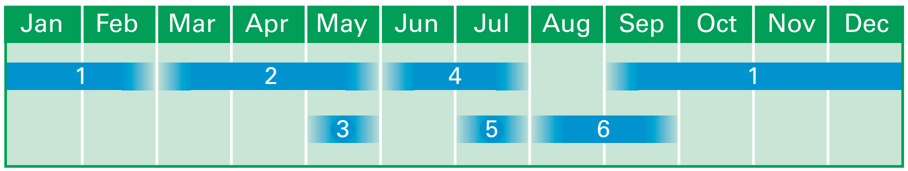
It can also damage sugar beet, causing distortion of the growing point, multiple crowning and poorly yielding plants.

Other species of capsid may also cause damage.

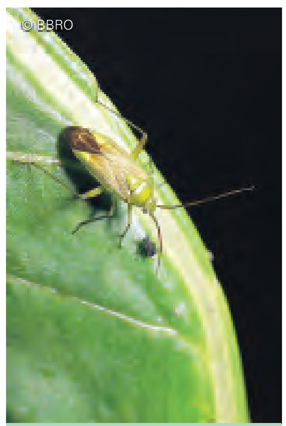
Risk factors

The nature of the surrounding vegetation in terms of provision of alternative hosts and an overwintering site may be a risk factor.

Life cycle



1. Adults overwinter on evergreen foliage and in leaf litter.
2. Adults emerge in March/April and begin feeding on plant tissues.
3. Females lay eggs in plant tissue.
4. Nymphs develop through six instars and adults are produced by July.
5. Adults feed.
6. Another generation is produced in August/September.



Adult capsid bug

Tarnished plant bug (*Lygus rugulipennis*)

Identification and symptoms

Adult bugs are 5–6 mm long, oval-shaped and brownish-green with dark markings. They usually appear to be 'tarnished'. They have a small head with a pair of long, jointed antennae.

Eggs are elongate and slightly curved. They are inserted into the tissues of terminal shoots, buds and fruits.

The nymph is green with black spots on its thorax.

Usually, the first signs of damage are small brown spots on young leaves. Because the area surrounding each feeding site dies, affected plants fail to grow properly and plant parts become malformed.

In summer, other species of capsid feed on the leaf veins of older plants, causing puckering and yellowing. Close to the puncture site, the tissue is often blackened.

Monitoring

Pheromone traps are available for monitoring adult tarnished plant bugs.

Blue sticky traps are more effective than yellow sticky traps.

Thresholds

None established.

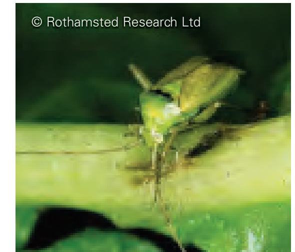
Non-chemical control

Trap crops have been used successfully in strawberry, sometimes in conjunction with vacuuming the trap crop to reduce infestations. Further research would be needed to evaluate such approaches for field vegetables.

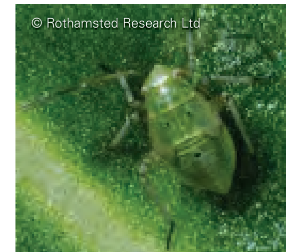
Some variation in susceptibility between carrot cultivars was identified some years ago.

Insecticide resistance

None known.

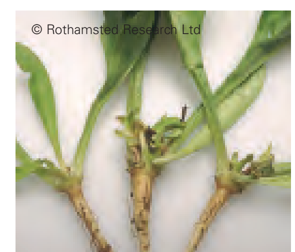


Adult capsid bug



Capsid nymph

Capsid bug damage



Capsid bug damage

Willow–carrot aphid (*Cavariella aegopodii*)

Crops affected

- Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- ✔ Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

Importance

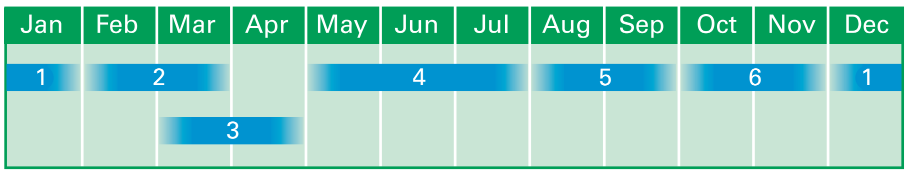
Willow–carrot aphid can affect carrot, celery, parsnip and parsley. Severe infestations can distort the foliage and stunt plants, killing them if they are very young.

The aphid is also the vector of parsnip yellow fleck virus and the two viruses that cause carrot motley dwarf disease. It can also transmit carrot red leaf virus, parsnip mosaic virus and celery mosaic virus.

Risk factors

Insecticidal control of the aphids may have little impact on virus transmission. Willow–carrot aphid generally overwinters on willow trees. Dry sunny weather in late May/June favours a large-scale migration to host crops but cold rainy weather inhibits it.

Life cycle



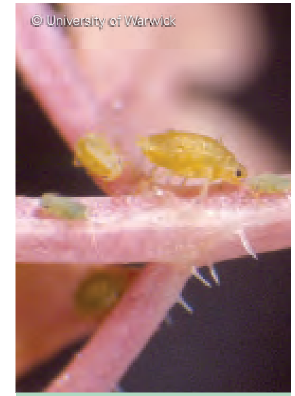
1. The aphid overwinters mainly as eggs, which are laid around the buds of willow.
2. Eggs hatch.
3. The aphids feed and reproduce on the willow.
4. Winged forms are produced and migrate to carrot and other host plants over a five to six week period, usually with a peak in early June. Late seasons can delay migration for two to three weeks.
5. Further winged generations disperse to wild hosts.
6. Winged aphids migrate to willow to mate and lay eggs.

Winged willow–carrot aphid

In warmer locations, a small proportion of the population may overwinter as mobile stages on crops in field storage or on wild hosts and produce colonies early the following spring.

Willow–carrot aphid (*Cavariella aegopodii*)

Identification and symptoms



Willow–carrot aphids

The adult wingless form is 1–2.6 mm long, green or yellowish-green, elongate oval and somewhat flattened. There are two tubes (siphunculi) at the rear end, which are swollen towards the tips. A small outgrowth is present above the tail. The winged form is darker and has a black patch on the upper surface of the abdomen.

The aphids infest carrots at the cotyledon stage but can also invade older plants. When many are present, the leaves may be discoloured, distorted and sometimes shiny from honeydew excretion. The plants and ground below may become covered with cast skins.

Parsnip yellow fleck virus can cause stunted plants and blackening of the central core. Carrot motley dwarf disease produces a yellow mottling of the leaves and stunts the plants.

Feeding damage may be confused with damage due to carrot fly and sometimes drought stress, which produces similar foliage symptoms.

Monitoring

AHDB Aphid News provides information on winged aphid migration.

A day-degree forecast has been developed to predict the start of the migration from willow to carrot and other host plants. More information is available in the AHDB Horticulture Pest Bulletin.

Thresholds

None established.

Non-chemical control

The mobile forms are attacked by a number of natural enemies, including ladybirds. Young aphids may be parasitised by certain species of wasp, whose larvae eventually kill the aphid, which forms a hard gold-coloured 'shell' known as a 'mummy'. To date, biological control with natural enemies has not been evaluated in the UK but the efficacy of several biopesticides is being evaluated.

Insecticide resistance

None known.

Minor and/or emerging pests

Potato leafhoppers (*Edwardsiana flavescens, Empoasca decipiens, Eupterycyba jucunda* and *Eupteryx aurata*)

Crops affected	
	Cereals
	Oilseeds
	Vegetable brassicas
✔	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

Four species of leafhopper commonly attack potato but they seldom cause economic damage.

Leafhoppers are around 5 mm long, with elongated yellow or green bodies and they tend to fly or jump away when disturbed.

The potato leafhoppers are common inhabitants of hedgerows, moving into the crop in early summer to feed on the underside of leaves. Pale, slender eggs are laid on stems and leaf veins. Several generations can be completed in a year.

Feeding causes pale speckling of the leaves, while the injection of their saliva into the phloem causes 'hopperburn', a yellowing/browning of the foliage. Severe cases can result in brown, wilting and dying leaves.

Potato leafhopper

Potato leafhopper

Further information

Alerts and bulletins

AHDB Aphid News: **cereals.ahdb.org.uk/pests**

AHDB Horticulture Pest Bulletin: **horticulture.ahdb.org.uk/latest-pest-bulletin**

AHDB Horticulture Publications

Available at **horticulture.ahdb.org.uk**

Factsheet 10/14: Cabbage whitefly (2014)

Factsheet 35/12: Minor pests of Brassicas (2012)

Factsheet 03/12: Pea aphid control (2012)

Factsheet 21/11: Virus diseases of carrots (2011)

AHDB Cereals & Oilseeds Publications

Available at **cereals.ahdb.org.uk/publications**

Information Sheet 42: Controlling aphids and virus diseases in cereals and oilseed rape (2015)

Research Review 86: A review of pest management in cereals and oilseed rape in the UK (2016)

AHDB Cereals & Oilseeds neonicotinoid information: cereals.ahdb.org.uk/neonics

AHDB Potatoes Publications

Available at **potatoes.ahdb.org.uk/knowledge-hub**

Guidelines for preventing and managing insecticide resistance in aphids on potatoes (2011)

Information from other organisations

Fera Plant Disease Factsheet: Aphid transmitted viruses of potato (2009)

APHMON – National yellow water trap data **www.aphmon.fera.defra.gov.uk**

Pests:

Flies, thrips and sawflies

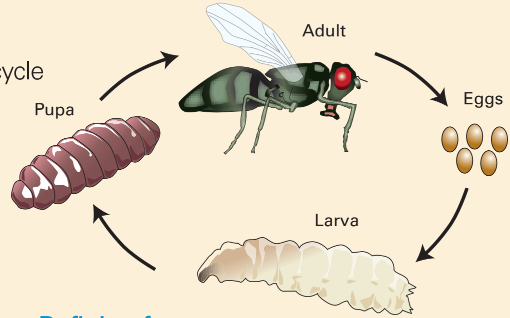
Contents – Pests: Flies, thrips and sawflies

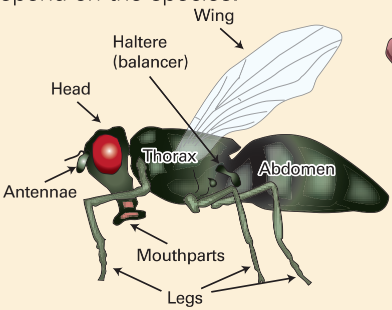
Flies (Diptera)

Flies are, typically, the most numerous insects found on farmland and, although some are crop pests, others help perform important functions such as helping control crop pests (see page 185), recycling organic matter and acting as food for farmland birds.

Life cycle

There are four stages to the fly life cycle and the length of each stage will depend on the species.

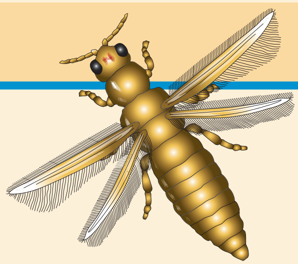




Defining features

Flies are defined by having only a single pair of wings. Fly larvae are mostly legless maggots.

Thrips (Thysanoptera)



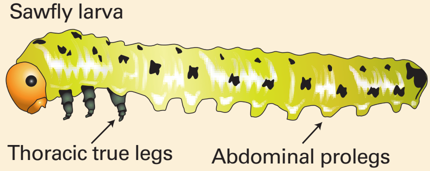
Thrips, commonly known as thunderflies, are not true flies. They are tiny, slender insects with fringed wings.

Sawflies (Hymenoptera: Symphyta)

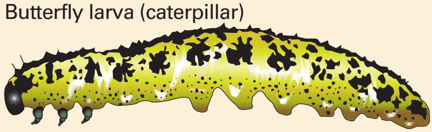
Sawflies are not true flies: they are related to bees, wasps and ants. The adults look similar to wasps but are distinguished by a broad connection between the abdomen and thorax (unlike the 'wasp waist' of other species of Hymenoptera).

The larvae look like caterpillars but have six or more pairs of prolegs on the abdomen, whereas caterpillars have five pairs or fewer with the first two abdominal segments legless. Sawfly larvae also have a smooth head capsule with distinct small black eyes.

Sawfly larva



Butterfly larva (caterpillar)



Bean seed flies (*Delia platura* and *Delia florilega*)

Crops affected	
✔	Cereals
	Oilseeds
✔	Vegetable brassicas
	Potatoes
	Carrots
✔	Alliums
✔	Peas
✔	Field beans
	Sugar beet
	Lettuce

Bean seed fly adult

Importance

Damage can be localised and sporadic, even though the adult flies are common.

In beans, the most serious damage is caused in the spring. Usually, the first sign of damage is the patchy emergence of seedlings and it is impossible to control an infestation at this point.

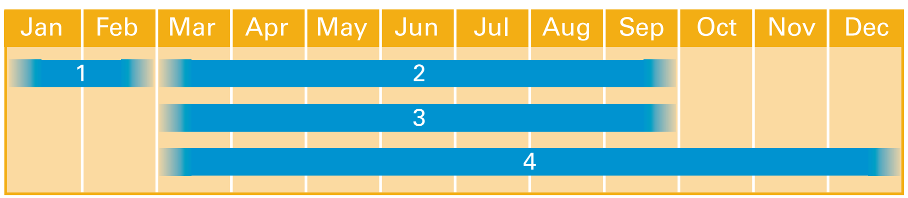
Seeds of other crops (eg alliums and sweetcorn) are also vulnerable, especially if sown in later spring or early summer.

Risk factors

Females prefer to lay eggs in freshly disturbed soil, especially where there are residues of vegetable matter or where farmyard manure has been applied. The presence of plants is not required for bean seed flies to lay eggs.

Any factors that slow down the speed of germination and shoot vigour increase the risk of damage, in particular, low temperatures and excessively deep sowing. High levels of moisture are also thought to increase the risk of damage.

Life cycle

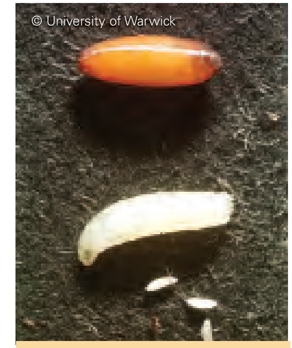


1. Bean seed flies overwinter as pupae in the soil.
2. Flies start to emerge and, after feeding and mating, the female lays eggs just below the soil surface, generally singly. They may lay as many as 40 eggs in a day. There is generally a period of several days before a further batch of eggs is laid.
3. In the absence of a suitable host plant, the larva is able to complete development by feeding on decomposing organic matter.
4. The larvae pupate in the soil at varying depths.

Bean seed flies can complete between three and six generations per year, depending on the ambient temperature.

Bean seed flies (*Delia platura* and *Delia florilega*)

Identification and symptoms



Bean seed fly life stages

The adult is a small greyish-black fly, 4–5 mm long. The egg is white, elongated and about 1 mm long. The larva is a white maggot, which reaches 5–8 mm in length when fully grown and the pupa is reddish-brown and about 5 mm long.

The larvae feed on the buried seed or the cotyledons of the seedling before sprouting. Damage to all crops is manifested mainly as patchy emergence of seedlings or seedling death. When runner or French beans are very severely attacked, the growing point may be lost, seedlings then emerge in a twisted condition known as 'snake head' and soon die.

Damage to onions may appear as poor emergence, since the larvae usually attack the seedling between germination and emergence. Plants are often killed at the 'loop' or 'crook' stage.

Damage in cereals can be hollowed grains. Newly transplanted cucurbits may be damaged soon after planting. The plants collapse completely, often within days of being transplanted. Later attacks cause plants to wilt during dry weather. On asparagus, the attacked spears are deformed, often split, and have a bitter taste.

Monitoring

Adult bean seed flies (both sexes) can be monitored using coloured sticky traps or water traps. Yellow, blue and white traps are all effective but white traps and certain colours of blue may be preferred. Water traps are also suitable for monitoring this species.

Thresholds

There are no thresholds to relate the risk of crop damage to numbers of flies captured in traps but trap captures do indicate when bean seed flies are active and how numbers change during the season.

Non-chemical control

The presence of organic matter in the soil is an important stimulus for egg laying. Properly burying any organic debris from previous crops should reduce risk.

Natural controls are likely to include generalist predators, such as certain species of beetle, spiders, insect-pathogenic fungi and parasitoids (beetles and wasps). Two species of *Aleochara* (rove beetle, see page 178), which can be both pupal parasitoids and predators of eggs and larvae, have emerged from bean seed fly pupae.

Insecticide resistance

None known.

Beet leaf miner (*Pegomya hyoscyami*)

Crops affected

- Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- ✔ Sugar beet
- Lettuce

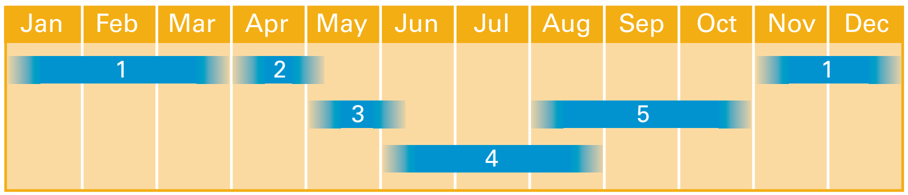
Importance

In recent years, there has been an increase in the incidence of late beet leaf miner and control options are very limited. Extensive damage can affect the plant's photosynthetic ability. In large numbers, they can almost defoliate whole plants.

Risk factors

The first generation is the most damaging, especially in late-sown crops with low leaf area. Later generations can be numerous but damage is less serious because they inhabit outer leaves and often coincide with periods of rapid growth, offsetting effects.

Life cycle



1. Beet leaf miner overwinters in the soil as pupae.
2. The first flies emerge throughout April. After mating, the females lay eggs on the underside of beet leaves.
3. Eggs hatch after 3–10 days and the larvae enter the leaf and feed between the two leaf layers. The mines join and blister as the larvae grow. After about 10–15 days, the fully grown larvae leave the leaf and fall to the ground, where they pupate.
4. There can be another one or two overlapping generations.
5. There can be another one or two overlapping generations.

Beet leaf miner larva

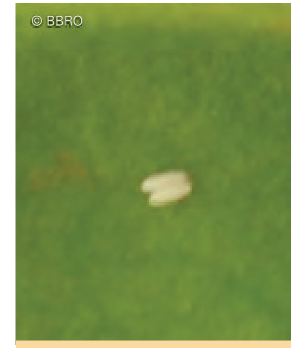
Beet leaf miner (*Pegomya hyoscyami*)

Identification and symptoms

The eggs are white, patterned and approximately 1 mm long. They are found on the underside of beet leaves in groups of between two and ten.

Larvae are translucent, whiteish to pale green and 6–8 mm long. They are not generally seen but their presence can be detected by the appearance of mines and blisters on the beet leaf. Symptoms of heavy infestations can resemble those of bacterial leaf blight.

The pupae are brown, oval and approximately 5 mm long.

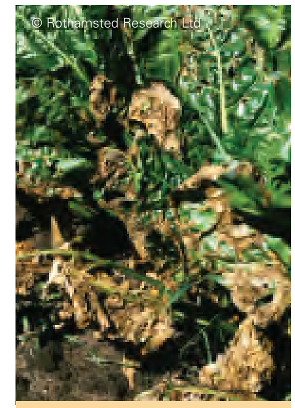


Beet leaf miner eggs

Monitoring

Eggs can readily been seen with the naked eye in groups on the underside of leaves. If mines are seen in the leaves, they should be checked to see if thresholds have been reached.

Timing of sprays is critical for good control because the larvae are hard to kill once inside the leaf. The optimum timing is at egg hatch.



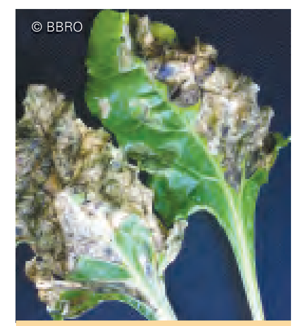
Beet leaf miner damage

Thresholds

The threshold for treatment is when the number of eggs and larvae exceeds the square of the number of true leaves. For example, a plant with four true leaves would need a population of 16 (4x4) or more eggs and larvae to warrant treatment.

Non-chemical control

The third generation is most susceptible to predation by natural enemies, such as parasitic flies (eg *Opius nitidulator*). The decision of whether to apply late applications of insecticide should balance the likelihood of success against the risk of harming these natural enemies.



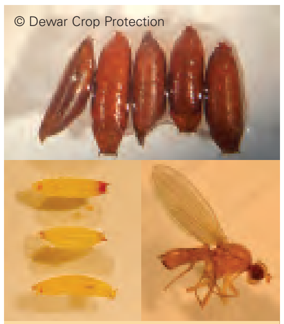
Beet leaf miner damage

Insecticide resistance

None known.

Crops affected

- Cereals
- ✔ Oilseeds
- ✔ Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce



Brassica leaf miner life stages

Importance

Although the brassica leaf miner is a native species of fly, it was not regarded as a pest of major economic importance on vegetable brassicas until recently. Damage to brassica salad crops, such as rocket and tatsoi, has been particularly severe.

Crop damage is caused by adult females, which puncture the leaf surface with their ovipositor to lay eggs, and by the larvae, which produce the characteristic white 'corridor-blotch' mines when feeding between the upper and lower surfaces of the leaf.

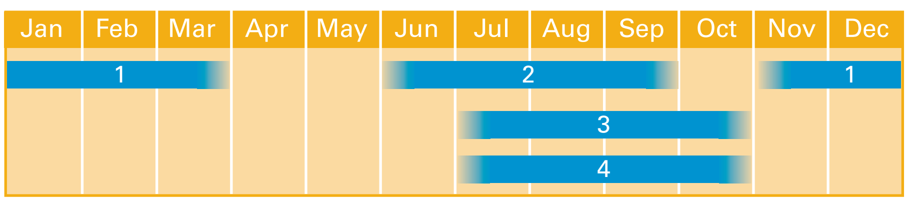
In oilseed rape, despite the unsightly mines, it is unlikely these pests will ever justify insecticide treatment. In general, it is only the first developing true leaves that are infested and these usually die during the winter.

Oilseed rape can also be attacked by cabbage leaf miner (*Phytomyza rufipes*). This mostly mines the leaf petioles and is often undetected. Since only the outer leaves are affected and these usually die during winter, cabbage leaf miner is not regarded as an economic pest and control is unnecessary.

Risk factors

There is no definitive information on the number of generations completed by this species in the UK although, according to the literature, adults are generally most abundant in September.

Life cycle



1. Brassica leaf miner overwinters as pupae in the soil.
2. Adults are generally most abundant in September, although local peaks of activity can occur in July or August. Females lay eggs in punctures made within the lower surface of the leaf and can lay more than 300 eggs.
3. In the UK, mines are typically seen between July and October.
4. Larvae usually drop to the ground to pupate but sometimes a separate pupation mine is used.

Identification and symptoms

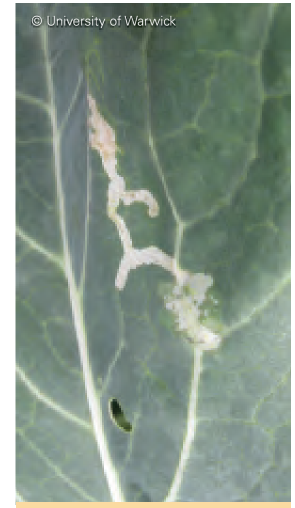
The adult is pale brown with faint stripes on the thorax and red eyes. The wings are about 50% longer than the head and thorax combined. It is about 3 mm long with a wing span of 6 mm.

Eggs (0.3–0.4 mm long, 0.2 mm wide) are laid singly but quite close to one another.

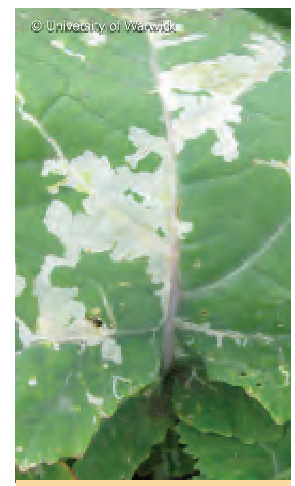
The larva is a cylindrical maggot, which becomes greenish in colour and is 0.4–5 mm long.

The pupa is brown, about 3 mm long, and is generally found in the soil.

The hatching larva initially moves towards the mid-rib, creating a long corridor. Once at the mid-rib, the larva forms a large irregular white/yellow blotch in the upper leaf surface with occasional excursions into the leaf blade. Several larvae may be present in the same mine and, if the leaf is small, the entire leaf may be occupied. In smaller leaves, the mine lies in the centre of the leaf and often touches the petiole, while in larger leaves the mine is to one side of the mid-rib. Frass (droppings) is usually deposited in green clumps near the margin of the mine.



Brassica leaf miner damage



Brassica leaf miner damage

Monitoring

Yellow water traps or white sticky traps can be used to monitor adults. No forecasting systems have been developed.

Thresholds

None established.

Non-chemical control

Vegetable brassicas could be protected by covering them with insect-proof netting at times when the adult flies are active and laying eggs.

Insecticide resistance

Populations have recently developed resistance to pyrethroid insecticides and AHDB Horticulture-funded research (FV 376) suggested that brassica leaf miner has become a more important pest of cruciferous crops as a result.

Brassica pod midge (*Dasineura brassicae*)

Crops affected

- Cereals
- ✔ Oilseeds
- Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

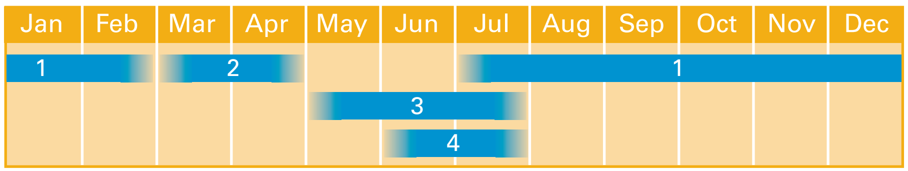
Importance

The brassica pod midge lays its eggs in developing pods in the holes left by seed weevils (see page 19). Larvae feed within the pod, causing swelling and, eventually, pod burst. With damage greatest on headlands and affected pods very conspicuous, the impact of this pest on yield can be overrated. However, spring oilseed rape yields can be severely reduced.

Risk factors

The largest yield losses often occur in small narrow fields. The adult midge is a weak flyer, so crops on headlands are more exposed to immigrant midges.

Life cycle



1. Larvae overwinter in the soil.
2. Adults emerge.
3. Adults mate and fly to oilseed rape, where they lay eggs in cabbage seed weevil holes and damaged areas of the plant.
4. Larvae feed, pods swell and burst. Larvae drop to the soil. Some develop, to give second and third generation adults.

Brassica pod midge (*Dasineura brassicae*)

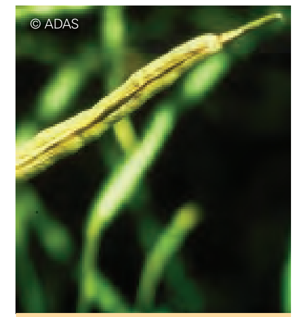
Identification and symptoms

The adults are small, dark orange midges that appear during flowering. To lay eggs, the midge is dependent on the pod being previously damaged – usually by the feeding and egg-laying punctures made by the cabbage seed weevil.

Numerous minute eggs are laid in clusters inside the pod, giving rise to large numbers of larvae, which feed on the inner walls of the developing pods. At maturity, the larvae are white, with no legs or distinct head, and 2 mm long, at which point they drop to the soil to pupate.

Infested pods yellow and split prematurely, occasionally becoming swollen and distorted ('bladder pods'). This results in a complete loss of seed.

Brassica pod midge larvae



Brassica pod midge symptoms

Brassica pod midge symptoms

Monitoring

Controlling cabbage seed weevil is the most effective means of avoiding damage from the brassica pod midge.

Thresholds

Control of brassica pod midge is dependent on the control of cabbage seed weevil. Thresholds for cabbage seed weevil are 0.5 weevils per plant in the north of the UK and 1 weevil per plant elsewhere. See page 19.

Non-chemical control

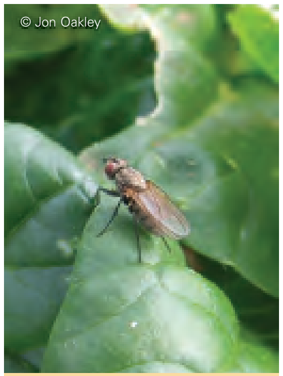
Blocking oilseed rape fields and rotating the crop around the farm helps reduce the impact of immigrant pests.

Several wasp parasitoids, including *Omphale clypealis* and *Platygaster subuliformis*, may attack pod midge, killing up to 75% of larvae. Other natural enemies include spiders, ground beetles, rove beetles and predatory flies.

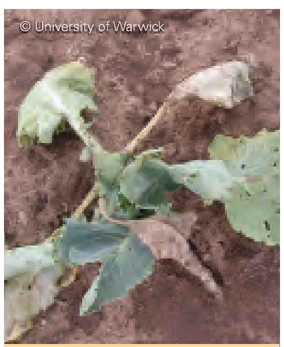
Insecticide resistance

None known.

Crops affected	
	Cereals
✔	Oilseeds
✔	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce



Adult cabbage root fly



Cabbage root fly damage

Importance

Cabbage root fly is present throughout the UK and can cause damage to cabbage, cauliflower, broccoli, Brussels sprout, kale, Chinese cabbage, swede, turnip and radish. It can also attack oilseed rape but is generally considered a minor pest.

If uncontrolled, almost 100% of plants may be infested but yield losses will depend on the impact of damage on plant growth and quality. Good levels of control are particularly important where the root is the marketed crop (swede, turnip, radish).

Plants with low levels of root damage usually survive, particularly if conditions are wet or irrigation is used, but this may affect uniformity within the crop, increasing the number of passes required at harvest (eg for cauliflower).

In certain circumstances, cabbage root fly larvae may also infest broccoli florets, Brussels sprout buttons and the foliage of Chinese cabbage.

Risk factors

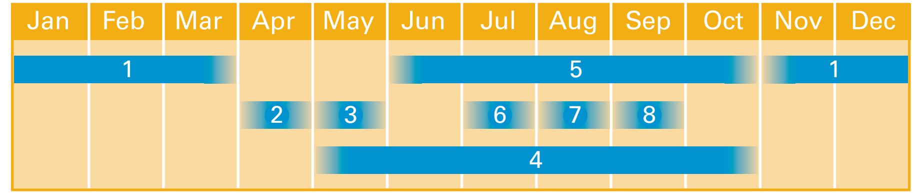
Young plants are most likely to be killed by cabbage root fly larvae, whereas older plants generally have a sufficiently large root system to be able to tolerate moderate to high levels of infestation, depending on species. Newly emerged drilled crops and recently transplanted module-grown plants are, therefore, likely to be most susceptible.

Plants where the marketable part of the plant is damaged (root crops, Brussels sprout buttons, broccoli florets, Chinese cabbage) may be at risk of 'cosmetic' damage by one or more generations of the pest.

In oilseed rape, crops that have emerged before the end of August are most at risk of attack.

Cabbage root fly (*Delia radicum*)

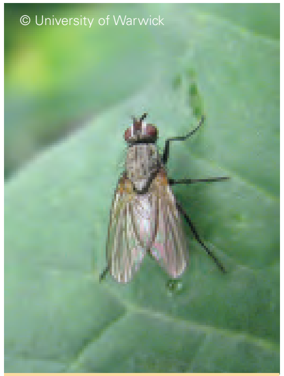
Life cycle



1. Pupae from late second and early third generations overwinter in soil.
2. Adult flies emerge and feed/mate.
3. Eggs are laid (first generation).
4. Larvae feed.
5. Pupae present in soil.
6. Eggs are laid (second generation).
7. Eggs are laid (late second generation, early third generation).
8. Eggs are laid (third generation).

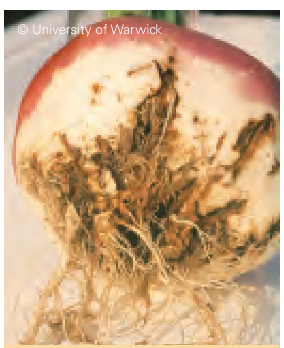
The life cycle is driven by temperature, so activity will be earlier in warm years/locations. In the UK, depending on temperatures, there are generally two to three generations of adults in the south and only two generations in the north.

There are some areas of the UK where a proportion of the cabbage root flies emerge later in the spring than would be expected. These are called 'late-emerging' flies and they are genetically different from 'early emerging' flies. Relatively large numbers of late-emerging flies occur in some parts of Devon and south-west Lancashire.



Cabbage root fly adult

Cabbage root fly larvae



Cabbage root fly damage on swede

Identification and symptoms

The adult flies are greyish-brown and resemble small houseflies. The male is 5–6 mm long and the female 6–7 mm.

The eggs are white, about 1 mm long and are laid mainly in the soil around the stems of brassica plants.

The larva is more or less transparent, tapering and legless with a reduced head. The mouthparts look like black hooks. Fully grown larvae are 5–8 mm long.

The pupae are dark brown and barrel-shaped, with smoothly rounded sides and most are found 8–12 cm below the soil surface.

The larvae feed primarily on the roots of brassica plants, although they sometimes feed on the aerial parts. Where most of the root system has been damaged, the plants may wilt or even die. When plants have large root systems, damage may not be apparent until the plant is harvested. Damage to the aerial parts is generally not apparent until the plants are harvested and damaged produce may be difficult to identify even at this stage.

Monitoring

Adult flies can be captured in yellow water traps or more specialised traps that release a semiochemical (related to the distinctive chemical compounds produced by brassica plants).

The soil around plants can be sampled to determine the presence of eggs.

A weather-based forecast for the timing of egg laying has been developed with AHDB Horticulture/Defra funding and outputs are available to UK growers via the AHDB Horticulture Pest Bulletin.

Thresholds

There are no current validated thresholds for cabbage root fly. Most vegetable brassica crops need to be treated prophylactically as once larvae have established they are very difficult to control.

Non-chemical control

Fine mesh netting (crop covers) has been used successfully to prevent egg laying by female cabbage root flies on susceptible crops (eg swede). Female flies can lay their eggs on or through the netting if it touches the crop but the incidence of this seems to be low.

Other physical and cultural approaches (companion planting, vertical fences, trap crops) have been investigated but control is not as effective as the use of currently available insecticides or fine mesh netting.

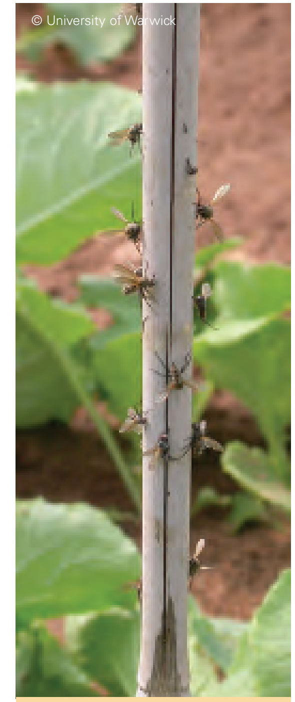
A range of natural enemies contribute to controlling background levels. These include two parasitoids, spiders, ground and rove beetles, and predatory flies (Muscidae).

To date, biological control with predators or parasitoids has not been commercially viable. There is evidence that the use of insect-pathogenic nematodes or insect-pathogenic fungi may be effective in certain situations.

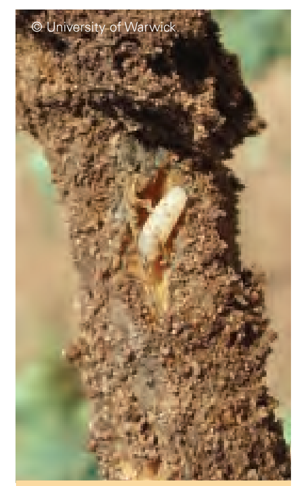
There is no host plant resistance available at present but some crop types are more susceptible than others.

Insecticide resistance

None known.



Cabbage root flies killed by a fungus



Cabbage root fly larva

Crops affected

- Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- ✔ Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

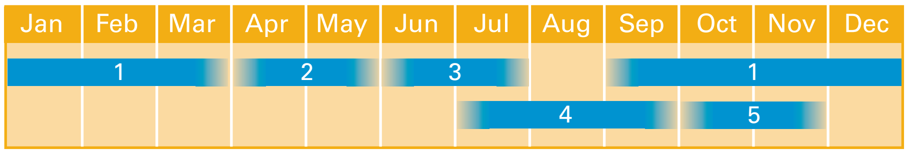
Importance

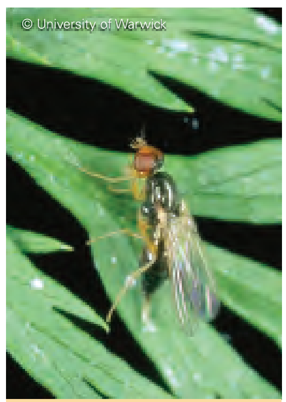
Carrot fly is present throughout the UK. The larvae feed on the roots of carrot and other susceptible crops, making tunnels (mines) as they grow. When the carrots are small, the plants are killed; larger plants are made unmarketable through the presence of even a few relatively superficial mines.

Risk factors

Carrot fly adults do not disperse over great distances so crops that are most at risk are those close to fields that were infested previously with carrot fly. Damage is likely to be greatest at the edges of fields.

Life cycle



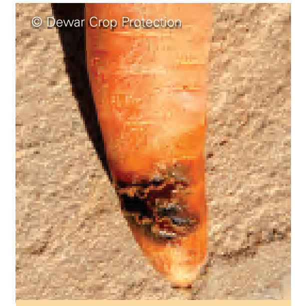


Carrot fly adult

1. Carrot flies overwinter as pupae or as larvae, which continue to feed on overwintered crops and then pupate the following spring.
2. The first generation of adult flies emerges in April–May and most eggs are laid during May.
3. Larvae feed and pupae are formed.
4. Adults emerge from mid-July onwards to produce the overwintering generation.
5. In warm locations, a third generation of adults may emerge in October–November. It is believed that the progeny of these flies do not develop sufficiently before the winter to cause further damage.

The rate at which the carrot fly completes its life cycle is dependent on temperature and more generations will be completed in warm locations. In the UK, depending on temperatures, there are two to three generations of adults in the south and only two generations in the north.

Identification and symptoms



Carrot fly damage

Adult carrot flies are 6–8 mm long, with two pairs of iridescent wings. The body is black and shiny, the head is reddish-brown and the legs are yellow. The white-coloured eggs are elongate (0.2 mm diameter, 0.6–0.7 mm long). The larva is creamy white in colour and is 8–10 mm long when fully grown. The brown puparium is about 5 mm long and 1.5 mm in diameter.

The larvae first feed on the lateral roots of carrot plants and then proceed to burrow into the tap root as they grow. With young plants, where most of the root system has been damaged, plants may wilt or even die. When plants have large root systems, damage may not be apparent until the plant is harvested.

Monitoring

Adult flies can be captured on yellow/orange sticky traps. Orientating the traps at an angle of 45˚ to the vertical makes them more selective for carrot flies, which land on the lower surface.

A weather-based forecast for the timing of egg laying has been developed with AHDB Horticultre/Defra funding and outputs are available to UK growers via the AHDB Horticulture Pest Bulletin.

Thresholds

None established. Treatment timing will depend on whether the insecticide used is targeted at flies or larvae.

Non-chemical control

Crop rotation and the separation of new crops from sources of carrot fly is a very effective method of managing carrot fly populations. Where feasible, delaying sowing of susceptible crops until after the first generation has laid most of its eggs will also suppress populations.

Fine mesh netting (crop covers) has been used successfully to prevent egg laying by female carrot flies on susceptible crops. Other physical and cultural approaches (companion planting, vertical fences, trap crops) have been investigated but control is not as effective as the use of currently available insecticides or fine mesh netting.

To date, biological control with predators or parasitoids has not been commercially viable. There is evidence that the use of insect-pathogenic nematodes may be effective in certain situations. Some cultivars are less susceptible to carrot fly damage than others but none have complete resistance.

Insecticide resistance

None known.

Frit fly (*Oscinella frit*)

Crops affected

- ✔ Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

Importance

Frit fly is usually most damaging to late-sown cereals after grass and spring-sown oats. There are three generations of frit fly per year. The first generation is damaging to winter cereals, grasses, maize and late-sown spring oats. The second generation lays eggs in developing oat grains and the third lays eggs on grasses and winter cereals.

Risk factors

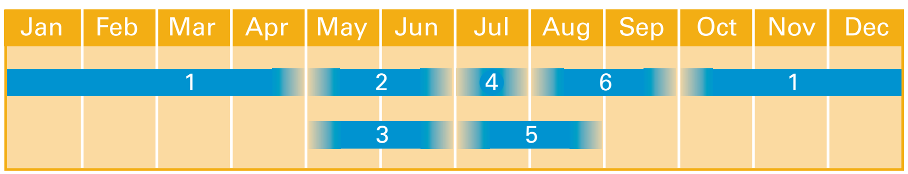
Winter crops are at most risk of damage, while spring crops usually only suffer damage if sowing has been delayed or if crop growth is checked for other reasons.

The risk of frit fly attack is greatest after grass leys or in areas in which grass is a common crop.

Crops are most susceptible to shoot damage up to the four-leaf stage.

From late July, emerging adults lay eggs on oat husks, which can lead to serious damage to the ears of spring oats. However, as these are only susceptible for a short time, sowing crops early or choosing those that develop rapidly can narrow the period of risk.

Life cycle



1. Larvae feed slowly in shoots of cereals and grasses.
2. First generation adults emerge and lay eggs on grasses and young cereals.
3. Larvae burrow into the central shoot of young cereals.
4. Second generation adults emerge and lay eggs beneath oat husks and grasses.
5. Hatching larvae feed on oat kernels.
6. Third generation adults lay eggs on grasses in stubble and early winter cereals.

Because there are three generations per year, damage can occur to crops at different times of the year and to different parts of the plant (shoots and grain).

Adult frit fly

Frit fly larvae

Frit fly (*Oscinella frit*)

Identification and symptoms

Frit fly damage

The frit fly adult is small (about 1.5 mm long), shiny and black. It rests in cold, wet weather but is active in fine conditions. The larva is a small, white maggot, about 3 mm long when fully grown. The larvae are usually found inside the damaged shoot. The pupa is protected by a reddish-brown casing.

Damage in cereals is most evident as 'deadhearts', where the central leaf of the plant turns yellow, withers and dies, often falling out completely. Very young plants can be killed. Older plants can produce several tillers in response to the death of the main shoot, although these may also be invaded. This leads to plants with a large number of weak shoots which produce poor yield and later-ripening grain. In oats, deadhearts can be mistaken for stem nematode damage, in which the base of the plant is also swollen and the leaves are pale, stunted and twisted.

Spring oats may be damaged prior to ear emergence, which can lead to blind, withered spikelets. Adults hatching in July lay eggs on the ears of oats. The hatching larvae burrow into the husk to feed on the kernels. Damage to oat ears is difficult to detect and the blackened, thinned kernels can only be seen by opening the grains.

In maize, severe damage can be seen as ragged leaves that are often torn into strips. Mild damage is evident as neat rows of holes across leaves.

Monitoring

A risk assessment for winter cereals can be made by sampling the grass or stubble for frit fly eggs/larvae before ploughing. Key monitoring takes place after full emergence (see Thresholds).

Thresholds

Examine plants soon after full emergence. If more than 10% are damaged, an insecticide is recommended.

Non-chemical control

To minimise damage to winter cereals, plough grass and leave it at least four weeks before sowing. If there is no live buried grass, the frit fly larvae will soon die from starvation. For spring oats, early sowing is the best method of avoiding attack. There is only a narrow window of opportunity to control frit fly in spring cereals before they burrow into the crop. If damage is seen, it is too late to treat with insecticides. Any husbandry, such as rolling, that encourages rapid establishment and growth will help to minimise frit fly damage. Natural enemies include spiders, ground beetles, rove beetles, predatory flies and many parasitoid species.

Insecticide resistance

None known.

Gout fly (*Chlorops pumilionis*)

Crops affected

- ✔ Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

Adult gout fly

Importance

Gout fly is present across the UK and is an occasional minor pest of cereals. It can damage wheat, barley and triticale. There are two generations per year. The first lays eggs in May/June and the second lays eggs in late August/September.

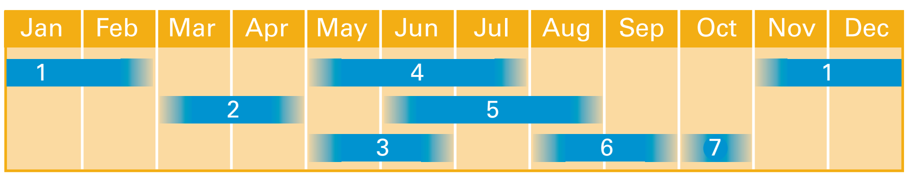
In autumn-sown crops, yield losses can range from 0.25 tonnes/ha to, in exceptional circumstances, total crop failure if half or more of the crop is damaged. Winter damage kills affected tillers and any still dependent on the mother plant. At lower levels of incidence, unaffected tillers with developed crown root systems can compensate for damage and survive.

Shoots damaged by spring generations of gout fly lose 30% of grain yield on average but this can rise to up to 50% yield loss in late-sown spring crops.

Risk factors

Crops emerged by the end of September are at greatest risk from the autumn generation of flies. Late-sown winter and spring crops are at greatest risk from the spring generation. Crops at, or beyond, GS37 by mid-May in southern England or late May in the Midlands usually suffer only minor damage. Oats and maize are not affected.

Life cycle



1. Larvae overwinter in the centre of the plant, close to the root.
2. Larvae pupate.
3. Adult flies emerge and lay eggs on leaves close to the central shoots.
4. Hatching larvae burrow into the centre of the shoot.
5. Larvae pupate.
6. Adult flies emerge and lay eggs on leaves close to the central shoots on early sown winter cereals, weed grasses and volunteer cereals in stubble. Eggs hatch in 7–10 days.
7. If conditions are mild, adults may remain active.

Gout fly (*Chlorops pumilionis*)

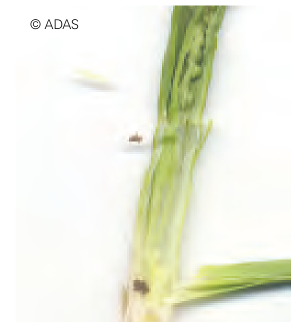
Identification and symptoms

Adult flies are yellow with black markings and 4–5 mm long. Minute, creamy white torpedo-shaped eggs are laid on leaves close to the central shoots, usually one per shoot. Larvae are legless, translucent-white and lack a distinct head. When fully grown, they are yellowish-white and 5–6.5 mm long, after which they form a somewhat flattened, brownish pupa.

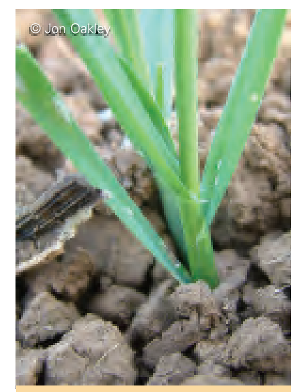
In autumn-sown crops, damage is visible as swollen, gouty and short tillers. This can kill the plant or result in other tillers producing weak ears in summer.

In spring-sown cereals, if the attack occurs before stem elongation, the tiller will be stunted, swollen and gouty and never produce an ear. If the plant is more developed, damage will be less severe; a poorly developed ear emerges with immature grains spoiled on one side, resulting in yield being halved.

Gout fly larva in spring barley



Gout fly leaf damage



Gout fly eggs

Monitoring

Gout fly is sometimes seen near woodlands and hedgerows.

Plants can be checked for the presence of eggs at GS12 in May and June and September/October. These can be seen with the naked eye.

Thresholds

Limited evidence suggests that treating winter crops is economic if eggs are found on more than half of plants at GS12.

Currently, there is no threshold for spring-sown crops.

Non-chemical control

Sow winter wheat and barley after late September if in sheltered fields near woodland. Sowing spring crops as early as practical in high-risk areas will minimise damage.

Two parasitoid species are known.

Insecticide resistance

None known.

Crops affected	
✔	Cereals
✔	Oilseeds
✔	Vegetable brassicas
✔	Potatoes
✔	Carrots
	Alliums
✔	Peas
✔	Field beans
✔	Sugar beet
✔	Lettuce

Importance

Leatherjackets are the larvae of crane flies (daddy longlegs). They are soil-inhabiting pests that mainly feed on roots and the underground parts of the stem.

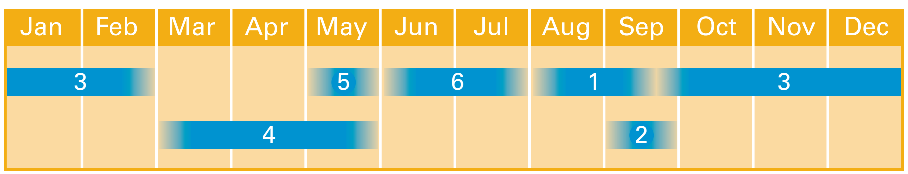
Risk factors

Attacks frequently occur following a grass rotation. Larvae continue feeding in ploughed down turf, moving on to feed on the new crop when the turf rots away. This leads to damage suddenly appearing some weeks after crops emerge.

Leatherjackets are usually most numerous after prolonged damp conditions in late summer and early autumn. Dry September weather can reduce numbers considerably because eggs and young leatherjackets are vulnerable to desiccation.

Winter cereals, particularly those sown late, may be attacked in autumn and mild winters (soil temperatures >0.5°C). Seedlings of spring-sown crops are most vulnerable in April and May, when the leatherjackets are large and voracious. Cereal crops are less likely to suffer economic damage once they have tillered.

Life cycle



1. Adults emerge and lay eggs.
2. Eggs hatch.
3. Larvae feed when soil >0.5°C.
4. Main larval feeding period.
5. Larvae pupate near soil surface.
6. Pupae.

Adult crane fly

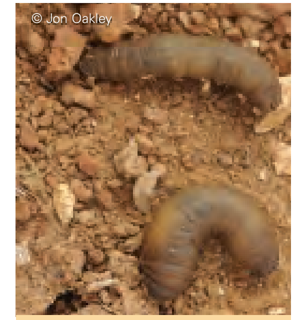
Leatherjackets (*Tipula paludosa* and *Tipula oleracea*)

Identification and symptoms

The larvae (leatherjackets) are greyish-black and grow to 40 mm. They have a tough skin and are plump and soft.

The adults (crane flies) have a long body (approx. 25 mm), ungainly legs and narrow wings. Adults emerge from August to September.

Leatherjackets usually feed just below the soil on roots and stems but on warm, damp nights they may feed on the surface, making ragged holes in leaves and cutting off stems like cutworms.



Leatherjackets (crane fly larvae)

Monitoring

Leatherjacket numbers can be assessed before ploughing by soil sampling using a 10 cm diameter soil corer. A total of 20 cores are taken from an area not exceeding 4 ha. The soil is then washed and sieved in a laboratory to extract the leatherjackets. Alternatively, a Blasdale apparatus can be used, which drives leatherjackets into trays of water by heating the soil cores from above.

An alternative method is to drive plastic pipes (30 cm by 10 cm) into the ground by 5 cm and fill them near the brim with brine. Any leatherjackets will float to the surface. This method is less effective in recently cultivated soil as pipes are less effective at retaining brine. Proprietary brine-based testing kits are available.

Thresholds

Spring cereals: 50 leatherjackets/m^2, or 5 in 12 pipes, or 5/m of row.

Oilseeds: >50 leatherjackets/m^2, or >5 in 12 pipes, >5/m of row.

Non-chemical control

Cultivations decrease the populations of this pest. Ploughing in July and early August (before the main egg-laying period) and ensuring the old sward is well covered by soil can largely prevent attacks but could increase the risk of wheat bulb fly in the east of the UK. If ploughing occurs later, thorough consolidation and a good tilth can enable a crop to grow away, minimising the period in which it is vulnerable.

The larvae of the main pest species, *T. paludosa*, stop feeding by mid-June, so establishing crops, particularly vegetable brassicas, later than this can avoid damage to seedlings.

Insecticide resistance

None known.

Crops affected	
	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
✔	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

Importance

Onion fly is a very localised pest in the UK.

Onion seedlings attacked by onion fly larvae quickly collapse and die. Larger plants are rendered unmarketable by the damage caused by larval feeding.

Risk factors

Using implements that damage onion plants can increase the likelihood of infestation by onion fly.

Life cycle

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	1	1		4	4		1	1	1	1
				2	2	5	5				
				3	3	6	6				

1. Onion flies overwinter as pupae in the soil.
2. The first generation of flies emerge in May/June and the first eggs are usually laid towards the end of May.
3. Larvae move through the soil and burrow into the bases of plants, where they feed on soft tissue.
4. Pupation occurs in the soil near to the host plant.
5. The second generation of flies emerges in July/August.
6. Second generation of larvae.

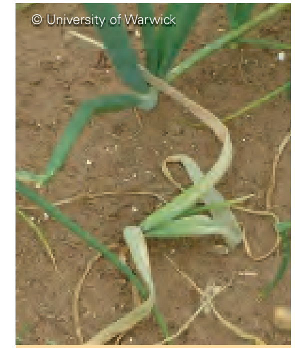
Onion fly life stages

There are usually two generations per year but, in warm locations, there may be a partial third generation.

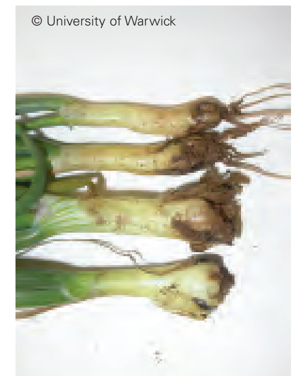
Identification and symptoms

The adult fly is pale grey, hairy and 5–7 mm long. The egg is elongate (1 mm long) and white in colour. Eggs are laid in batches of up to 30 in soil adjacent to host plants or in leaf sheaths. Females may lay 100–500 eggs during their lifetime. The larva is a white maggot which reaches 9–10 mm in length when fully grown. The pupa is oval, reddish-brown to dark brown and 6–7 mm long.

Onion seedlings attacked by onion fly larvae quickly collapse and die. When onion fly maggots are present in large numbers this can lead to patchy crops. Older plants wilt and then the foliage may discolour and then dry out or start to decompose. Larger bulb onions withstand attacks but eventually the foliage will die. When bulbs are cut open, larval feeding damage is evident.



Onion fly damage



Onion fly damage

Monitoring

Coloured water or sticky traps can be used to monitor onion fly adults. White, blue and yellow traps have been used. There is no validated forecasting system for onion fly in the UK.

Thresholds

There are no established thresholds but trap captures do indicate when onion flies are active and how numbers change during the season.

Non-chemical control

Onion fly is a very localised pest in the UK and crop rotation may be an effective way of reducing the risk of infestation.

Natural controls are likely to include generalist predators, such as certain species of beetle, insect-pathogenic fungi and parasitoids (beetles and wasps).

Irradiated sterile male onion flies are released annually into some onion crops grown in the Netherlands. If they mate with wild female flies, the eggs are sterile.

Insecticide resistance

In North America, onion fly populations have developed resistance to a number of insecticides, including the organophosphate chlorpyrifos.

Crops affected	
✔	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

Importance

Orange wheat blossom midge larvae feed on the developing seeds, causing small, shriveled grains with poor germination. Damage to the outer layer of the grain (pericarp) allows water to enter, resulting in sprouting in the ear and facilitating secondary attack by fungi causing fusarium and septoria. This affects both the yield and quality of grain harvested.

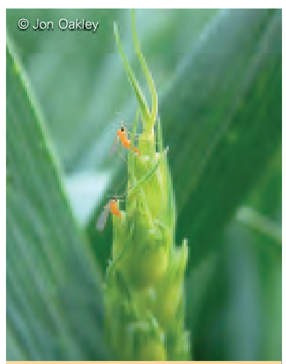
Risk factors

Potentially damaging midge populations may be found in any field where wheat has been grown over the past four years. Larvae pupate in warm, moist soil, usually after heavy rainfall. Midges usually fly when the air temperature exceeds 15°C. On mild, sunny days they will fly later in the evening.

Life cycle

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		1		2	3	5			1		
						4					

1. Larvae overwinter in a cocoon. They can survive in the soil inside cocoons for ten years or more. They pose a major threat for up to four years.
2. Larvae emerge and move to the soil surface. If the soil is warm (>13°C) and moist, the larvae pupate. If not, they return to the cocoon stage.
3. Adults emerge, resting at the crop base during the day and laying eggs in the florets from dusk.
4. Eggs hatch within 4–10 days and larvae feed on the developing grain. Larvae that hatch after flowering do not develop properly and cause little damage.
5. Larvae feed on developing grain for about 2 weeks, then drop to the ground and burrow into the soil.



Adult orange wheat blossom midge

Identification and symptoms

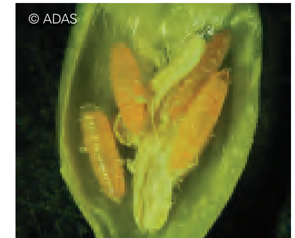
Adult midges are orange and about 3 mm long. Males have long, feathery antennae. Females have a short ovipositor and lay cylindrical eggs. Larvae are orange and up to 3 mm long.

Monitoring

Susceptible crops should be monitored from the start of ear emergence (GS53–59). Pheromone traps provide the earliest warning of midge activity. Place two traps in each field where the midge has been at damaging levels in the past two years, even if the current crop is not a cereal. Set traps at crop height at GS45 one week before ear emergence and leave until flowering (GS61).

Monitoring for adults laying eggs on ears during ear emergence is usually best done from mid-evening when the midges are more evenly spread. Part the crop and count the number of midges.

Yellow sticky traps can also be hung at ear height at the start of ear emergence. A catch of around 10 midges per trap indicates a significant risk. The presence of midges in spider webs is also a good indication that the pest is active.



Orange wheat blossom midge larvae

Thresholds

Pheromone traps

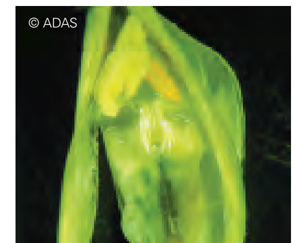
30 or more midges: General risk in the next week. Monitor crops for females.

More than 120 midges: Very high risk. Treat wheat crops in surrounding fields at susceptible growth stages (GS53–59) as soon as possible.

Visual crop inspection

For feed crops: 1 midge per 3 ears

For milling and seed crops: 1 midge per 6 ears



Orange wheat blossom midge damage

Non-chemical control

Growing resistant varieties is a very effective way of minimising risk. Refer to the AHDB Recommended List for more information. In more sheltered fields, reducing the frequency of wheat crops in the rotation can help reduce midge populations.

This pest is attacked by a number of generalist predators but the most important natural enemies are small parasitic wasps, especially *Macroglens penetrans*, which lay their eggs in the midge eggs. The resulting parasitoid larvae develop on the midge larva once it has overwintered, so crop damage is not immediately reduced. Parasitism levels can exceed 80%, however, so a useful level of control can be achieved.

Insecticide resistance

None known.

Pea midge (*Contarinia pisi*)

Crops affected

- Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- ✔ Peas
- Field beans
- Sugar beet
- Lettuce

Importance

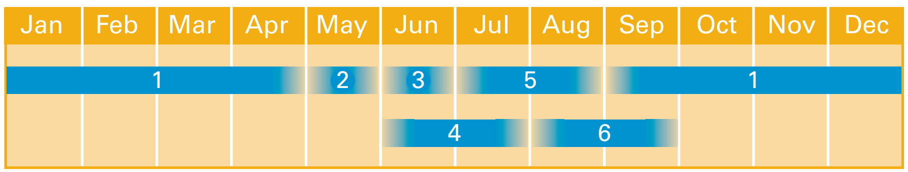
Pea midge attacks can result in loss of yield, which can be very serious where populations have built up in intensive pea-growing areas. Vining peas can be more susceptible than combining peas and yields may be substantially reduced.

Risk factors

Attacks are generally more severe in areas where peas have been grown previously.

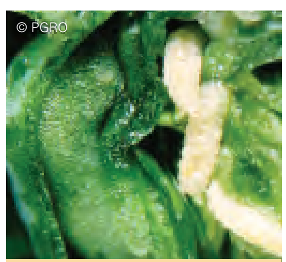
Crops are most susceptible at the early green bud stage. From the Humber northwards, vining peas may not be attacked until late June, so early crops may escape serious damage.

Life cycle



1. Larvae overwinter in soil in cocoons.
2. Larvae pupate. Some may remain in the soil for a year or more.
3. First generation adults emerge and lay eggs on the crop. Hatching larvae enter buds to feed.
4. First generation larvae drop into the soil. Some pupate to create second generation while others remain to overwinter.
5. Second generation adults emerge and lay eggs on the crop. Hatching larvae enter buds to feed.
6. Second generation larvae drop into the soil to overwinter.

Pea midge adult



Pea midge larvae

Pea midge (*Contarinia pisi*)

Identification and symptoms

Pea midge damage

The adults are gnat-like flies with a yellow-grey body about 2 mm long and six long legs. The head is dark, with a pair of very fine antennae. The semi-transparent wings are slightly longer than the body and are folded together along its back when the midge is at rest.

The eggs are approximately 0.3 mm long, oval with a tail-like tip and have a translucent, jelly-like appearance. They are laid in batches of 20 or more on the rudimentary buds and the leaves surrounding them.

Hatching larvae enter the developing buds, where they feed at the base of the ovaries. They may also feed in the clustered leaves of the terminal shoot and the pods. After about ten days, larvae reach maturity and drop to the soil. At this stage, they are 2–3 mm long and a dirty white colour.

Infested buds become swollen, gouty and do not produce pods, thereby directly affecting yield. Larval feeding can also cause the leading shoots to become deformed, limiting their extension growth and producing a "cabbage" or "nettle-head" appearance. Attacked pods become malformed and contain numerous white larvae. In wet periods, damaged tissue may also provide a site for infection by fungi such as *Botrytis* spp.

Monitoring

A monitoring system (Oecos Ltd) provides advance warning of adult emergence. The system comprises four sticky traps with pheromone lures. These should be placed 10 m apart in the previous year's pea field by the third week of May to monitor emergence from overwintering sites. Traps should be inspected at least twice weekly and the sticky cards replaced each time.

Thresholds

If more than 500 midges are caught on one trap, susceptible pea crops in the near vicinity should be examined for the pest. This should be done as late in the day as possible, as the female midges fly into the crop in the afternoon.

Non-chemical control

Cultural controls include early spring sowing, the selection of early varieties, crop rotation and deep ploughing to bury the overwintering larvae. Sowing peas on land adjoining previously infested land should be avoided.

A number of parasitoids have been indentified and the bright red larvae of the midge, *Lestodiplosis pisi*, prey on the pea midge larvae.

Insecticide resistance

None known.

Crops affected

- ✔ Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

Importance

Saddle gall midge is a sporadic pest of cereals, which usually persists at low population levels. In 2010 and 2011, local epidemics were reported in central England, particularly in continuous cropping or tight cereal rotations.

Yield loss is caused by the constriction of the vascular supply to the ears and also by lodging of gall-weakened stems in high winds.

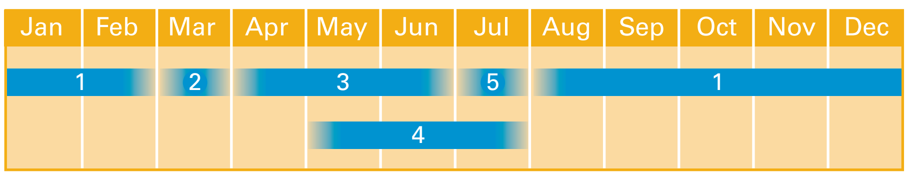
Risk factors

Large populations are associated with heavy soils. Warm and damp soil conditions in May/June are ideal for adults to emerge and lay large quantities of eggs within a short period.

Crops are at most risk when larval feeding coincides with stem extension. Late-sown winter wheat and barley and spring-sown cereal crops are, therefore, at greatest risk. Winter-sown oats attract adults for egg laying but are rarely seriously damaged.

Overwintering larvae are able to delay pupation to subsequent years if soil conditions are unsuitable, ie very dry, so pest numbers have previously been able to build up in continuous cereals.

Life cycle



1. Larvae overwinter in soil.
2. Larvae pupate.
3. Adults emerge and lay eggs along the veins of cereal and grass leaves.
4. Hatching larvae move down the leaf to feed on the stem underneath the leaf sheath. This feeding causes a saddle-shaped gall.
5. Mature larvae fall off the plant, into the soil to overwinter.

Adult saddle gall midge

Identification and symptoms

Adult midges are red and up to 5 mm long. Blood-red eggs are laid in a chain or raft-like pattern along leaf veins on either side of leaves. Hatching whitish-green larvae make their way down to the protection of the leaf sheath to feed on the surface of the stem. By maturity in mid-July, the larvae have developed into an orange-red colour.

Larval feeding causes the formation of characteristic saddle-shaped galls. They usually occur on the top three internodes. The stem can be completely destroyed if numerous galls fuse together. Galls are often hidden beneath the leaf sheath. Symptoms may be more apparent as uneven contours on the stem surface.

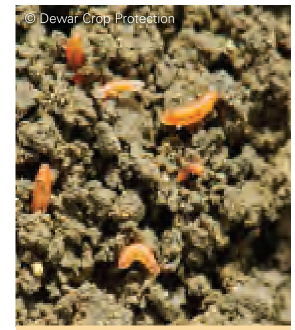
Larval feeding also restricts nutrient supply to the ear and can result in white heads.

Saddle-shaped galls on wheat under the leaf sheath

Monitoring

Yellow water traps are effective at catching adult midges and yellow sticky traps may also be used.

Midge development in soil can be monitored by taking regular soil samples and extracting the developmental stages by wet sieving.



Saddle gall midge larvae

Thresholds

None known.

Non-chemical control

Non-cereal break crops in the rotation will allow population levels to decline. The use of oats, which act as a trap crop may also reduce the risk. Early sowing in September can also reduce the risk of damage.

Carabid beetles, staphylinid beetles and spiders may give some control by preying on larvae in the soil. Some evidence of control by parasitoids has been recorded in Germany.

Saddle gall midge eggs

Insecticide resistance

None known.

Swede midge (*Contarinia nasturtii*)

Crops affected	
	Cereals
	Oilseeds
✔	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

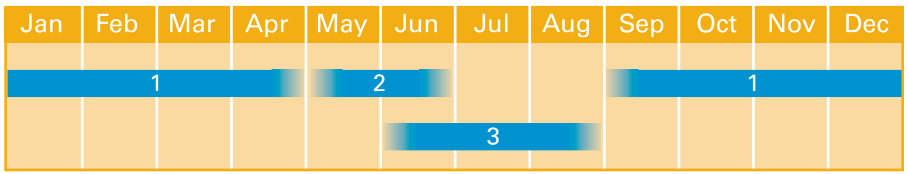
Importance

The larva of the swede midge attacks many types of brassica crop and leads to loss of yield and quality. It is a sporadic pest in the UK. There is a suggestion that outbreaks may occur in years of high humidity and temperature.

Risk factors

With multiple generations and a high reproductive potential, swede midge populations can build up very quickly under continuous production of a host crop.

Life cycle



There are usually three generations in a year. During periods of drought, the larvae may enter a period of dormancy but development resumes after rainfall.

1. The larvae of the third generation overwinter in the soil.
2. These larvae pupate in the spring and adults emerge.
3. Each female lays 60–120 eggs in batches of 15–20 on the younger parts of the plant, particularly the terminal bud. The larvae feed mostly on the growing point but can live on almost any part of the plant within an almost liquid environment. When fully grown, the larvae move to the ground, form cocoons in the soil and pupate. The pupa works itself out of the cocoon and moves to the soil surface until the front end protrudes and then the adult emerges.

Adult swede midge on sticky trap

Swede midge (*Contarinia nasturtii*)

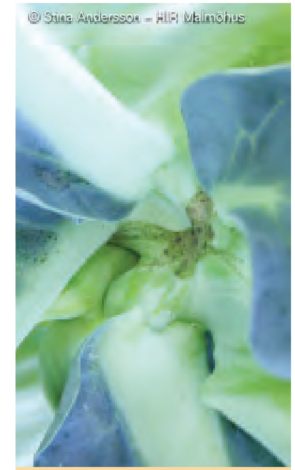
Identification and symptoms

The adult is a tiny, greenish-yellow to light brown fly (1.5–2 mm), which is difficult to distinguish from other closely-related midge species. It has very hairy wings.

The egg is very small (0.3 mm), transparent and then turns creamy white as it develops.

The larva is a small maggot, initially 0.3 mm in size and reaching a final size of 3–4 mm. Larvae are initially translucent, becoming increasingly yellow until lemon-yellow at maturity. The swede midge pupates in the soil.

Damage symptoms include swollen flowers, scarring in the growing point and on leaf petioles and flower stalks, blindness and crinkled leaves. It often kills the main shoot, in which case the side shoots grow out causing a many-necked plant.



Damage due to swede midge larvae

Monitoring

Pheromone traps are available; however, knowledge of insect identification and a microscope are required to separate the male swede midges from other species of fly that accidentally enter the traps.

Thresholds

None known.

Non-chemical control

Annual crop rotation is the single most effective way to reduce swede midge populations in the field.

Crop covers might exclude swede midge, provided the mesh size is sufficiently small.

Insecticide resistance

There is no evidence of insecticide resistance in UK populations. It is believed that there is a risk of resistance developing in Canada, where it is becoming a serious pest.

Crops affected	
	Cereals
	Oilseeds
✔	Vegetable brassicas
	Potatoes
	Carrots
✔	Alliums
✔	Peas
✔	Field beans
✔	Sugar beet
	Lettuce

Importance

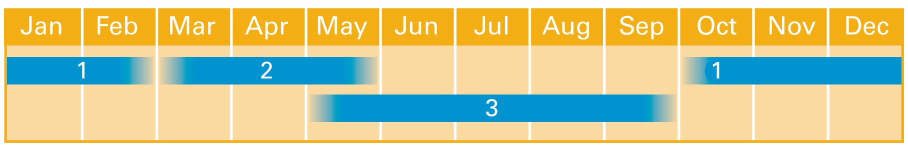
Field thrips (*Thrips angusticeps*) attack pea and bean crops at early emergence, feeding inside the tightly rolled leaves of the growing point, and continue to feed throughout the growing season. They also damage sugar beet foliage.

Pea thrips (*Kakothrips pisivorus*) attack pea crops during and after flowering, causing damage to the pods.

Onion thrips (*Thrips tabaci*) are a pest of several crops in the UK, particularly leek, salad onion, stored cabbage and sugar beet. Plants with obvious thrips feeding damage are considered unacceptable for sale in many cases and, therefore, the economic impact of a thrips infestation can be severe.

In addition to field thrips and onion thrips, sugar beet leaves are also damaged by *Caliothrips fasciatus*.

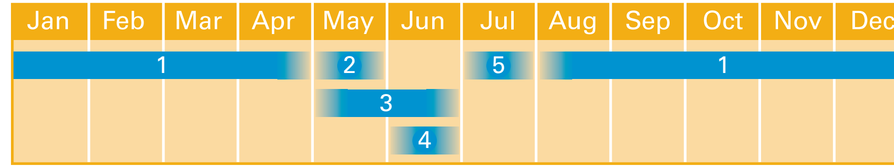
Life cycle – Field thrips



1. Field thrips overwinter in soil as short-winged flightless adults.
2. Field thrips emerge from soil to feed on young crops.
3. Adult field thrips with normal-sized wings migrate to other crops.

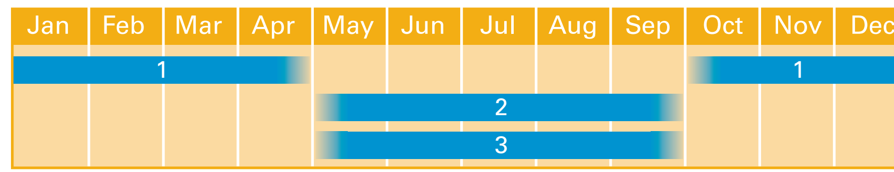
Thrips

Life cycle – Pea thrips



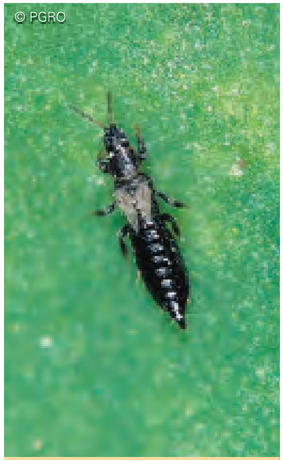
1. Nymphs overwinter in soil.
2. Nymphs pupate.
3. Winged adults emerge and move into crops. Eggs are laid in flowers and on pods. Hatching nymphs feed on the crop.
4. Populations peak mid-June.
5. Nymphs descend into soil.

Life cycle – Onion thrips

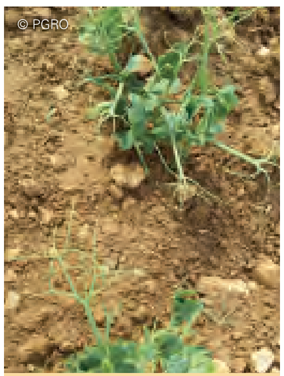


1. In the UK, onion thrips overwinters in the adult stage. Overwintered host vegetable crops such as leek are preferred overwintering sites but they will overwinter in other locations, such as overwintered cereal crops.
2. Once temperatures rise in the spring, female thrips start to lay eggs, either after dispersing to new hosts or on the overwintering host if this is still a suitable food source.
3. Following egg hatch, there are two active larval stages and two inactive stages (pre-pupa and pupa).

A generation (egg to adult) takes about 52 days at 12.5°C and 15 days at 25°C.



Field thrips



Field thrips damage

Risk factors

Field thrips and pea thrips

Attacks are most severe during periods of slow growth, in cold, dry springs, and in particular on stony soils. In good conditions, the crop will usually tolerate damage and grow away.

Onion thrips

Onion thrips populations thrive in warm and dry conditions, which not only promote fast larval development but are ideal for flight. The cryptic behaviour of onion thrips means that they are a very difficult target for insecticides that work by contact action. This may be particularly true for the larvae, which do not move onto the higher and more exposed parts of the plant.

During the winter of 2006/07, there were a number of reports of onion thrips damage to stored cabbage. The winter was exceptionally warm and it is likely that this favoured the continued development of thrips inside cabbage maintained in ambient stores.

Identification and symptoms

Field thrips and pea thrips

The adult thrips are narrow-bodied, dark and shiny, and able to reach approximately 2 mm in length. Adults have two pairs of wings, usually folded along the back, which they can use to migrate large distances. The two species are indistinguishable without microscopic examination.

Minute, kidney-shaped eggs are embedded into the tissues of flowers and pods. The immature stages are similar in shape to the adults but have no wings and are bright yellow with a conspicuous black tip at the rear end.

Field thrips causes damage to the surface of leaves, resulting in mottled patches and distortions. It may be possible to find these thrips by carefully unfolding the leaflets of affected seedlings. On beans, the leaves may appear shiny and speckled with sooty black markings. The undersides of bean leaves develop a rusty brown discolouration. On peas, field thrips cause the foliage to thicken and pucker, with a translucent spotting developing on the surface of leaves. Pea thrips attack later in the season and cause silvery blemishes on the surfaces of pea pods.

In many situations, peas and beans can outgrow the initial attack, with no long term effects on the crop. However, occasionally, when the attack is severe, peas may produce blind shoots that form no flowers, develop multiple secondary shoots and develop as small bushy plants. This is called 'Pea Dwarfing Syndrome' and plants will not recover fully. Bean leaves may die off completely and severely arrest the growth for a week or two.

Onion thrips

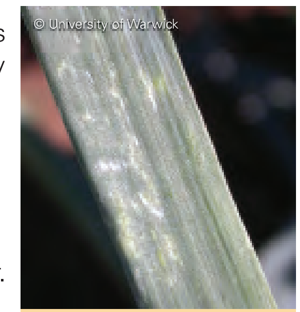
The adult thrips are usually brown in colour and have two pairs of wings fringed with long hairs. They are approximately 1 mm in length. The eggs are minute (0.3 mm long), kidney-shaped and white/yellow in colour. Larvae are yellow/cream in colour, starting around 0.5 mm in length and feeding until they have reached the size of the eventual adult.

Feeding by adult and larval thrips damages the host plant via direct removal of cell contents. As individual plant cells are killed, scarring of the leaf in the form of silvering is observed. On cabbage, feeding by thrips can result in small, brownish-grey growths on the leaf surface as well as silver-coloured lesions.

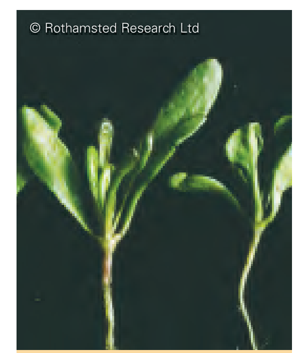
Sugar beet

On sugar beet, thrips feed mainly on young leaves, causing superficial silvering, puckering or reddening. Attacks on heart leaves that are still curled can prevent normal growth and leaf expansion. Damage to the hypocotyl near the soil surface is hard to prevent and can cause seedling death.

Onion thrips larva



Onion thrips damage



Thrips damage in sugar beet

Monitoring

Field thrips and pea thrips

Frequent examinations of the emerging crop should be made. In peas, this should be from the first appearance of pods until the pods are full. Examining late-emerging bean crops is often unnecessary, as they usually escape damage.

Onion thrips

Adult onion thrips can be monitored using sticky traps. Blue and white are considered to be the preferred colours. It may be sufficient to trap thrips at one or two locations within a region, as the pattern of activity appears to be consistent in any year. Thrips infestations can also be monitored directly by examining the crop and it is probably easier to assess damage than to count thrips on plants. The best approach may be to assess the youngest leaves on allium crops: this will indicate the current level of damage rather than old damage.

Thresholds

Field thrips and pea thrips

Treatment in peas and beans is justified as soon as damage is seen. In beans, as most damage occurs while the crop is young, treatment after mid-May is not worthwhile.

Onion thrips

In many cases, adult thrips have been captured on sticky traps before thrips were found on allium plants, indicating that traps could be used to provide an early warning of colonisation. However, there seems to be little opportunity to use the actual numbers of thrips captured on traps to predict the severity of infestation on plants.

Non-chemical control

Thrips are predated by spiders, ladybirds, predatory flies and lacewings.

Field thrips and pea thrips

For field thrips and pea thrips in high-risk areas, sow late-emerging crops.

Onion thrips

Varietal resistance to onion thrips exists in some cultivars of onion and, in the USA, use of some resistant onion varieties was more effective in control of onion thrips populations than application of insecticides. There has been no comprehensive survey of resistance in cultivars grown in the UK.

Intercropping has been investigated as a method of thrips control in onion crops and was found to reduce infestations by 50% or more. Similarly, undersowing with clover has shown excellent potential for the reduction of thrips populations in leek. With both approaches, competition between the crop and companion plants may limit their usefulness, together with the additional costs of taking such an approach.

Irrigation to reduce thrips populations is employed by growers in many countries and there appears to be a consensus that this is effective.

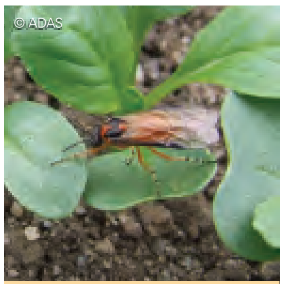
There has been some success in controlling thrips species with predators, although this is mainly in protected crop environments and using augmentative or inundative techniques. This technique has not been evaluated outdoors in the UK.

Entomopathogenic nematodes were investigated as a potential biological control agent on leek in a Defra project. The nematodes appeared to survive for several days in water droplets at the base of the leaves of leek plants but did not do so on the foliage and there was no evidence that they reduced thrips numbers. It is not known whether nematodes trapped in the droplets are able to parasitise nearby thrips and there is the potential for further work in this area to determine whether they are effective either against the larval stages on the foliage or the pre-pupal and pupal stages in the soil. Identification of the susceptible stage would influence the application strategy that might be used.

Insecticide resistance

Insecticide resistance to pyrethroid insecticides in field populations of onion thrips in the UK was confirmed in 2006. There is no evidence of resistance in the other species.

Crops affected	
	Cereals
✔	Oilseeds
✔	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce



Adult turnip sawfly

Importance

The turnip sawfly was considered a serious pest of brassicas in the 18th and 19th centuries but was thought to have been eradicated early in the 20th century. However, since the 1940s, sporadic, minor outbreaks have been have been reported and, in 2006, a major outbreak caused significant crop damage in southern England. The larvae are general and potentially severe feeders on the leaves of brassica plants.

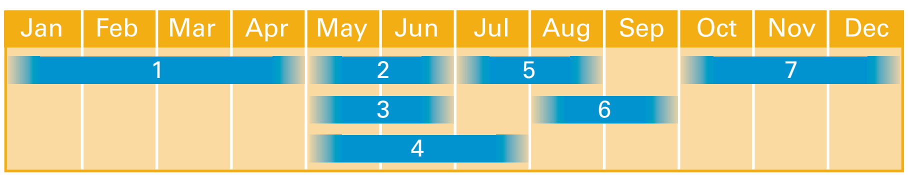
Risk factors

Warm conditions increase adult activity, as they only fly at temperatures above 18°C. Favourable winds increase the possibility of mass immigrations from mainland Europe, where the pest is more common, meaning that southern counties are at greater risk.

A third generation can occur after hot summers and the arrival of the adults in oilseed rape then coincides with the early stages of crop emergence.

The ability of a crop to compensate for turnip sawfly larval attack is largely dependent on how quickly it is able to establish and grow away. Where crops emerge slowly, there is a greater risk of significant defoliation by virtue of the low green leaf area indices.

Life cycle

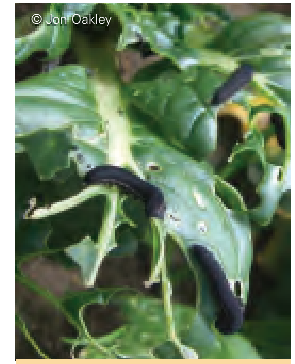


1. Pupae overwinter in soil.
2. First generation of adults emerge and lay up to 300 eggs in the margin of host leaves.
3. Eggs hatch in 6–8 days and larvae feed inside and then externally on the underside of the leaf.
4. At maturity, the larvae drop to the soil to pupate.
5. Second generation of adults emerge and lay eggs.
6. Third generation of adults emerge and lay eggs.
7. Pupae overwinter in soil.

Identification and symptoms

The adults are orange and black in colour, around 7-8 mm in length. The abdomen is entirely orange, while the thorax is orange with two black 'shoulder pads' (other similar sawflies have an entirely black upper surface to the thorax). Legs are orange with black bands.

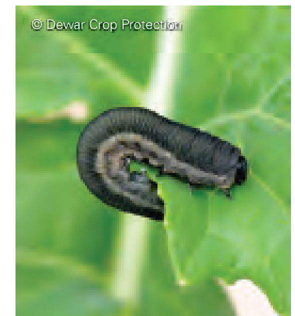
The caterpillar-like larvae are greenish-black in colour with a paler stripe along the side of the body, have a shiny black head and can grow to 18 mm long. The larvae feed gregariously on leaves, which can be quickly skeletonised.



Turnip sawfly larvae

Monitoring

Adult sawflies feed on pollen and nectar, so their presence in flowering hedgerows can give an early warning of imminent attack. Yellow sticky traps and water traps can also be used to monitor the presence of adults. Monitoring should begin in May and continue until September. The purpose of monitoring should be to detect sudden increases in adult activity, which might indicate that a mass immigration has occurred. Turnip sawfly larvae should be easily visible on damaged leaves or close to damaged plants.



Turnip sawfly larva

Thresholds

Oilseed rape: 1–2 larvae/plant.

Please note that this is a German threshold and little information is available on its validity under UK conditions; it is, therefore, offered for guidance only.

Non-chemical control

Spring-sown crops should be situated away from known overwintering sites (such as autumn-sown oilseed rape), wherever possible.

High value, sensitive crops can be protected from adults using covers, such as insect-proof mesh.

Turnip sawflies are hosts for parasitic wasps and flies.

Turnip sawfly larvae and damage

Insecticide resistance

None known.

Wheat bulb fly (*Delia coarctata*)

Crops affected

- ✔ Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

Wheat bulb fly adult

Importance

Wheat bulb fly is one of the most serious pests of wheat in the east of the UK, although it is not abundant every year.

Yield loss depends on tiller density at the time of attack. Crops at the single shoot stage in February are most vulnerable and may be totally destroyed. Up to 100 larvae/m^2 can be tolerated by a well-tillered crop without an economic impact on yield.

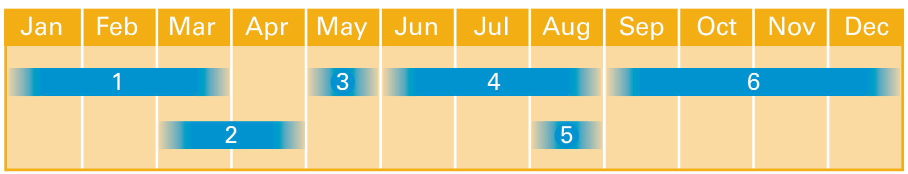
Risk factors

All cereals except oats are attacked, with autumn- or winter-sown crops being most susceptible. Spring wheat and barley are at risk if sown before March but experience little or no damage if sown later.

Eggs are laid on bare soil following fallows, set-aside or early harvested crops, such as vining peas, where cultivation occurs between mid-July and mid-August.

Adults will also lay eggs between row crops, such as potatoes, sugar beet, celery and onions, under hot, dry conditions, especially if the foliage is wilting.

Life cycle



1. Larvae hatch and invade roots of wheat, barley and rye.
2. Larvae attack 3–5 further shoots.
3. Larvae pupate at base of plants.
4. Adult flies emerge and feed on saprophytic fungi on host plant.
5. Eggs laid on bare soil and between row crops.
6. Overwinter as eggs.

Wheat bulb fly larva

Wheat bulb fly (*Delia coarctata*)

Identification and symptoms

Deadheart symptoms

Adults are slightly smaller than, but similar in appearance to, house flies.

Hatching larvae are legless, white, without a distinct head and are pointed at the front end and blunt at the hind end. Once a host has been found, the larvae bore into the plant at the base of the stem to feed. Between mid-April and early May, larvae leave the plant to pupate in the soil.

Damage is seen as classic 'deadheart' symptoms. These symptoms may be difficult to detect without careful examination until February or March.

Monitoring

Egg numbers can be estimated from soil samples. An AHDB Cereals & Oilseeds-funded survey is done by ADAS to aid decision-making on chemical control. See **cereals.ahdb.org.uk/pests** to see which regions and rotations have reached threshold levels. The timing of egg hatch can also be determined by soil sampling.

When deadhearts are found, plant samples can be examined to determine the number of larvae present.

Thresholds

A seed treatment may be necessary in all instances except where there are less than 100 eggs/m^2 in crops drilled Nov–Dec. The risk, however, increases the later the drilling and the higher the egg count.

Non-chemical control

Ground beetles and their larvae are the main predators of wheat bulb fly eggs. Wheat bulb fly larvae may be parasitised by small rove beetles, particularly *Aleochara bipustulata*, with up to 50% killed.

In fields going into cereals, avoid bare ground in July/August and delay cultivation until after egg laying. On bare fallows, a crop of mustard sown to cover the soil by mid-July will also reduce egg laying. The impact of the pest can be reduced by sowing early with an increased seed rate, as the crop will have started to tiller before eggs hatch and be able to tolerate attack.

Insecticide resistance

None known.

Yellow cereal fly (*Opomyza florum*)

Crops affected	
✔	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

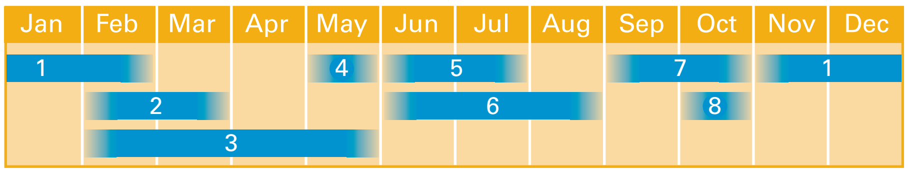
Importance

Each yellow cereal fly larva damages only a single shoot, so economic impact is generally low. Most crops can withstand a considerable number of larvae by producing compensating tillers.

Risk factors

Crops at greatest risk are those with low plant populations and early sown crops in sheltered fields close to woodland.

Life cycle



1. Eggs overwinter.
2. Eggs hatch.
3. Larvae enter and feed on wheat shoots.
4. Larvae pupate in the shoot or soil.
5. Adult flies hatch.
6. Adults spend the summer in woodland.
7. Flies move to early sown wheat crops.
8. Eggs are laid at the base of plants.

Yellow cereal fly adult

Yellow cereal fly (*Opomyza florum*)

Identification and symptoms

The adult fly is small (5–5.5 mm long) with an orange-brown body and black wing markings. Females lay eggs on soil near host plants.

Upon hatching, the larvae crawl up host plants, making their way under the ensheathing leaves to the growing point. The larvae enter the shoot by making an incision in the side or just above the first node. This can be seen as a clean, brown line encircling or spiralling around the shoot (in contrast to the ragged hole left by wheat bulb fly). The larvae are yellow with pointed ends and are thinner than wheat bulb fly larvae but similar to frit fly larvae (though occurring later in the winter). At maturity, the larvae either pupate in the shoot or leave to do so in the soil, forming a hard brown puparium.

Larval feeding results in classic 'deadheart' damage, where the central shoot becomes yellow and dies. Symptoms are similar to frit fly damage (see page 95), particularly in winter wheat, but are not noticeable until spring, long after frit fly attack has ceased.

Yellow cereal fly larva

Entrance hole

Monitoring

It is possible to dissect plants to determine the level of pest infestation but the economic impact of yellow cereal fly is generally low, as it only infests a single tiller.

Thresholds

None known.

Non-chemical control

Ground beetles feed on soil-borne eggs and pupae. Ladybirds and soldier beetles feed on pupae.

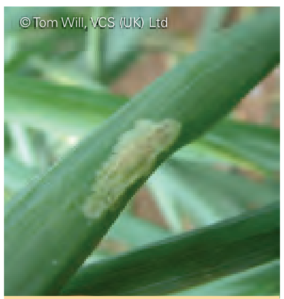
It should be possible to avoid economic damage by planting at least 200 plants/m^2 in vulnerable situations.

Insecticide resistance

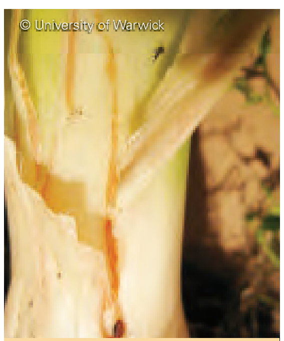
None known.

Allium leaf miner (*Phytomyza gymnostoma*)

Crops affected	
	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
✔	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce



Allium leaf miner damage



Allium leaf miner damage

The allium leaf miner was first detected in the UK in 2002, since when it has spread, particularly in the Midlands. While this species was initially a pest of allotments and gardens, it has now been found damaging commercial crops of onion, leek and garlic.

Relatively little is known about the biology of this new pest. It is likely that it has two generations per year in the UK: the first generation laying eggs in March/April and the second generation laying eggs in October/November.

Before laying eggs on the stems or bases of leaves, the female flies feed by making punctures in the leaves and sucking up the exuding sap. This causes distinctive lines of white dots on the foliage. The larvae make tunnels in the foliage, stems and bulbs. Pupation takes place mainly within the stems and bulbs but some pupae may end up in the soil, especially where plants have rotted off.

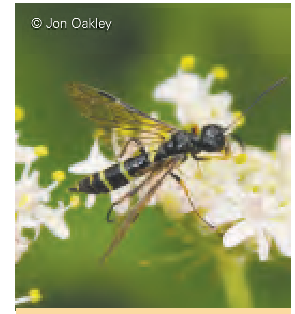
Plants affected by allium leaf miner tend to rot due to secondary infections from fungi and bacteria that develop in the damaged tissues.

Plants could be protected by covering them with insect-proof netting at times when the adult flies are active and laying eggs.

Cereal stem sawfly (*Cephus pygmaeus*) and leaf sawflies

Crops affected	
✔	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

The cereal stem sawfly (*Cephus pygmaeus*) is seldom of importance; however, crop losses can occur in some years when there are large numbers of the pest. Winter wheat is usually attacked but damage can sometimes be seen in spring wheat and barley.



Cereal stem sawfly adult

A number of species of leaf sawfly also attack cereals, causing damage in early summer; however, this is rarely economically important.

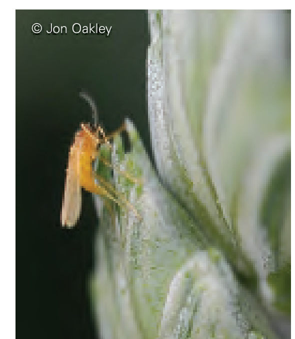
There are several parasitoid species that attack cereal sawflies.

Yellow wheat blossom midge (*Contarinia tritici*)

Crops affected	
✔	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

Yellow wheat blossom midge is less common than orange wheat blossom midge and is rarely damaging. It follows a similar life cycle but is less persistent, with larvae pupating within three years of entering the soil. Adults emerge at a similar time to orange wheat blossom midge but lay eggs slightly earlier (as the boot splits to reveal the ear).

The larvae feed on the stigma, preventing pollination and development of the grain, and then on the anthers, which are retained within the floret. After two to three weeks of feeding, they jump from the floret in wet weather. Some larvae pupate in September, forming a partial second generation that feeds on couch grass.



Yellow wheat blossom midge adult

Further information

Alerts and bulletins

AHDB Horticulture Pest Bulletin: horticulture.ahdb.org.uk/latest-pest-bulletin

AHDB Horticulture Publications

Available at **horticulture.ahdb.org.uk**

Factsheet 03/13: Bean seed fly (2013)

Factsheet 35/12: Minor pests of Brassicas (2012)

Factsheet 10/11: Leafminers of cruciferous salad crops (2011)

Factsheet 09/11: Control of thrips in Allium and Brassica crops (2011)

Factsheet 11/10: Turnip sawfly: biology and control (2010)

Factsheet 28/05: Swede midge control in brassica crops (2005)

AHDB Cereals & Oilseeds Publications

Available at **cereals.ahdb.org.uk/publications**

Information sheet 53: Orange wheat blossom midge (2016)

Information Sheet 51: Wheat bulb fly (2016)

Information Sheet 15: Biology and control of saddle gall midge (2012)

Research Review 86: A review of pest management in cereals and oilseed rape in the UK (2016)

AHDB Cereals & Oilseeds neonicotinoid information: cereals.ahdb.org.uk/neonics

Pests: Moths and butterflies

Contents – Pests: Moths and butterflies

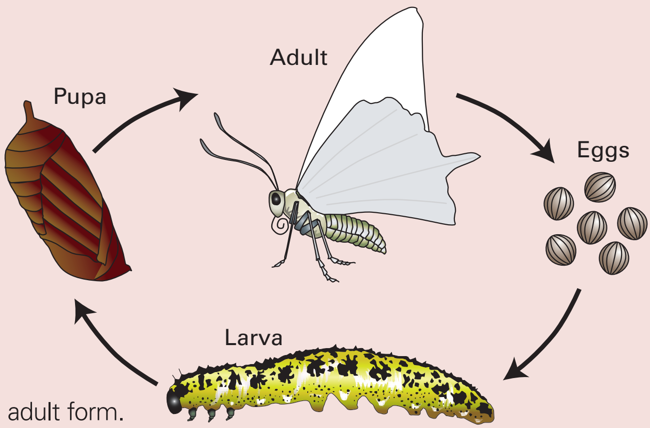
Moths and butterflies (Lepidoptera)

Butterflies and moths can be important pollinators but their larvae (caterpillars) are sometimes pests.

Life cycle

Male and female moths usually find each other by scent. This means that pheromone traps can be used to monitor them. For butterflies, the initial attraction is by sight.

The outer skin of the larva (caterpillar) cannot grow and so must be shed in a series of moults as it grows. When the larva is fully grown, it turns into a pupa or chrysalis. This is a non-feeding stage, inside which the larval body is broken down and reassembled in the adult form.

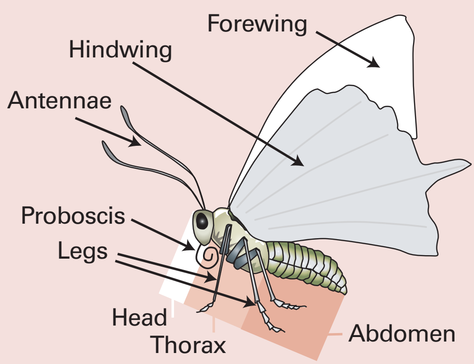


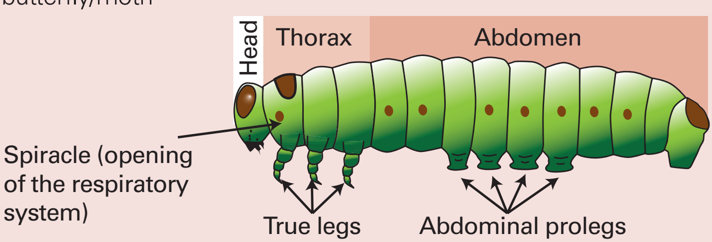
Defining features

Butterflies and moths are distinguished from other insects primarily by the presence of scales on the external parts of the body, particularly the wings.

The larvae, caterpillars, have a toughened head capsule and a soft segmented body with three pairs of true legs and up to five pairs of abdominal prolegs.

See page 80 for a comparison of sawfly larvae and butterfly/moth caterpillars.





Crops affected

- Cereals
- Oilseeds
- ✔ Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

Importance

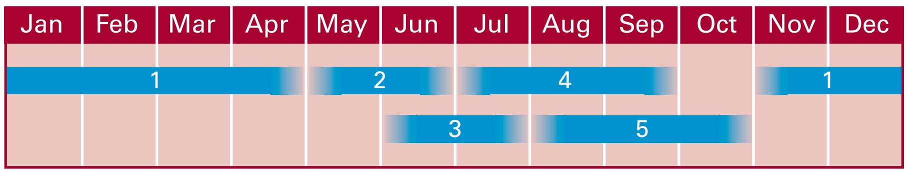
Feeding by the larvae of the cabbage moth can rapidly skeletonise the outer leaves of large plants and sometimes destroy small plants. Large larvae may also bore into the hearts of plants such as heading cabbage. Frass (droppings) and the larvae can contaminate fresh produce.

Risk factors

While vegetable brassicas are the most susceptible crops, larvae will feed on a wide range of plant species, including potato and other vegetables (though without causing economic damage).

Eggs may not be detected until damage has occurred.

Life cycle



1. Cabbage moth generally overwinters as a pupa in the soil, although it may also overwinter as a larva.
2. Adult moths (1st generation) emerge from pupae and lay eggs.
3. Larvae feed/pupae formed.
4. Adult moths (2nd generation) emerge from pupae and lay eggs.
5. Larvae feed/pupae formed.

Cabbage moth eggs

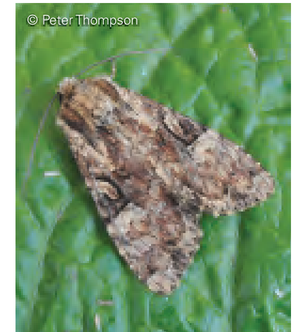
The second generation is the most damaging to brassica crops. Large larvae may be found on crops quite late in the season.

Cabbage moth larva

Cabbage moth larvae

Cabbage moth (*Mamestra brassicae*)

Identification and symptoms



Adult cabbage moth

Adults are greyish-brown mottled with dark brown and the forewings have a span of 35–50 mm. There is a kidney-shaped marking with a white outline on each forewing and an irregular white transverse line near the wing margin.

Eggs are hemispherical (0.5–0.6 mm diameter) and white in colour, darkening close to hatching. They are laid in batches of up to 50.

Newly hatched larvae are green and feed gregariously on leaves. As the larvae grow, their colouring becomes more variable and they may be green, brown or even almost totally black. Older larvae have a dusky dorsal stripe, speckled with white and a yellowish, light green or dusky brown stripe low down on the sides. The larvae are 40–50 mm long when fully grown and the larva pupates in a cocoon in the soil.

Monitoring

Male moths can be captured by pheromone traps. This information can be used to time crop walking to determine whether treatment is required.

Thresholds

None established.

Non-chemical control

This pest is attacked by a number of polyphagous predators. The eggs or larvae may also be parasitised by certain species of wasp or fly, which eventually kill the larva. The larvae continue to feed for some time after they are parasitised and so crop damage is not reduced immediately. Larvae may also be killed by viruses.

Biological control with egg parasitoids (*Trichogramma* spp.) has been investigated overseas but not in the UK. Pesticides based on certain microbial control agents (fungi, nematodes, viruses) may be effective; however, care should be taken when choosing biopesticides based on *Bacillus thuringiensis* (Bt), as some strains are relatively ineffective against this pest.

There is no host resistance available in commercial cultivars at present. Sources of resistance in brassicas have been identified in the past.

Insecticide resistance

None known.

Cutworms (Noctuid moths, eg *Agrotis segetum*)

Crops affected	
	Cereals
	Oilseeds
✔	Vegetable brassicas
✔	Potatoes
✔	Carrots
✔	Alliums
✔	Peas
	Field beans
✔	Sugar beet
✔	Lettuce

Importance

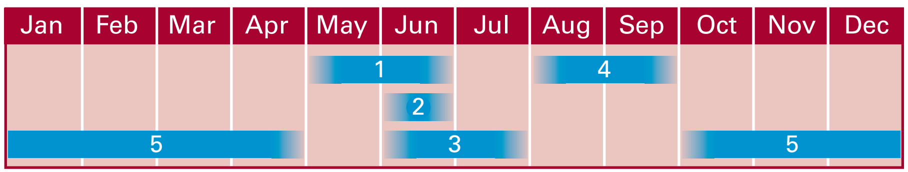
Cutworms are the larvae of certain Noctuid moths, in particular the turnip moth. Older larvae feed underground, damaging plant roots and stems, sometimes so badly that the plant stem is severed. Although cutworms are sporadic pests, damage can be severe, leading to the loss of plants and reductions in quality.

Young lettuce and leek plants are easily bitten through by cutworms. Roots and onion bulbs can be rendered unmarketable by cutworm feeding.

Risk factors

The most vulnerable crops are lettuce, leeks and red beet. Moderately susceptible crops include brassicas, carrot, celery, parsnip and sugar beet.The least susceptible crops are onion, potato, swede and turnip. Cutworm damage is most severe in light, sandy soils. The risk of damage is increased in hot, dry years.

Life cycle



1. Adult turnip moths lay eggs on plants or on pieces of litter and debris in the soil.
2. Eggs hatch in around 8–24 days, depending on temperature and the young larvae seek out and feed on the aerial parts of plants.
3. In a further 10–20 days, again depending on temperature, the larvae go through their second moult, becoming 'third instar' caterpillars. It is at this point that they adopt the cutworm habit, becoming subterranean and feeding on roots.
4. A second generation of turnip moths may emerge in late summer but the caterpillars of this generation do not appear to be damaging.
5. The pest overwinters as the larvae of the second generation, with pupae forming in April-May.

Adult turnip moth

The life cycles of other species may vary from this pattern. For example, *Euxoa nigricans* (garden dart moth) lays eggs in the late summer, which hatch in the following spring. The larvae feed on beet seedlings during April and May before pupating.

Cutworms (Noctuid moths, eg *Agrotis segetum*)

Identification and symptoms

Adult turnip moths have a wingspan of about 40 mm. The forewings are pale greyish-brown with dark brown markings which include rings and lines.

The eggs are globular, about 5 mm in diameter and white in colour, later turning cream with reddish-yellow markings and an orange band.

Fully grown caterpillars are greyish-brown and about 40 mm long.

Seedlings and young plants are severed from their roots and die. Cutworms make cavities in stems, rhizomes, tubers and roots of large plants, similar to slugs. Cutworms may move along the rows of crops such as lettuce or leek, cutting plants off one after another. Damage to root crops may not be evident until harvest.

The potato stem borer attacks sugar beet, potatoes and other crops. In sugar beet, it tunnels inside the crown and upper part of the root of young plants: the roots blacken internally and, externally, there may be blackening on the crown of the root.

Cutworms

Cutworm damage to sugar beet

Monitoring

Male moths can be captured by pheromone traps.

The 'cutworm model' is a computer programme that uses weather data (air temperature and rainfall) to predict the rate of development of turnip moth eggs and caterpillars. It then predicts the level of rain-induced mortality among the early instar caterpillars and target dates at which to apply irrigation or insecticides.

Thresholds

None established.

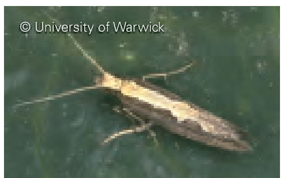
Non-chemical control

Young larvae are very susceptible to irrigation while feeding above ground on plant foliage and well-timed irrigation can be a very effective method of control. To date, biological control with predators or parasitoids has not been investigated in the UK. Pesticides based on microbial control agents (eg Bt) may be effective.

Insecticide resistance

None known.

Crops affected	
	Cereals
✔	Oilseeds
✔	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce



Diamond-back moth adult

Importance

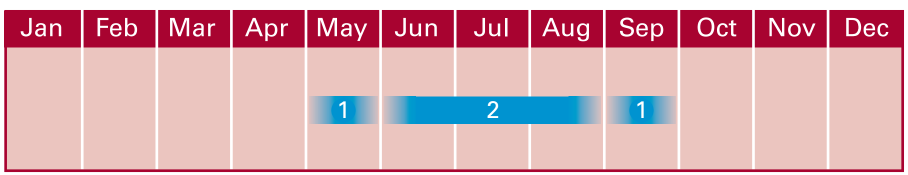
Diamond-back moth may infest crops throughout the UK and the larvae can cause damage to the foliage of cabbage, cauliflower, broccoli, Brussels sprout, kale, Chinese cabbage, swede, turnip, oilseed rape and radish. Large infestations can cause damage to up to 100% of plants but yield losses will depend on the impact of damage on plant growth and quality. Good control is particularly important where the marketable part of the plant is damaged (cabbage, cauliflower, broccoli, Brussels sprout). Plants with low levels of damage usually survive but this may affect uniformity within the crop.

Risk factors

Infestations are sporadic, so control may not be necessary in every crop in every year.

Weather that favours migration from continental Europe increases the risk of infestation, as the diamond-back moth does not overwinter in the UK in large numbers at present. The moths are relatively poor flyers but may be transported long distances by the wind.

Life cycle



Relative risk of egg laying and damage: ① Low. ② High.

The rate of development of diamond-back moth is dependent on temperature, so more generations will be completed in warm locations. In the UK, depending on when moths arrive, there may be two to three generations per year. Eggs may hatch within 2–3 days of being laid and a complete generation takes about 5 weeks at 15°C.

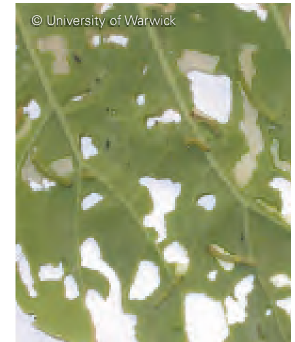
Identification and symptoms

Adult moths are about 6 mm long. They are brownish and have three light brown to white triangular marks on the trailing edge of each forewing. When the adults are at rest, the triangular marks on the forewings meet to form diamond shapes.

The eggs are yellow and laid singly or in small groups, mainly alongside the mid-rib or leaf veins.

The larva is light green and has a tapering body that is widest in the middle. Larvae that are disturbed wriggle violently. Fully grown larvae (15 mm) construct a flimsy cocoon on the leaf surface before developing into a pupa about 9 mm long.

The larvae destroy the foliage of most types of brassica crop. They generally eat almost all leaf material except the upper epidermis, which makes the leaves appear as if they are covered by lots of windows. Large infestations will destroy the leaves entirely. They will damage plants of any age.



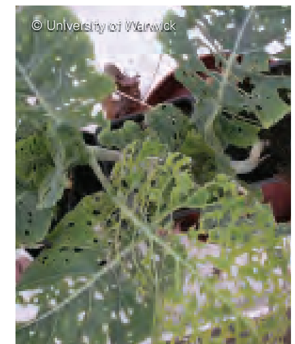
Diamond-back moth larvae on cauliflower leaf

Monitoring

Male moths can be captured by pheromone traps. This information can be used to time crop walking to determine whether treatment is required.

Thresholds

There are no current validated thresholds for diamond-back moth in the UK, although thresholds have been developed in the USA and elsewhere. Such thresholds would need to be dependent on plant type and size.



Diamond-back moth larval feeding damage

Non-chemical control

Fine mesh netting (crop covers) has been tested as a method of preventing egg laying by female moths but eggs were laid on the mesh and the larvae crawled through onto the crop. Other physical and cultural approaches (companion planting, trap crops) have been investigated but are not as effective as the use of currently available insecticides.

To date, biological control with predators or parasitoids has not been investigated in the UK. Pesticides based on microbial control agents (Bt and viruses) can be effective.

Insecticide resistance

Resistance to pyrethroids has been confirmed in the UK.

The diamond-back moth is an important pest worldwide, particularly in tropical regions where populations have developed resistance to almost all of the insecticide groups to which they have been repeatedly exposed.

Garden pebble moth (*Evergestis forficalis*)

Crops affected

- Cereals
- Oilseeds
- ✔ Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

Importance

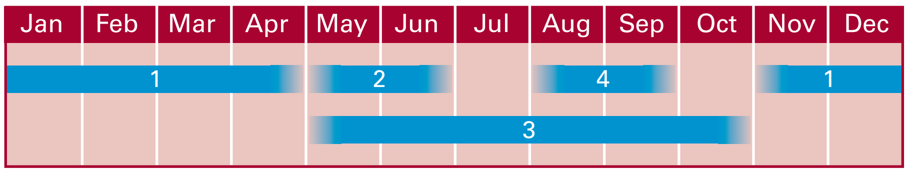
Feeding by the larvae of the garden pebble moth can cause damage to plant foliage. Larvae sometimes mine into the hearts. Frass (droppings), larvae and silk webbing can contaminate fresh produce.

Garden pebble moth tends to be a localised pest.

Risk factors

The larvae hide themselves within plant foliage and infestations may not be detected until damage has occurred.

Life cycle



1. Pupae overwinter in the soil.
2. Adults (1st generation) emerge and lay eggs.
3. Larvae feed/pupae formed.
4. Adults (2nd generation) emerge and lay eggs.

The second generation is the most damaging to brassica crops.

Adult garden pebble moth

Garden pebble moth (*Evergestis forficalis*)

Identification and symptoms

Adults have a wingspan of 25–30 mm. The forewings are yellowish-white, with brown veins, and covered with a series of oblique brown lines and shaded areas.

Eggs are laid in batches of about 20 on the undersides of leaves. They are shiny, oval and flattened and are initially translucent before becoming yellow.

Young larvae are yellowish-green but later become glossy pale green with yellowish mid-dorsal and lateral stripes. A fully grown larva is 18–20 mm long with a row of black spots along each side. Larvae feed on the underside of leaves, frequently as a group within leaf folds and beneath protective silk webbing. The larvae pupate in cocoons in the soil.

Monitoring

Male moths can be captured by pheromone traps. This information can be used to time crop walking to determine whether treatment is required.

Thresholds

None established.

Non-chemical control

This pest is attacked by a number of polyphagous predators. The eggs or larvae may also be parasitised by certain species of wasp or fly, which eventually kill the larvae. The larvae continue to feed for some time after they are parasitised and so crop damage is not reduced immediately.

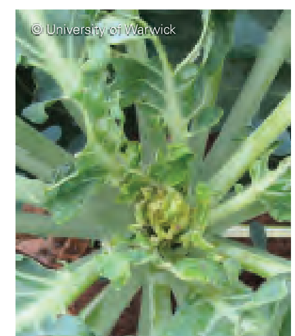
To date, biological control with predators or parasitoids has not been investigated in the UK. It is not clear how susceptible the larvae are to products based on *Bacillus thuringiensis* (Bt).

Insecticide resistance

None known.

Young garden pebble moth larva

Garden pebble moth larva



Garden pebble moth damage

Ghost moth (*Hepialus humuli*) and **Swift moth** (*Korscheltellus* (*Hepialus*) *lupulinus*)

Crops affected

- ✔ Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- ✔ Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- ✔ Lettuce

Importance

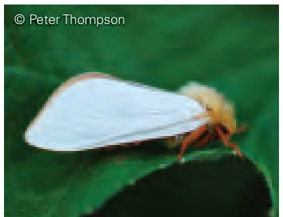
The larvae cut off plants just below ground level or tunnel into roots or stems.

They are minor and localised pests.

Risk factors

The ghost moth, or ghost swift moth, is common in grassland, so any crop following a grass ley is liable to attack.

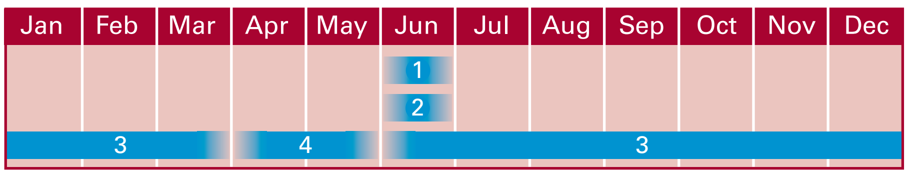
Lettuce is especially liable to damage from the swift moth, or garden swift moth.



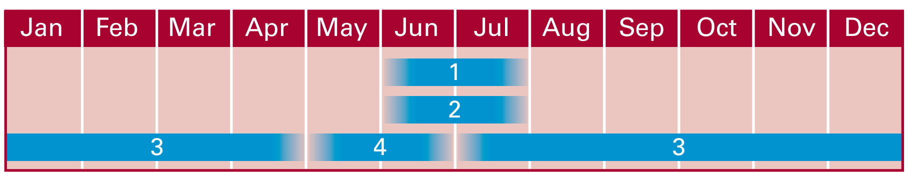
Male ghost moth

Female ghost moth

Swift moth life cycle



Ghost moth life cycle



1 Moths. 2 Eggs. 3 Larvae. 4 Pupae.

Swift moths emerge in late May/early June and females lay about 200 eggs. The eggs are dropped singly while the female moth is flying. Young larvae feed in the summer and autumn but severe damage occurs only during the late autumn and spring of the following year, especially in February/March. The larvae of the ghost moth usually feed for two years before pupating.

Ghost moth (*Hepialus humuli*) and **Swift moth** (*Korscheltellus* (*Hepialus*) *lupulinus*)

Identification and symptoms

Adult swift moths have a wingspan of 30–40 mm with dark brown forewings with white streaks meeting to make a 'v' shape. The hindwings are plain brown. A significant proportion of individuals of both sexes are plain buff or brown with no pattern. The larvae are white and the head is orange-red and well protected. They reach 30–40 mm when fully grown.

Adult ghost moths have a wingspan of 40–65 mm. The male is silvery white and the female is pale buff with a series of pale pink markings on the forewing. The eggs are oval and shiny white. The larvae are similar to those of the swift moth.

Adult swift moth

Monitoring

There are no recognised ways of monitoring these pests. Infestations may not be detected until damage has occurred.

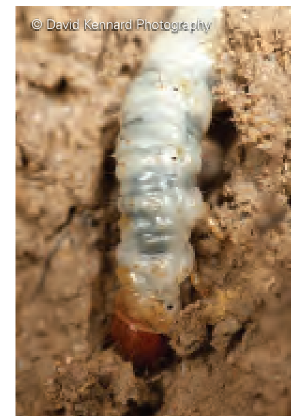
Thresholds

None established.

Non-chemical control

Larvae may be killed by cultivation.

These pests are attacked by a number of polyphagous predators, including birds and moles. The larvae may also be parasitised by certain species of wasp which eventually kill the larvae. The larvae continue to feed for some time after they are parasitised and so crop damage is not reduced immediately. Larvae may also be killed by a fungal disease.



Swift moth larva

To date, biological control has not been investigated in the UK.

Insecticide resistance

None known.

Crops affected

- Cereals
- Oilseeds
- ✔ Vegetable brassicas
- Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

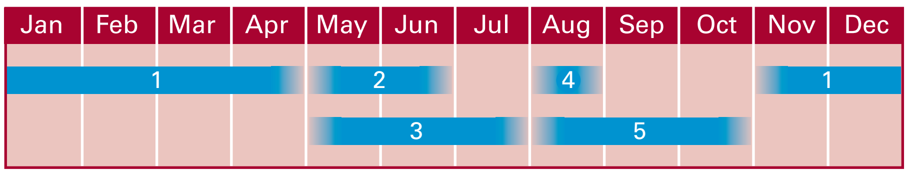
Importance

Feeding by the larvae of the large white butterfly damages foliage and can skeletonise leaves, particularly on field margins. Frass (droppings) and the larvae can contaminate fresh produce.

Risk factors

The larvae hide themselves within plant foliage and infestations may not be detected until damage has occurred. Eggs are usually laid in large numbers on only a few plants, so these can be severely damaged while other plants escape. This species is not such a significant problem as the small white butterfly, whose larvae are well camouflaged and widely distributed in the crop.

Life cycle

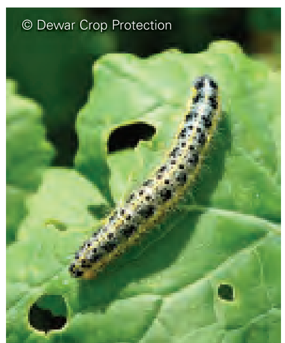


1. Pupae overwinter.
2. Adults (1st generation) emerge from pupae and lay eggs.
3. Larvae feed/pupae formed (1st generation).
4. Adults (2nd generation) emerge from pupae and lay eggs.
5. Larvae feed/pupae formed (2nd generation).

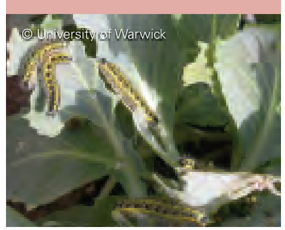
The second generation is the most damaging to brassica crops.

Large white butterfly eggs

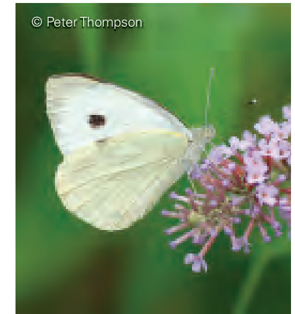
Young large white butterfly larvae



Large white butterfly larvae



Identification and symptoms



Adult large white butterfly

Adults are white butterflies with a wingspan of 60–70 mm. The tips of the forewings are black and the female has large black spots on the upper surface of each forewing.

Eggs are yellow and flask-shaped (1.5 mm high and 0.6 mm at their base) and laid in batches of 20–100 on the undersides of leaves.

Young larvae are pale green initially but soon become mottled blue-green. When fully grown, a larva is 25–40 mm long and has three yellow longitudinal stripes along the body. It is covered with black markings and has groups of short, stiff white hairs that arise from fleshy protuberances along the body. When fully grown, the larva leaves the plant and finds a sheltered site to pupate on a vertical or overhanging surface. The pupa is grey-green in colour and is attached by a silken girdle.

Monitoring

Adult butterflies can be captured in yellow water traps or on yellow sticky traps.

Thresholds

None established.

Non-chemical control

This pest is attacked by a number of polyphagous predators, including some birds and large beetles.

Natural mortality of larvae can be high, due to a species of parasitic wasp (*Cotesia glomerata*) and also as a result of infection by a baculovirus. The small, bright yellow cocoons of the parasitic wasps can often be seen clustered alongside dead or dying larvae from which they have emerged. The larvae continue to feed for some time after they are parasitised and so crop damage is not reduced immediately.

The larvae can be controlled with products based on *Bacillus thuringiensis* (Bt). The possibility of control by inundative releases of egg parasitoids (*Trichogramma* spp.) has been investigated overseas, as has the use of fungal pathogens but neither approach has been evaluated in the UK.

Because the eggs are laid in batches and the larvae feed gregariously, it is relatively easy to spot plants damaged by large white butterfly and either control the pest by hand-picking them or avoid the affected plants at harvest.

Insecticide resistance

None known.

Crops affected

- Cereals
- Oilseeds
- Vegetable brassicas
- Potatoes
- Carrots
- ✔ Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

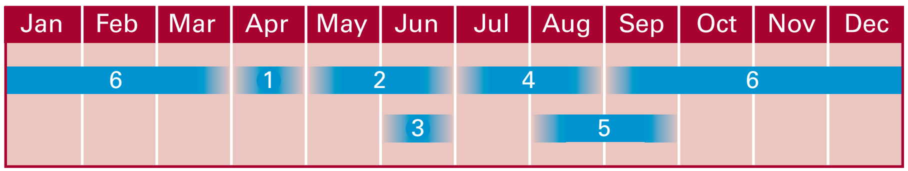
Importance

Leek moth larvae (caterpillars) make 'shot holes' in folded leaves and this damage and associated decay render leeks unmarketable.

Risk factors

Leek moth may be more of a problem in warm locations towards the south of the UK.

Life cycle



Adult leek moth

1. Adult moths emerge in April and lay eggs (up to 100 per female) singly on foliage towards the base of the plant.
2. The larvae feed during May and June. At first, they mine the leaves, leaving the epidermis intact but then they bore through the folded leaves to feed near the centre.
3. The larvae pupate in flimsy silken cocoons attached to the host plants.
4. Adults (2nd generation) emerge and lay eggs.
5. Larvae (2nd generation) feed.
6. Pupae overwinter.

There are likely to be two generations in the UK, with the second generation larvae feeding in August and September.

Leek moth (*Acrolepiopsis assectella*)

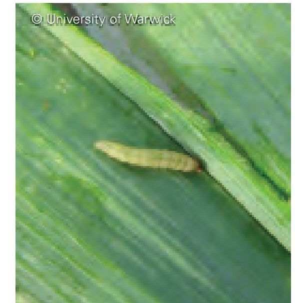
Identification and symptoms

The adult moth has a wingspan of 15 mm. The forewings are slender and narrow and have a variable brown colour, with paler scales near the apices. There is a conspicuous white triangular mark halfway along the rear margin of each forewing. The rear margins of the forewings are fringed with pale-coloured hairs.

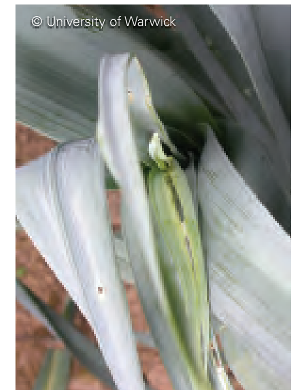
The egg is oval-shaped, white, iridescent and about 0.4 mm in diameter.

The larva is 13–14 mm long when fully grown and has a brown or yellow head and a yellowish-green body with inconspicuous grey-brown patches, especially around the spiracles, and yellow plates on the first and last segments. The pupa is about 6 mm long and brown.

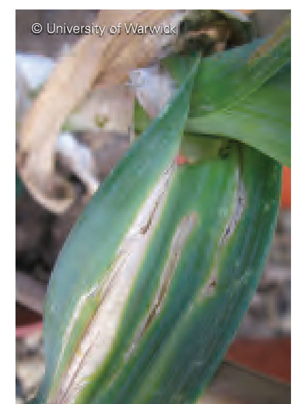
Mining of the leaves of leeks by young larvae leads to patches of papery, necrotic tissue. Older larvae make 'shot holes' in folded leaves. Severely damaged leaves sometimes rot and if the rotting is extensive the plant will die.



Leek moth larva



Leek moth damage



Leek moth damage

Monitoring

Male moths can be captured by pheromone traps. This information can be used to time crop walking to determine whether treatment is required.

Thresholds

There are no validated thresholds for the UK.

Non-chemical control

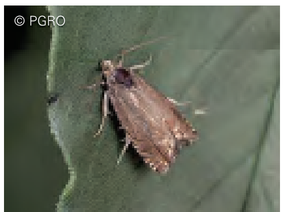
Crop rotation and locating new crops away from previously infested soil are necessary to prevent reinfestation. Crop debris can be destroyed to kill pupae. Leek moth larvae can be attacked by natural enemies, including parasitic wasps. Biopesticides based on *Bacillus thuringiensis* can be used to control the larvae. The use of insect-pathogenic nematodes has also been evaluated experimentally and appears to be effective.

Insecticide resistance

None known.

Pea moth (*Cydia nigricana*)

Crops affected	
	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
✔	Peas
	Field beans
	Sugar beet
	Lettuce



Pea moth

Importance

Pea moth is one of the most damaging pests of peas in the UK. The larvae feed on peas inside the pod, with the resulting economic damage largely due to contamination and reductions in quality.

In vining peas, the presence of damaged peas, which cannot be removed mechanically, can result in crop rejection.

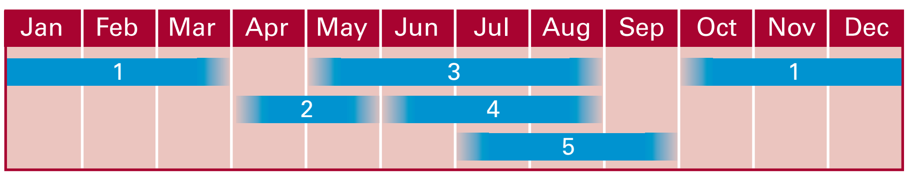
In combining peas for premium markets, including human consumption and for seed, damaged peas are removed by the merchant and the price paid to the grower is reduced in proportion. Reductions in yield are rarely significant and the presence of damage in peas for animal feed compounding is not important.

Risk factors

Any pea crop in flower or in pod in June or July is liable to attack to a greater or lesser degree.

Risk of economically damaging infestations is far greater where damage in previous crops has been severe and control may only be justifiable in these cases.

Life cycle



1. Overwinter in cocoon underground.
2. Caterpillar emerges to form a second cocoon at soil surface. Pupation occurs upon leaving this cocoon.
3. Moths emerge in late May/early June and lay eggs on pea plants from early June until mid-August.
4. Hatched caterpillars enter young pods to feed.
6. Fully fed caterpillars bite their way out of their pod and descend to the soil to form a cocoon underground.

Pea moth (*Cydia nigricana*)

Identification and symptoms

The moths are dull grey-brown with markings at the tip of each forewing. They are approximately 6 mm long, with a wingspan of around 15 mm. The eggs are small and flattened and are laid singly or in small groups on leaves and stipules of pea plants.

The caterpillars are pale yellow with black head and legs and are approximately 10 mm long when mature. They have a brown ring on the prothorax, with eight brown dots on the following segments. Each pea pod rarely contains more than two caterpillars. Overwintering cocoons are found about 10 cm below ground, while spring cocoons can be found at the soil surface.

Damage from the pest occurs within the seed pods. Damaged pods may appear yellow and ripen early. Opening the pods will reveal one or two caterpillars, partially eaten seeds and frass (droppings).

Pea moth larva

Pea moth larva

Monitoring

Pheromone traps that attract males have been developed. Traps are placed within crops by the middle of May and are examined for moths at two-day intervals. The traps are used to time sprays so that larvae are targeted from the time of hatching to the point at which they enter the pods. This is done with the aid of a computer model, which helps predict egg development using daily minimum and maximum temperatures. See **www.pgro.org** for the latest pea moth alerts.

Thresholds

Dry harvested peas for human consumption: Ten or more moths caught in traps on two consecutive occasions.

Vining peas: Traps are used to determine if moths are present. Growers should be guided by the factory fieldsman: even very small infestations can lead to rejection.

Non-chemical control

Large pea moth populations can develop where pea crops are left in the field to full maturity. Therefore, areas where combining peas are grown are likely to be a reservoir of the moths. In other situations, unharvested green peas should be ploughed in before the larvae have left the dried pods. Early maturing and early or late-sown peas may miss the moth flight period, so may be unaffected. Four species of parasitic wasp and a pathogenic fungus attack the pea moth.

Insecticide resistance

None known.

Crops affected

	Cereals
✔	Oilseeds
✔	Vegetable brassicas
	Potatoes
✔	Carrots
	Alliums
✔	Peas
✔	Field beans
✔	Sugar beet
✔	Lettuce

Importance

Feeding by the larvae (caterpillars) of the silver Y moth can cause damage to plant foliage. Frass (droppings) and the larvae can contaminate fresh produce.

Risk factors

Lettuce is one of the most susceptible crops. The eggs are laid singly on susceptible host plants and infestations may not be detected until damage has occurred.

Silver Y moth is a migratory pest, so crops in the south and east may be more at risk. Large numbers of moths can arrive in crops quite suddenly.

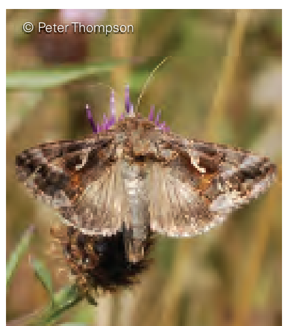
Life cycle

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	1	2	3	3	6	6		1	1	1
				4	4	4					
				5	5	5	7	7			

1. Overwinter overseas.
2. Immigrant moths may arrive.
3. Peak period of immigration.
4. Eggs laid.
5. Larvae feed.
6. Pupae formed.
7. Moths migrate southwards.

This species cannot survive the winter in the UK. Spring migrants use fast-moving airstreams to travel north to colonise host plants in northern Europe from winter breeding sites in North Africa and the Middle East. Migration patterns vary widely from season to season, so there is no consistent, predictable pattern to population development in much of Europe.

It is estimated that 10–240 million immigrants reach the UK each spring, and that summer breeding results in a fourfold increase in the abundance of the subsequent generation of adults, all of which emigrate southwards in the autumn.



Adult silver Y moth

Depending on when they arrive in the UK, silver Y moths may be able to complete more than one generation in some years.

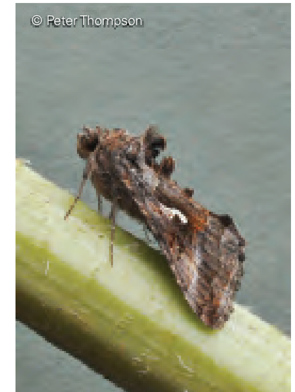
Silver Y moth (*Autographa gamma*)

Identification and symptoms

Adults are grey to greyish-brown in colour and the forewings have a span of 35–40 mm. There is a distinct silver Y mark on each forewing.

Eggs are usually laid singly on foliage. They are oval (0.5–0.6 mm diameter) and white in colour, darkening close to hatching. Female moths can lay up to 1,500 eggs but usually lay an average of 150–650 eggs.

The larvae are 24–40 mm long, green (varying from bright green to very dark green) and have a dark green dorsal line edged with white. A light yellow line runs over the sides. The caterpillars 'loop' as they walk. When fully grown, the larva pupates on a leaf within a loose web-like cocoon.



Adult silver Y moth

Monitoring

Male moths can be captured by pheromone traps. Traps sometimes capture very large numbers of male moths.

Moths are also caught in light traps run by moth enthusiasts. In 2013, the first silver Y moths captured by light traps in Dorset were caught on 26 April (a cold spring). In 2012, which had a warmer spring, the first silver Y moths were caught there on 28 March.

Silver Y moth larva

Thresholds

For vining peas, the threshold is reached when the cumulative catch (pheromone traps) exceeds 50 moths by the first pod stage (GS204).

For sugar beet, the threshold is five caterpillars per plant.

Non-chemical control

This pest is attacked by a number of polyphagous predators. The larvae may also be parasitised by certain species of wasp or fly, which eventually kill the larvae. The larvae continue to feed for some time after they are parasitised and so crop damage is not reduced immediately. Larvae may also be killed by viruses.

To date, biological control with predators or parasitoids has not been investigated in the UK. Pesticides based on microbial control agents (eg Bt) may be effective.

Insecticide resistance

None known.

Crops affected	
	Cereals
	Oilseeds
✔	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

Importance

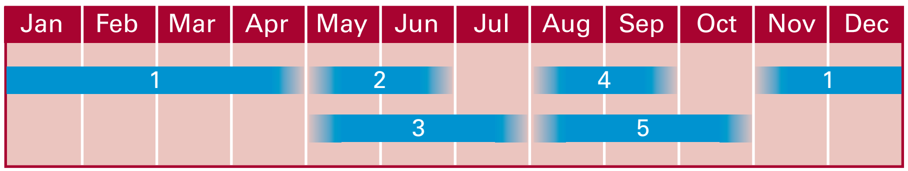
Feeding by the larvae of the small white butterfly can cause damage to plant foliage. Frass (droppings) and the larvae can contaminate fresh produce.

Risk factors

The eggs are laid singly on susceptible host plants, the larvae hide themselves within plant foliage and infestations may not be detected until damage has occurred.

The second generation usually causes more damage than the first.

Life cycle

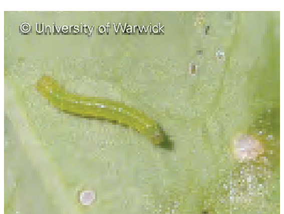


1. Pupae overwinter.
2. Adults (1st generation) emerge and lay eggs.
3. Larvae feed/pupae formed (1st generation).
4. Adults (2nd generation) emerge and lay eggs.
5. Larvae feed/pupae formed (2nd generation).

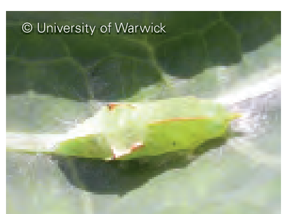
Adult butterflies of the second generation emerge in August and this generation is the most damaging to brassica crops.

Adult small white butterfly on kale

Small white butterfly egg



Small white butterfly larva



Small white butterfly pupa

Identification and symptoms

Adults are white butterflies with a wingspan of 50 mm; the forewings have conspicuous black tips. The female has two small black spots on the upper surface of each forewing, while the male has one black spot in the middle of each forewing.

Eggs are yellow and bottle-shaped and laid singly on the undersides of leaves.

The larvae have a green velvety appearance, with a dorsal yellow line and elongate yellow patches along their sides and are solitary. When fully grown, a larva is 25 mm. When fully grown, the larva usually pupates on the plant, to which it is attached by a silken girdle.

Adult small white butterfly

Monitoring

Adult butterflies can be captured in yellow water traps or on yellow sticky traps.

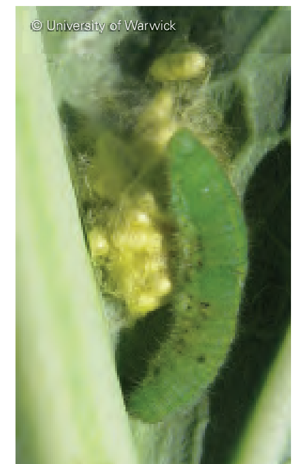
Thresholds

There are no current thresholds for small white butterfly in the UK.

Non-chemical control

This pest is attacked by a number of polyphagous predators, including some birds and small beetles. Natural mortality of larvae can be high due to species of parasitic wasp. The larvae continue to feed for some time after it is parasitised and so crop damage is not reduced immediately.

The larvae can be controlled with products based on *Bacillus thuringiensis* (Bt). The possibility of control with other biopesticides is being evaluated in the UK.



Parasitised small white butterfly larva

Insecticide resistance

None known.

Minor/emerging pests

Flax tortrix moth (*Cnephasia asseclana*)

Crops affected	
	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
✔	Peas
	Field beans
✔	Sugar beet
✔	Lettuce

The caterpillar of the flax tortrix moth ties together the upper leaves of pea plants with a fine web and feeds within the bunched leaves.

Damage can be observed in spring, just before flowering, but is not severe and will not cause yield loss.

Caterpillars have usually pupated and the new generation of moths left the crop before harvest, so no control is necessary.

Flax tortrix moth damage

Further information

Alerts and bulletins

AHDB Horticulture Pest Bulletin: **horticulture.ahdb.org.uk/latest-pest-bulletin**

AHDB Horticulture Publications

Available at **horticulture.ahdb.org.uk**

Factsheet 04/12: Silver Y moth in vining peas and green beans (2012)

AHDB Cereals & Oilseeds Pubications

Available at **cereals.ahdb.org.uk/publications**

Research Review 86: A review of pest management in cereals and oilseed rape in the UK (2016)

Pests:
Nematodes

Contents – Pests: Nematodes

Nematodes (Nematoda)

Unlike the species in the first four sections, nematodes are not insects, they are a diverse group of slender worms.

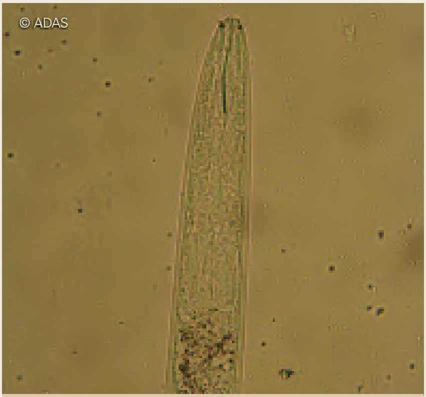
Life cycle

It is estimated that more than half of nematode species are parasitic. Some, like those described here, are damaging to plant health. Other species are predatory and may be purchased as a form of pest control.

Defining features

Nematode species are difficult to distinguish and most are too small to be seen without magnification.

Male stubby root nematode



Stubby root nematode head region, showing curved spear used to penetrate plant roots

Root lesion nematode

Free-living nematode

Crops affected	
	Cereals
✔	Oilseeds
✔	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
✔	Sugar beet
	Lettuce

Cysts of beet cyst nematode

Importance

Beet cyst nematode (BCN) is one of the most important pests of sugar beet. It also infests crops related to sugar beet, such as spinach, mangold, fodder and red beet, and can complete its life cycle on some brassica crops, such as oilseed rape, cabbage and Brussels sprouts.

In sugar beet, the nematodes damage the roots and stunt the plants through direct feeding, causing wilting during periods of drought. Yield reductions of 30% to 60% have been reported, depending on the level of infestation.

In parts of northern Europe, the yellow cyst nematode (*Heterodera betae*) is also found. It has not, so far, been found in the UK.

Risk factors

Cysts can be spread in soil attached to beet roots, farm machinery or footwear. They are most common in sandy or peaty soils. Cysts can also be spread by floodwater.

Oilseed rape and other brassica seed crops are particularly efficient hosts of BCN and can lead to a quick build-up of the pest. BCN is most likely to be found on sites with close rotations of beet and/or brassica crops and where host weed species, such as charlock and fat hen, are not controlled.

Life cycle

Cysts in the soil can hatch with or without the presence of hosts but root stimulants produced by host plants encourage additional hatching and attract the larvae to the roots.

The juveniles move through the roots. After developing into adults, the males return to the soil. The females remain within the root and, after mating, begin to swell, forming cysts. Initially white, the cysts containing eggs and larvae turn brown and can fall off into the soil to repeat the cycle. Cysts can remain viable in the soil for many years and each cyst contains up to 600 eggs.

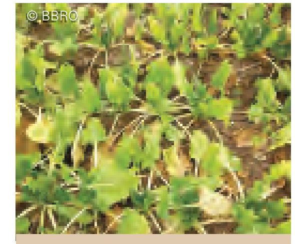
The life cycle is affected by soil temperature and is completed in 300 degree-days above a base temperature of 10°C. In northern Europe, it can complete two or three generations per year, depending on weather conditions.

Identification and symptoms

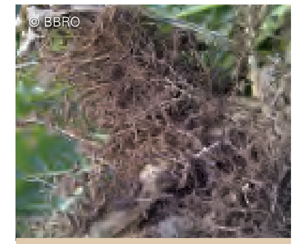
The juveniles of these nematodes have slender, transparent bodies and are too small to be seen without magnification, measuring 0.5 mm in length.

The cysts are lemon-shaped (0.5 x 1 mm) and are initially white but turn brown as they mature. They can be seen on the roots of beet from the seedling stage until harvest. They can sometimes be seen with the naked eye but can easily be confused with grains of sand. It is easier to see them if the roots have been gently washed and magnification is used.

Crop damage is usually evident as patches of stunted beet, which wilt easily in dry periods. Affected plants produce many lateral roots in response to the root damage: an effect known as 'bearding'.



Beet cyst nematode damage



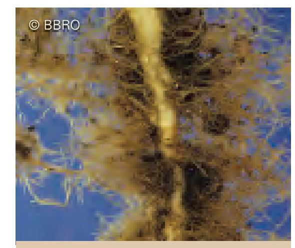
Bearding symptoms due to beet cyst nematode

Monitoring

The level of BCN infestation in the soil can be determined by soil sampling and services are offered by a number of companies.

Thresholds

Thresholds vary widely across Europe. In the UK, latest results show an economic benefit from using BCN-tolerant varieties above two eggs and larvae per gram of soil.



Beet cyst nematode symptoms

Non-chemical control

The number of cysts in the soil can be reduced by widening the rotation. Oilseed rape and other brassica seed crops should not be used as break crops for cereals in rotations that include sugar beet.

Nematode-resistant brassica catch crops, such as white mustard and oil radish, are growing in popularity. Sown in the autumn, they encourage eggs to hatch but are resistant to colonisation by the juveniles, preventing an increase in inoculum for the following beet crop.

Nematode-tolerant sugar beet varieties have been developed for use in the UK and there are a number on the recommended list. While yields are improving, they are currently still lower yielding than conventional varieties in the absence of nematodes.

Insecticide resistance

None known.

Crops affected

	Cereals
	Oilseeds
	Vegetable brassicas
✔	Potatoes
✔	Carrots
	Alliums
	Peas
	Field beans
✔	Sugar beet
	Lettuce

Stubby root nematode damage to sugar beet seedlings

Carrot 'fanging' caused by nematodes

Importance

Free-living nematodes (FLN) are important as virus vectors and also reduce crop quality and yield by feeding on the roots. Stubby root nematodes (*Trichodorus* spp. and *Paratrichodorus* spp.) and needle nematodes (*Longidorus* spp.) are generally considered the most damaging free-living species.

Stubby root nematodes transmit tobacco rattle virus (TRV) to potato, producing an internal disorder of the tubers called spraing. This reduces tuber quality but does not affect yield. In some seasons, this can result in severe losses, as affected tubers are unacceptable for sale. Although FLN can also transmit TRV to sugar beet, its effects are less serious than the damage caused by the nematodes.

Yield reductions can occur in most crops if sufficient nematodes are present but are most common in potatoes, carrots, parsnips and sugar beet. Yield losses of up to 17 t/ha have been estimated in sugar beet. The quality of root crops can also be reduced by nematode feeding. Root 'fanging' is particularly important in carrots, parsnips and sugar beet.

Risk factors

FLN are generally most numerous in sandy and other light, open-textured soils. Depending on the species, needle nematodes can be found in soils ranging from lighter soils in the north of the UK to heavier soils in the south but they tend to favour relatively undisturbed conditions.

Wet growing seasons and regular irrigation can increase the incidence of spraing, as the nematodes require adequate soil moisture to move between plants. Damage in sugar beet is reported to be more severe in years with heavy rain in May.

In potatoes, most infections occur soon after tuber initiation. Some potato varieties show spraing symptoms more readily than others.

Life cycle

Stubby root nematodes have an extremely high rate of reproduction when soil temperatures are between 15°C and 30°C. They feed on a range of crop and non-crop species throughout the year.

Needle nematodes multiply relatively slowly on a range of crop and non-crop species. Several generations occur each year, so both adults and juveniles occur together.

Identification and symptoms

In many crops, the feeding of stubby root nematodes causes a proliferation of thickened, 'stubby' roots. This causes poor top growth and reductions in yield, and can make the plant more susceptible to drought stress and mineral deficiencies.

Spraing can be recognised as chestnut-brown arcs, circles or lines through the tuber. Spraing-affected tubers usually produce healthy plants but these can have short stems with crinkled, malformed and discoloured leaves, known as stem mottle. The tubers these produce can also contain brown flecks.

FLN feeding on tap roots can cause the root tip to die, causing lateral roots to take over. In carrots, parsnips and sugar beet, this feeding can cause multiple tap roots to form, known as 'fanging' (in carrots and parsnips) or 'Docking disorder' (in sugar beet). Affected plants in the field are stunted and healthy plants are often seen next to stunted plants, a symptom known as 'chick and hen'.

Monitoring

The number of FLN in soil can be determined by soil extraction. This service is available from a number of accredited laboratories. Some also offer a service to detect the whether stubby root nematodes are carrying TRV. Soil samples for extraction should be transported very carefully, as the nematodes are easily damaged.

Thresholds

In sugar beet, it has been suggested that severe symptoms often occur in soils with *Trichodorus* populations of more than 1,000 nematodes per litre of soil or with *Longidorus* populations of more than 100 nematodes per litre of soil.

Non-chemical control

In potatoes, choice of healthy certified seed or propagating stock can help prevent introducing nematodes to a field. In areas of greater risk from spraing, using varieties with a lower susceptibility to TRV is recommended. Rotating potatoes with non-host crops and lengthening the rotations (growing potatoes at least one year in six) will help reduce nematode populations. Weeds can act as alternative hosts and a source of TRV.

Insecticide resistance

None known.

Crops affected

- Cereals
- Oilseeds
- Vegetable brassicas
- ✔ Potatoes
- Carrots
- Alliums
- Peas
- Field beans
- Sugar beet
- Lettuce

PCN cysts (G. rostochiensis*)*

Importance

Potato cyst nematode (PCN) is the most important pest of potatoes in the UK. There are two species: *Globodera pallida* (white PCN) and *G. rostochiensis* (yellow PCN). They damage the roots of potatoes, which can result in poor growth, wilting during periods of water stress, early senescence and a reduction in tuber yield by as much as 80%.

Risk factors

The nematode is mainly spread by the movement of cysts in soil attached to potato tubers, farm machinery or footwear. Cysts can also be spread by wind and floodwater.

Cultivars vary in their tolerance to PCN, with some still able to produce an acceptable yield in the presence of PCN. Varieties resistant to *G. rostochiensis* are available and will help to minimise the build up of PCN but there is only partial resistance to *G. pallida*.

Life cycle

In the presence of the crop, large numbers of eggs hatch in April/May and juveniles infest crop roots.

In the absence of the crop, smaller numbers hatch in April/May and these will die unless they find a host.

Nematodes continue to hatch and invade crop roots over the summer and white/cream coloured cysts can be seen on the crop roots.

Mature cysts become detached from the roots at harvest and can remain in the soil for up to ten years. Each cyst contains hundreds of eggs.

Identification and symptoms

These nematodes have slender, transparent bodies, reaching approx. 1 mm in length. As the females mature, they swell, forming spherical cysts 1 mm in diameter, which are initially white or cream coloured. At this stage, they can usually be seen attached to the roots. As the females mature and die, the cysts develop a reddish-brown hard skin. If infested plants are lifted carefully, the mature cysts can sometimes be seen attached to the roots but usually become detached at harvest, remaining in the soil as a source of infection for future potato crops.

The nematodes damage the roots and affect yield, even when no symptoms are evident in the haulm. Roots may be killed with severe infections, resulting in

stunted, often chlorotic plants with a patchy distribution.

PCN cysts (G. pallida*)*

Monitoring

The level of PCN infestation in soil can be determined by soil extraction. This service is available from a number of accredited laboratories. The need for nematicide treatment is related to the number of PCN eggs/g soil.

Under EU Directive 2007/33/EC, seed potatoes or potatoes for export must only be planted on land that has been found to be free from PCN infestation following an official soil test. This test must be undertaken by a Plant Health and Seed Inspectorate (PHSI) inspector. The growing of ware potatoes will be permitted, subject to the implementation of a Control Programme (see **www.fera.defra.gov.uk/plants/plantHealth**)

Thresholds

The AHDB Potatoes PCN Model is a support tool that assists in developing an integrated PCN control plan. To manage PCN population levels (eggs/g) and species, varieties, rotation and cultural control methods must be taken into consideration and advice sought from an agronomist.

- Low – 1–10 eggs/g – Nematicide use is recommended
- Medium – 10–20 eggs/g – Nematicide treatment is highly recommended
- High – >20 eggs/g – Take into account all factors and, if appropriate, consider other ground

Non-chemical control

Various measures can be adopted to reduce or prevent the risk of nematodes affecting crops. These include selecting resistant or tolerant cultivars (see the British Potato Variety Database, maintained by AHDB Potatoes), using PCN-free certified seed (in seed crops or potatoes for export), and extending the interval between potato crops and rotations using non-host crops. Volunteer potatoes are probably unlikely to have a significant effect on high PCN infestations but may help to maintain infestations at a low level from one crop to the next. Effective control will minimise this risk. In the absence of the crop, nematode numbers will gradually decline.

Insecticide resistance

None known.

Crops affected	
	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
✔	Alliums
	Peas
✔	Field beans
✔	Sugar beet
	Lettuce

Stem nematode damage in garlic (top), with a healthy bulb (bottom) for comparison

Importance

Stem nematode is a destructive pest of a range of plants. Infested seedlings or young plants become deformed.

Risk factors

The spread of nematodes is passive, as they do not move more than a few centimetres each year. They may be transferred in soil or host plants, including seed. The nematodes may also be spread by rain, flood water and wind. There is a risk of infesting clean fields by planting or sowing infested plant material.

Life cycle

Stem nematodes live as parasites within plant tissues, where both males and females can occur in large numbers. Their feeding causes the breakdown of cell walls. Females lay up to 500 eggs and there are a total of four moults.

The stem nematode can survive, mainly as desiccated fourth-stage juveniles, for several years. These tend to aggregate at the surface of heavily infested plant tissue to form clumps of 'nematode wool'. The nematodes become active again when the wool is moistened. In wet soil, they can live in the absence of host plants for more than a year.

Identification and symptoms

Stem nematodes are internal parasites of plants. They are slender and colourless and impossible to see without magnification. The adult body is just over 2 mm long and tapers at each end.

The problem is usually identified because of plant symptoms.

Onions: Infested seedlings or young plants become swollen at their bases and have malformed and twisted leaves. Infested tissue has a loose puffy texture and the epidermis is dull in appearance (known as 'bloat'). Rotting then occurs at soil level, so badly infested plants can be pulled to leave their roots in the soil. Eventually, infested plants die.

Stem nematode (*Ditylenchus dipsaci*)

Slight infestations may not be noticed but may hasten the deterioration of stored bulbs.

Sugar beet: The tissues of infested seedlings become swollen and spongy, galls may be formed and the growing points may become deformed or killed. New growing points then develop, leading to multiple crowns and small distorted leaves. In the autumn, the damaged crown may rot, encouraging secondary pathogens. Usually, relatively few plants are affected in any one field.

Beans: Damage usually shows as stem discolouration.

Stem nematode damage to sugar beet

Monitoring

Soil testing for the presence of nematodes could be considered. Dissection of plant tissue and immersion in water can be used to confirm the presence of the pest. This is only likely to be done by a laboratory.

Thresholds

There are no validated thresholds for stem nematode. The presence of stem nematodes in soil usually means the land is avoided for cropping with onions.

Stem nematode damage to bean plant

Non-chemical control

Races of stem nematode are highly host-specific, so employing a three-year crop rotation can deprive the nematodes of a suitable host and starve the population.

Because some weeds serve as hosts for nematodes, controlling weeds in fields decreases the number of susceptible hosts and the ability of the nematodes to survive and spread.

Insecticide resistance

None known.

Cereal cyst nematode (*Heterodera avenae*)

Crops affected	
✔	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
	Sugar beet
	Lettuce

Cereal cyst nematode is the main nematode pest of cereals. In the UK, it is more damaging to oats than to other cereals.

Intensification of barley growing from the 1960s onwards led to fears that cereal cyst nematode might become a serious problem in this crop. After initial increases, however, infestations declined (mainly because of fungal parasites of the nematode that are favoured by intensive cereal growing).

Infected crops show patches of stunted plants sometimes tinged with red or purple. Infected oats have a typical bushy root system. Significant infestations of cereal cyst nematode are relatively rare.

Cereal cyst nematode eggs and larvae

Cereal cyst nematode damage

Pea cyst nematode (*Heterodera goettingiana*)

Crops affected	
	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
✔	Peas
✔	Field beans
	Sugar beet
	Lettuce

Pea cyst nematode cysts on root

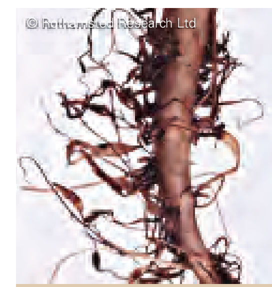
The pea cyst nematode attacks the roots of pea and bean crops, with the latter rarely showing symptoms. The pest is not ubiquitous and incidence varies from year to year.

Symptoms begin to appear in early summer before flowering, with areas of the crop becoming pale and stunted. Plants yellow, have an upright appearance, small leaves and may flower prematurely. Pods often fail to develop and plants may die prematurely. Root systems are often poorly developed and will contain tiny, white, lemon-shaped cysts containing nematode eggs, which later turn brown and can remain viable for up to 20 years.

Crops in areas that have a long history of frequent pea cultivation and those on lighter, sandier soils tend to be at greatest risk. Yield losses can be sustained with soil populations of 5 eggs per gram of soil.

Root knot nematode (*Meloidogyne* spp.)

Crops affected	
	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
✔	Sugar beet
	Lettuce


Root knot nematode symptoms

This is an important plant nematode pest, worldwide. Of the 50 described species, only a few infest sugar beet.

The life cycle is similar to that of the beet cyst nematode (p. 151) and infested plants are stunted and tend to wilt in warm weather. Root knot nematodes cause galls to form on the lateral roots of plants. Where early infestations are severe, plants may be killed.

Control methods include the use of granular nematicides, trap cropping, lengthening the rotation and control of weed hosts.

Further information

AHDB Potatoes information

PCN calculator: potatoes.ahdb.org.uk/online-toolbox

Research Review 276: Free-living nematodes and spraing (2006)

AHDB Cereals & Oilseeds Publications

Available at **cereals.ahdb.org.uk/publications**

Student Report 21: Integrated management of cyst nematodes in oilseed rape (2013)

Student Report 13: New cyst nematode threats to cereals in the UK (2009)

Information from other organisations

Information from Fera is available at **www.fera.defra.gov.uk/plants/plantHealth**

Fera Plant Pest Factsheet: Potato cyst nematodes (Fera, 2009)

Fera Plant Disease Factsheet: Spraing disease of potato (2009)

Information from SRUC is available at **www.sruc.ac.uk**

SAC Technical Note 631: Potato tuber pests (2010)

SAC Technical Note 603: Soil dwelling free-living nematodes as pests of crops (2007)

Pests: Others

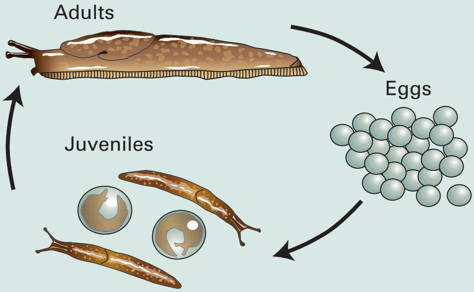
Contents – Pests: Others

Slugs (Gastropoda)

Unlike the species in the first four sections, slugs are not insects, they are gastropod molluscs. The word "slug" is generally applied to any species of terrestrial gastropod mollusc that has no (or a very reduced or internal) shell.

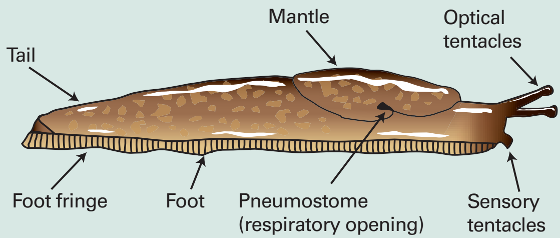
Life cycle

Unlike insects, the juveniles emerging from the eggs are very similar to the adult slugs. They do not undergo metamorphosis



Defining features

Slugs are legless, unsegmented and boneless. The body of a slug is made mostly of water and, without a shell, they are prone to desiccation. They generate protective mucus and are usually most active on still nights when the soil is wet and the atmosphere is humid (particularly just after rain). They hide in damp places during drier periods and wind and heavy rain can decrease their activity.



Soil pest complex
(millipedes, subterranean springtails and symphylids)

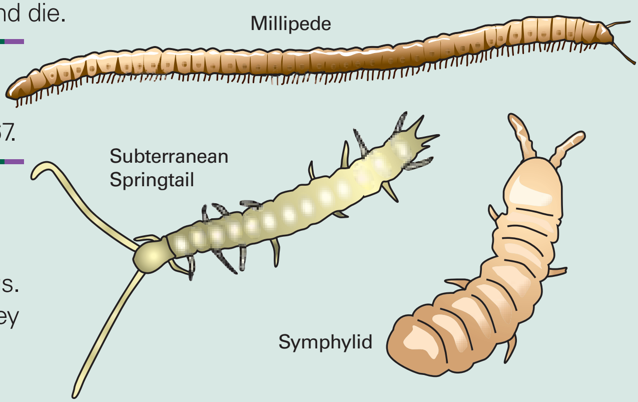
While not related, these species are grouped together because they can appear at the same time and cause similar types of damage by feeding on roots, causing seedlings to collapse and die.

Life cycle

The life cycle varies for each species, see p. 167.

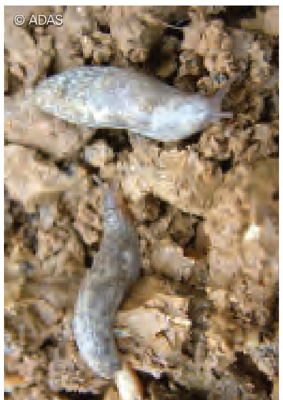
Defining features

These creatures live underground and have variable numbers of legs. Being subterranean, they are generally white or pale in colour.



Crops affected

- ✔ Cereals
- ✔ Oilseeds
- ✔ Vegetable brassicas
- ✔ Potatoes
- ✔ Carrots
- ✔ Alliums
- ✔ Peas
- ✔ Field beans
- ✔ Sugar beet
- ✔ Lettuce



Grey field slugs

Importance

Slugs can cause damage all year round, whenever weather and temperature conditions are suitable, but are particularly damaging in autumn crops and potatoes.

Early stages of most affected crops and tubers in potatoes are most vulnerable. In cereals, seed hollowing is a particular problem. Both cereals and oilseed rape are susceptible to leaf grazing until the four-leaf stage. In potatoes, slugs affect crop quality by mining the tubers and providing an entry point for fungal pathogens. Potatoes are most vulnerable at the early stages of tuber bulking. For vegetables, attack in the early stages can cause plant loss and, at later stages, feeding can lead to cosmetic problems.

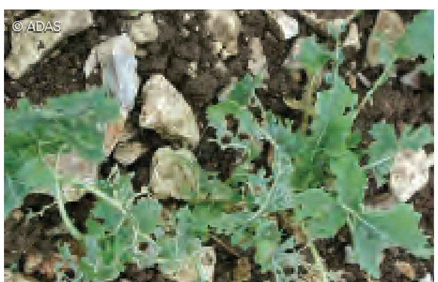
Risk factors

Slug activity, survival and reproduction are dependent on moisture. The optimum temperature is 17°C.

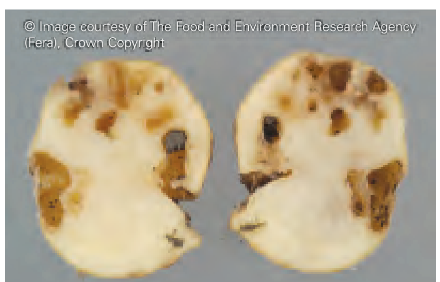
Slugs are most abundant in heavy soils with high clay or silt content with open, cloddy seedbeds allowing easy movement.

Damage is much greater after leafy crops. Crop residues or applications of manure, especially in the autumn, as well as weeds and volunteers, provide slugs with a source of food and shelter.

Lack of nutrients, poor drainage and weed competition can all result in slow crop growth, prolonging the vulnerable period of establishment.



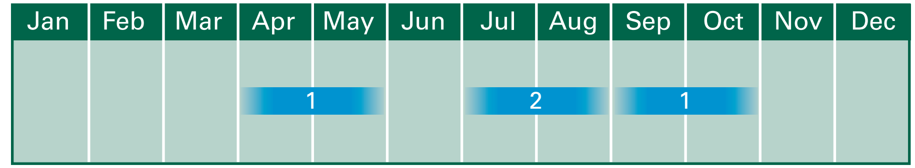
Slug damage in oilseed rape



Slug damage in potato

Life cycle

Slugs can be active all year round but the main breeding periods of the grey field slug and garden slug are shown below.



❶ Peak breeding (field slugs).

❷ Peak breeding (garden slugs).

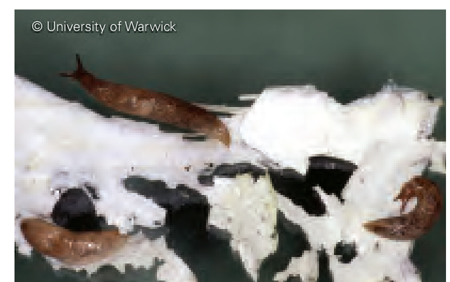
All slug species are hermaphrodite (each individual is both male and female). While some species are self-fertile, most mate before laying eggs in batches of 10 to 50 in soil cavities, between clods, under stones or at the base of plants.

Up to 500 eggs per slug may be laid over several weeks. Eggs develop slowly in the winter but will hatch within a few weeks when the temperature starts to rise.

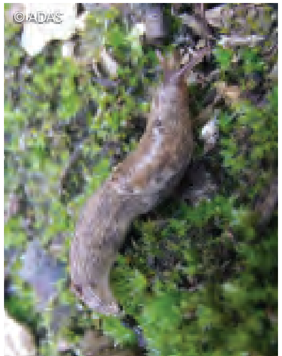
In their lifetime, slugs will travel only a few metres from their hatching site, in a circular route, in search of food. They are active and feed throughout the year, whenever conditions are suitable (see risk factors).

Slug eggs

Slug damage to grain



Slug damage to lettuce



Grey field slug

Garden slug

*Keeled slug (*Milax budapestansi*)*

Identification and symptoms

The key pest species are:

- grey field slug (*Deroceras reticulatum* and other *Deroceras* spp.)
- garden slug (*Arion hortensis* and *Arion distinctus*)
- keeled slug (*Milax, Tandonia* and *Boettgerilla* spp.)

Grey field slugs are the most common and injurious species. They are usually grey or fawn and adults are 35–50 mm.

Garden slugs are usually smaller than field slugs, with a dark upper body and a yellow to orange underside.

Keeled slugs are generally the largest pest species (50–75 mm) and are grey to dark-brown or black with a ridge down the centre of the back.

Slug feeding causes seed hollowing, leaf shredding and tuber damage. Leaf shredding produces irregular-shaped holes in leaves and can be especially damaging to seedlings. Slugs scrape a hole in a seed coat and hollow it out, often resulting in the removal of the cereal germ before it can germinate. Feeding on potato tubers causes ragged holes on the surface and larger cavities within the tuber.

Monitoring

Monitoring is most effective when soil is moist and temperatures range from 5–25°C. Sampling is best done using refuge traps. Traps consist of a cover such as a an empty sack, carpet square or a tile, with a non-toxic bait, such as chicken layers mash, to assess slug activity. Do not use slug pellets to bait traps.

Put slug traps out before cultivation, when the soil surface is visibly moist and the weather is mild. In each field, nine traps (13 in fields larger than 20 ha) should be set out in a 'W' pattern, concentrating on areas known to suffer damage. Leave the traps overnight and examine early the following morning.

Crops should also be monitored regularly for slug damage. The critical control periods will vary depending on the crop. See the publications listed in the Further information section for more details.

Thresholds

The following represent potential risk of damage when soil and weather conditions favour slug activity:

Winter cereals: 4 slugs per trap

Oilseed rape: 4 slugs per trap in cereal crops or 1 slug per trap in cereal stubble

Vegetables: No thresholds established

Other crops: 1 slug per trap

Non-chemical control

Ploughing can reduce slug populations but even minimum tillage gives a considerable reduction in slug damage compared to direct drilling. A fine, consolidated seedbed is important and will protect seeds and prevent slugs accessing seedlings before emergence. Increase the sowing depth of wheat to 4–5 cm if the seedbed is cloddy.

Damage in potato crops is partly related to tuber maturity, even occurring under dry conditions. Lifting the crop as soon as possible can limit damage by minimising the time the potatoes are exposed to feeding.

Phasmarhabditis hermaphrodita is a parasitic nematode that attacks slugs and, unlike pellets, can target soil-dwelling slugs and not just those active on the soil surface.

Natural enemies include ground beetles, rove beetles, parasitoids, birds, amphibians and hedgehogs, so providing habitats for these may help control slug populations.

Insecticide resistance

None known.

Slug infected with Phasmarhabitis hermaphrodita

Slug damage to sugar beet

Soil pest complex
(millipedes, subterranean springtails and symphylids)

Crops affected	
	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
✔	Sugar beet
	Lettuce

Flat millipede

Springtail

Symphylid

Importance
Rarely occurring as a single species, the soil pest complex can attack from germination onwards, causing feeding damage to the roots and stem below the soil.

Damage can sometimes be severe, causing seedling growth to slow and killing some seedlings, leading to bare patches in the field in the spring.

Symphilids may also attack crops such as potatoes, tomatoes and lettuce.

Risk factors
The risk is higher in cold, wet springs. The complex is more common in fields with plenty of fresh organic matter or an open soil texture.

Life cycle
Millipedes breed in spring and summer, laying eggs in 'nests' in the soil. The young have three pairs of legs and add more segments, each with a pair of legs, until they are fully grown after two to three years.

Springtails have two breeding peaks per year: one in late spring and the second in the autumn/winter.

Symphylids lay eggs throughout the year in batches of up to 20. Young symphilids have three pairs of legs and they go through a series of moults, adding a pair of legs each time until they have 12 pairs in total. This process takes three months and symphylids can live for several years.

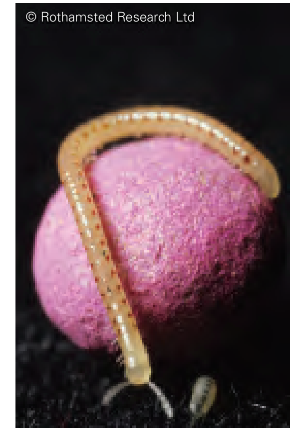
Identification and symptoms
Millipedes (*Blaniulus* spp., *Brachydesmus* spp., Polydesmus spp. and other species) occur in two types: snake and flat millipedes. All have a body with many segments and each segment has two pairs of legs. They are approximately 1 mm in diameter and between 10 mm and 20 mm in length.

Subterranean springtails (*Onychiurus armatus* and *Folsomia fimetaria*) are white and have an elongated body and, on average, are 1 mm in length.

Soil pest complex
(millipedes, subterranean springtails and symphylids)

Symphylid (*Scutigerella immaculata*) adults are active, with a slender body 5–7 mm in length. They are white and shiny, with two long antennae and 12 pairs of legs.

Some feeding damage is superficial but some can be deeper, causing pits in the roots, especially before emergence. Grazing of the root stem and root hairs causes the seedling to collapse and die. Sites where damage has occurred can be prone to secondary pathogenic fungi.



Spotted snake millipede

Monitoring
Bare patches in the field may suggest damage by the soil pest complex. Millipedes and symphylids may be seen in soil samples with the naked eye but magnification is needed to see springtails.

Thresholds
There are no thresholds to relate numbers to crop damage. Yield loss is due to loss of plants and crops with very low populations may need to be re-drilled with insecticide-treated seed.

Non-chemical control
Plants are less susceptible to attack by millipedes once they are beyond the four true leaf stage.

Insecticide resistance
None known.

Globular springtails (*Sminthurus* spp. and *Bourletiella* spp.)

Crops affected	
	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
✔	Sugar beet
	Lettuce

In contrast to the soil-living springtails, these springtails live above ground. They have a globular body and are light green or purplish in colour.

They feed on cell contents through puncture wounds on the cotyledons or true leaves, causing superficial damage, and they are not a serious pest.

On the leaf, however, green-coloured springtails may easily be mistaken for green aphids. They are readily distinguished from aphids because they jump when disturbed.

Two-spotted spider mites (*Tetranychus urticae*)

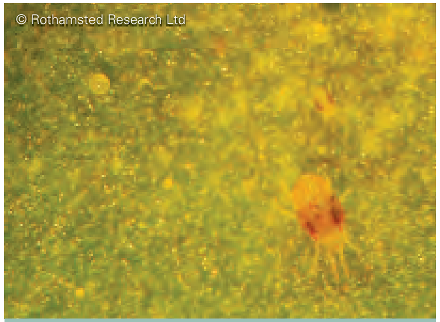
Crops affected	
	Cereals
	Oilseeds
	Vegetable brassicas
	Potatoes
	Carrots
	Alliums
	Peas
	Field beans
✔	Sugar beet
	Lettuce

Two-spotted spider mites are small, round, yellowish-brown in appearance and have two dark spots on the abdomen.

They invade crops from their overwintering hosts on parachutes of silken threads blown in the wind. As such, they generally appear first on headlands.

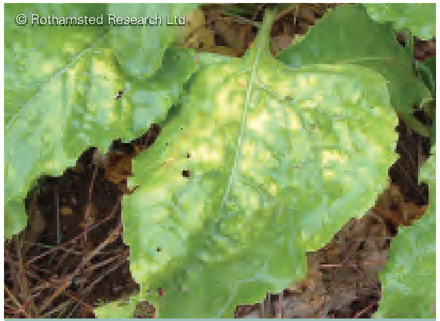
Symptoms are yellow spots on the leaf surface and a dark colouration underneath often with webs visible. They are visible with the naked eye. Damaged leaves die and defoliation can occur in severe infestations.

Two-spotted spider mites are favoured by warm dry weather. Control is usually by natural predators and there are no effective treatments against them.



Spider mite and egg

Spider mite damage under surface



Spider mite damage early symptoms

Spider mite damage severe symptoms

Further information

AHDB Publications

Available at **cereals.ahdb.org.uk/publications**

AHDB Information Sheet 02: Integrated slug control (2013)

AHDB Horticulture Publications

Available at **horticulture.ahdb.org.uk**

Factsheet 02/09: Slug control in field vegetables (2009)

AHDB Cereals & Oilseeds Publications

Available at **cereals.ahdb.org.uk/publications**

Research Review 86: A review of pest management in cereals and oilseed rape in the UK (2016)

Research Review 79: Implications of not controlling slugs in oilseed rape and wheat in the UK (2014)

AHDB Cereals & Oilseeds neonicotinoid information: cereals.ahdb.org.uk/neonics

Natural enemies

Contents – Natural enemies

Natural enemies

Natural biological control

Levels of both major and minor crop pest infestations vary between fields and years but are frequently regulated by their natural enemies (beneficial insects). Pesticides are only needed when the pests escape this control.

To encourage robust control at all times and locations, it is essential that a wide range of natural enemies are present, capable of controlling each of the pest's life stages. Different species may also work together (act synergistically), for example, parasitic wasps may cause aphids to fall to the ground, where they are subsequently predated by ground-foraging natural enemies.

To maximise pest control, it is important to encourage not only the species playing a major contribution, such as hoverflies (page 190) and parasitic wasps (page 194), but also overall levels of natural enemies providing background levels of control that prevent pests reaching outbreak levels.

Encouraging natural enemies

On some farms, a diverse landscape with many existing hedgerows and flower-rich grassland provides natural enemies with adequate habitat. Elsewhere, especially in open simple landscapes and where there are large fields, extra provision is needed.

Appropriate management will encourage populations of natural enemies within crops. Adopting integrated pest management (IPM) principles will ensure that insecticide inputs are only applied when necessary, helping to reduce spray costs, preserve natural enemies and prevent insecticide resistance developing.

Attributes of an effective natural enemy

A suite of regulating organisms, such as invertebrate natural enemies, insect-pathogenic fungi, nematodes and other microorganisms, will contribute to the control of a crop pest during each life stage.

Effective natural enemies share some common characteristics:

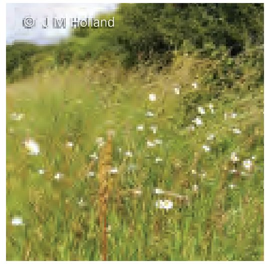
- Their primary prey or hosts are pest species
- Ability to seek out prey using visual or chemical cues
- Can vary their reproductive capacity in response to prey abundance or adverse farming practices
- Sufficiently mobile to penetrate the largest fields and reinvade after detrimental agricultural operations
- Consistent densities and ability to survive adverse farming practices

The main invertebrate orders and families containing the most important natural enemies of field crops are described here. The level of information available varies because some have been studied in more detail than others.

Natural enemies require appropriate resources to help keep pests in check:

S

Shelter

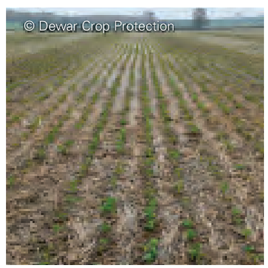


Hedgerows, associated margins and other shrubby areas protected from insecticides and intensive tillage provide habitats that enable beneficial insects to repopulate nearby crops. Strips of tussocky grasses and flower-rich grassland support high densities of some species. Natural enemies that only live for part of the year within a crop need other habitats in which to forage, breed or survive dormant periods. Provide shelter for natural enemies by:

- managing hedges to create different structures with varied plant species
- re-sowing degraded hedge bases covered in noxious weeds, eg ragwort or thistles, with a flower-rich grass mix
- protecting natural vegetation along hedge bases and fence lines, from insecticide and herbicide drift
- ploughing two furrows together to form a raised 'beetle bank', creating drier conditions favoured by insects and dividing larger fields – sow with tussock-forming grasses

A

Alternative prey



Pests often occur sporadically during the growing season. They have shorter life cycles than natural enemies. Other food sources (alternative prey) within and outside fields are needed to maintain natural enemy populations and can be provided by:

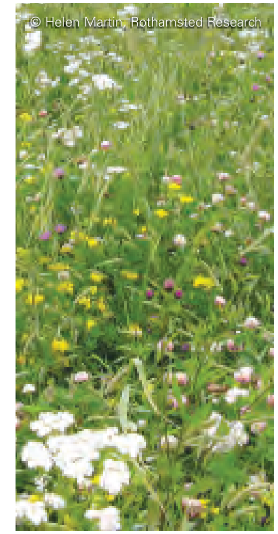
- other crops
- uncropped areas, such as field margins, woodland and less intensively managed grassland
- undersowing
- weeds (uncompetitive)
- minimum tillage
- organic manures

Minimum tillage and application of organic manures are especially valuable in providing suitable conditions for detritus-feeding invertebrates which serve as alternative prey for predators.

Utilising and enhancing natural enemies: the 'SAFE' approach

F

Flower-rich habitat



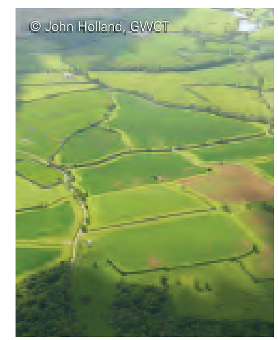
Pollen and nectar are essential for some groups of natural enemies, especially parasitic wasps and hoverflies, and are important foods for many other natural enemies.

Woodlands, hedges, margins, crops and agri-environment habitats containing wild flowers, annual arable plants or flowering wild bird seed plants can supply pollen and nectar. These flower-rich areas also support alternative prey.

Flower-rich areas can be created using either a mix of wild flowers and grasses or legumes. Mixes that provide both complex and simple flowers are the most beneficial as these support both short- and long-tongued insects.

E

Environment



Insect natural enemies thrive in diverse vegetation that has not been treated with insecticides, such as field margins. All approved insecticides affect them to some degree, so it is important to minimise usage by adopting integrated pest management and only treating when thresholds are reached. Other pesticides may adversely affect natural enemies, directly or indirectly, for example, removal of weedy habitats.

Correct management will help create a habitat structure providing natural enemies with cover and a suitable microclimate. The first step to maximise benefit from natural enemies is to manage habitats so that they:

- are spread across the farm – some natural enemies tend to remain close to margins
- are diverse – this encourages a range of natural enemies providing robust biological control

Beetles (Coleoptera)

Beetles occur in all types of habitats and are among the commonest insects on farmland. Larvae usually live in the soil or in dead wood. Most adult beetles can fly, although they spend the majority of their time on vegetation or on the ground.

There are many beneficial beetle species that feed upon crop pests or contribute to pollination but also some pest species (pages 16 to 41). They are also important in the diet of farmland birds and some mammals.

Ground beetles (Carabidae) – 350 species

Identification

Eggs are ovoid and usually laid singly in or under the soil.

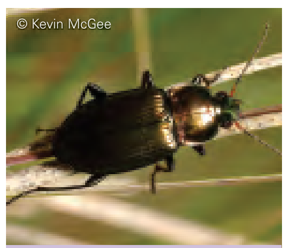
Larvae are elongated with biting mouthparts, three pairs of legs, each of which has six segments with two claws at the end and ten abdominal segments. They can be confused with rove beetle larvae but ground beetle larvae have more flattened heads.

Adult ground beetles are of variable size (2–25 mm), typically black or brown, often with metallic sheens; some are brightly coloured. They have biting mouthparts and are normally seen running on the ground. Most are flightless and they are usually nocturnal.

Life cycle

Within the ground beetles, there are varying life histories breeding either in the summer/autumn and then overwintering as larvae, or breeding in the spring and overwintering as adults. Others have flexible breeding times according to the weather, while some have prolonged resting periods as adults. The life cycle can last from one to several years, with between two and five larval stages. Larvae are carnivorous with the exception of Harpalini which feed upon seeds. Adults usually overwinter outside of the crop in field margins or woodland, whereas larvae are also found overwintering within fields at densities of up to one million/ha.

Carabid larva



The generalist predator, Poecilus cupreus

A seed-feeding beetle, Ophonus ardosciacus

Ground beetles (Carabidae) – 350 species

Benefits

Approximately 20–30 species are important for biocontrol; 5–10 are abundant on farmland. Beetles overwintering outside of the crop reinvade in the spring to help control pests but most remain within 60 m of the edge and, consequently, coverage of large fields may not be achieved.

Ground beetles are regarded as generalist predators, providing a background level of control for a wide range of pests such as aphids, fly eggs and larvae, moth/butterfly eggs and larvae, slugs and weed seeds. They also act synergistically with other natural enemies, for example, consuming pests dropping from the crop as they try to escape other predators or parasitoids.

Status

Although still abundant on farmland, numbers have declined with the advent of intensive farming. They are killed by most foliar-applied insecticides and intensive soil tillage.

How to encourage

Techniques to encourage ground beetles include:

– dividing large fields (>15 ha) with beetle banks to ensure a more even coverage

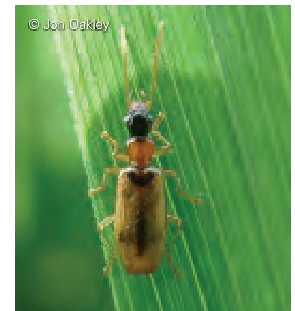
– having field margins containing tussock-forming grasses

– reducing the intensity of soil cultivations (minimum tillage)

– using spray thresholds to reduce insecticide applications

– allowing uncompetitive weeds to survive within the crop: low levels of weeds within crops also help support ground beetles by providing cover and alternative food (insects and seeds)

The common, ground-dwelling generalist predator, Pterostichus melanarius, *which overwinters as larvae in fields*



The climbing predator, Demetrias atricapillus, *which overwinters in field margins*

The ground-dwelling predator, Agonum muelleri

Identification

Eggs are white and either round or pear-shaped.

Larvae are elongate with three pairs of legs, each of which has five segments with one claw.

Adults are of variable size (1–25 mm), elongate with flattened bodies, typically with short wing cases that do not cover the abdomen, although this is not unique to this family. Some have distinctive colours, usually red and black, and are easy to recognise (see *Tachyporus hypnorum*) but most are black and indistinguishable. Most species can fly and climb well. They can be confused with earwigs.

Tachyporus hypnorum *feeds on insects and fungi and overwinters at base of tussocky grasses*

Life cycle

The breeding period of rove beetles varies between species, smaller ones breed earliest from February onwards and continue through to winter. For most species, adults emerge between May and August. Depending on the species, they overwinter either as larvae or adults. Larval stages are typically short: a few days to weeks but the adults are longer-lived.

Benefits

The huge diversity of species has resulted in a broad dietary range and includes species that are scavengers, generalist and specialist predators, fungal feeders, leaf and flower feeders and parasitic (see Aleocharinae box on the following page). Approximately 40–50 species are important for biocontrol, 5–10 are abundant on farmland.

In agricultural crops, the commonest species are omnivorous. The insect prey is frequently the eggs and larvae of flies, moths, butterflies, springtails and aphids. Rove beetles are in turn consumed by other insects, amphibians, reptiles, birds and bats.

Philonthus cognatus, *one of the larger farmland rove beetles, overwinters in fields*

Status

Once numerous on farmland, numbers have declined sharply in recent decades, especially fungal-feeding species, such as the Tachyporinae, possibly due to fungicide use. Rove beetles are especially vulnerable to insecticide sprays applied in the spring and autumn. Ploughing may not directly reduce numbers but rove beetle abundance and species diversity is higher with minimal tillage, due to indirect effects (more surface litter, weeds, soil moisture, fungi and detritivores).

How to encourage

They occupy most habitats, including crops, grassland and woodland. Rove beetles overwinter outside the crop in sheltered places, such as under rocks and bark or in grassy tussocks, or as larvae in the soil at densities of up to 0.5 million per hectare.

The same methods used to encourage ground beetles will also favour rove beetles, especially reduction of all pesticide inputs as they are considered more sensitive.

For high value nursery crops, *Atheta coriaria* can be reared and released for the control of sciarid and shore flies and potentially western flower thrips.

Aleocharinae

Their life cycles are highly variable according to their food. Many are generalist predators living on or in the soil but some are known to predate or parasitise crop pests or feed on fungi, such as mildew, on cereals.

This is a very diverse group of insects, common in most habitats, including farmland. Most are small, 3–5 mm, although they range in size from <1 mm to 35 mm. They are elongate with variable colour patterns, some quite distinct, but on the whole are difficult to identify.

Numbers have declined sharply in recent decades in cereal crops, probably as a consequence of fungicide use.

Aleochara lata, *with the typical shape of this highly abundant family of insects*

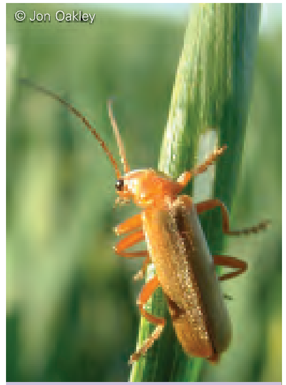
Soldier beetles (Cantharidae) – 41 species

Identification

Larvae are dark brown or grey, sometimes with a velvety appearance, highly segmented, almost worm-like.

Narrow elongated beetles (2–15 mm) with soft bodies whose name arose from the similarity of the red-coloured species to military uniforms. The wing-cases are long, thin and covered with short dense hair that gives them a dull, matt appearance. The adults can be brightly coloured either yellow or red (as in Red Soldier beetles), or are dark–brown or black (known as Sailor beetles) sometimes with yellow tipped wing cases.

Adults are good flyers and larvae are capable of moving from margins into fields.



Rhagonycha fulva *is typically seen mating on cow parsley and hogweed flowers*

Life cycle

One or two generations are produced each year. Adults feed predominantly on nectar, pollen and honeydew but can be carnivorous, feeding on live and dead soft-bodied insects, such as caterpillars, spider mites and aphids. They are often seen on flower heads of umbellifers at mating time.

Benefits

Larvae feed on vegetation but are rarely pests and, when larger, prey on fly larvae, caterpillars and earthworms.

Adults are carnivorous and feed on other flower visitors.

Five species are important for biocontrol, three are abundant on farmland.

The adults and soil-active larvae of Cantharis livida *are predatory*

Status

Abundant in meadows and flower-rich field margins, they are frequently observed visiting umbellifer flowers, for example, cow parsley.

How to encourage

Larvae prefer dense vegetation and cover crops in winter may encourage larvae into arable fields from field boundaries. Flower-rich habitats, especially those containing umbellifers, will attract adults.

Ladybirds (Coccinellidae) – 53 species

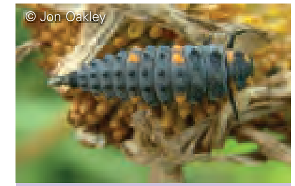
Identification

Eggs are easily recognisable, usually elongate, oval-shaped and laid end up in batches. Their colour varies between species varying from light yellow to dark orange.

Larvae are brightly coloured and have a distinctive appearance. They are commonly seen feeding on aphids in crops.

The larva of the non-native, invasive Harlequin ladybird

Adults (1–10 mm) are, typically, brightly coloured (yellow, orange or scarlet), usually with patterned (spots, bands or stripes) wing covers, domed bodies and short, club–shaped antennae.



Larva of the 7-spot ladybird

Life cycle

The life cycle usually lasts about one year, occasionally there are two generations per year. Eggs are laid in spring to early summer, close to their larval prey. Pupation occurs mid-summer and adults emerge mid–late summer. With sufficient food and warmth, larval development is faster and two generations per year are possible. They overwinter as adults in sheltered places, such as in leaf litter, grass tussocks, bark crevices and buildings. They emerge in spring and seek out mates.

Left: Adult 7-spot ladybird

Right: Adult cream spot ladybird preparing to fly

Benefits

Their most common food is aphids and scale insects, although a few species feed on fungi and the 24-spot feeds on plants. Five species are considered important for the control of aphids on cereals, potatoes and sugar beet. Ladybirds are good flyers; however, adult dispersal is random and it is only when they settle on a plant that more systematic searching occurs aided by olfactory cues.

Status

Threatened by the invasion of the non-native Harlequin ladybird, which competes for food and consumes the larvae of native ladybirds.

How to encourage

Adults are attracted to simple open flowers, for example, wild carrot, angelica and yarrow, where they feed on nectar and pollen. The use of broad spectrum insecticide sprays should be avoided.

Bugs (Hemiptera)

Bugs include true bugs (Heteroptera), aphids and whiteflies (Sternorrhyncha) and hoppers (Auchenorrhyncha).

Natural enemies are only found in the Heteroptera; their contribution to pest control is unknown. Of the carnivorous families, only Anthocoridae and Nabidae, occasionally Reduviidae, occur on farmland.

Flower and pirate bugs (Anthocoridae) – 33 species

Identification

Flower and pirate bugs are difficult to identify to species level. They are small (2–6 mm) and generally flattened, oval or long with a head with a parallel-sided snout. The end antennal segment is coloured.

Life cycle

There are one to three generations per year and they overwinter as adults. Eggs are laid singly just beneath the surface of their prey's host plant. Each female typically lays 50 or more eggs and there are five nymphal stages, reaching adulthood in about 50 days.

Benefits

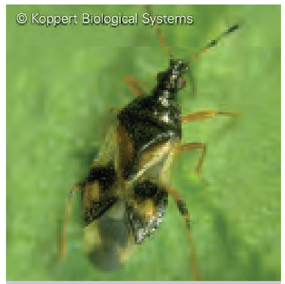
Nymphs are predatory and can consume up to 240 aphids. Most adults are highly mobile and seek out their prey, making them effective predators. They are most commonly found on trees and shrubs, where the larvae and adults feed on eggs, immature and adult stages of immobile insects, such as thrips, aphids, mites and whiteflies. Some are specialised and are capable of feeding on leaf-mining caterpillars.

Status

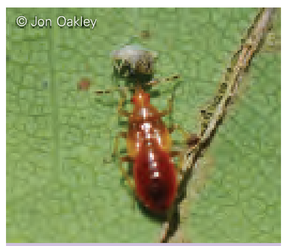
Unknown

How to encourage

They may benefit from floristically diverse field margins and non-crop habitats that contain alternative prey.



*Adult flower bug (*Anthocoris nemoralis*)*



Flower bug nymph

*Adult flower bug (*Orius insidiosus*) feeding on thrips*

Damsel bugs (Nabidae) – 12 species

Identification

All species are brown, slender with long legs and a four-segmented beak. They are approximately 6–12 mm long.

Life cycle

Damsel bugs have one generation per year, although they are capable of producing hundreds of eggs laid in rows of 5–10 on plant stems. They have either four or five nymphal stages, overwintering either as eggs or adults.

Benefits

The adults are frequently flightless but they are still mobile, aggressive predators that feed on a wide range of insects. They are found on plants on the ground and in margins, shrubs and trees.

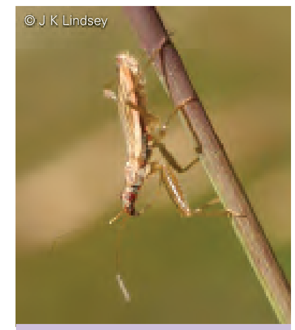
Status

Unknown

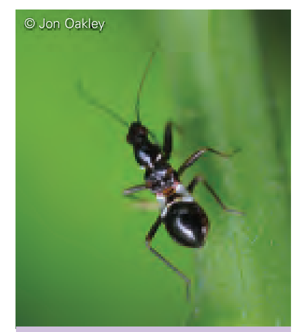
How to encourage

They may benefit from floristically diverse field margins and non-crop habitats that contain alternative prey.

*Marsh damsel bug (*Nabis limbatus*)*



*Damsel bug (*Nabis rugosus*)*



*Damsel bug nymph (*Himacerus mirmicoides*)*

Assassin bugs (Reduviidae) – 8 species

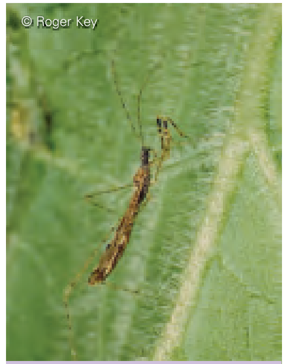
Identification
Assassin bugs can be large (4.5–18 mm) and have a short, curved rostrum.

Life cycle
They have one to two generations per year, although they sometimes take more than one year to reach maturity. Assassin bugs overwinter as eggs, larvae or adults.

Benefits
Larvae and adults are predators of immature and adult stages of flies, beetles and caterpillars. They inject a lethal saliva for extra-oral digestion. They may also bite humans.

Status
Unknown

How to encourage
They may benefit from floristically diverse field margins and non-crop habitats that contain alternative prey.



Thread-legged bug (Empicoris vagabundus)

Centipedes (Chilopoda) – 57 species

Identification
Centipedes are not insects but belong to the myriapods, meaning 'many legs'.

They have a variable number (always odd) of flattened segments, each bearing a pair of legs. The first pair of legs are modified to form a pair of pincers that inject venom into their prey. They are typically a drab brown colour and 30–60 mm long.

In contrast, millipedes are vegetarians and have two pairs of legs on each segment.

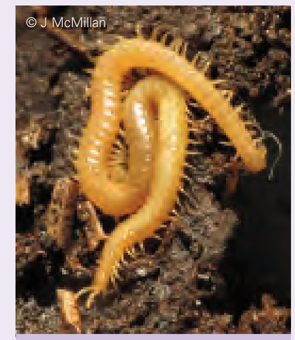
Life cycle
Eggs are laid singly or in batches and are cared for by some species. The larvae develop through a series of moults into adults. Generation time is usually one year but adults may live for several years.

Benefits
Most are predatory, living in the soil, dead wood or leaf litter and predating any soft-bodied insects and earthworms.

Status
Unknown.

How to encourage
Unknown.

Variegated woodland centipede



Western yellow centipede

Flies (Diptera)

The diptera is a very diverse order, with just over 7,000 species. Flies occur everywhere and are commonly known on farmland, where they may be pests (pages 80 to 125), pollinators or natural enemies.

Although there are numerous predatory species that are very common on farmland, relatively little is known about their ecology and contribution to pest control, except for the hoverflies (page 190). Likewise, many species may pollinate flowers but their overall importance for pollination is poorly understood. They also contribute to nutrient recycling of dung and vegetation.

Robber flies (Asilidae) – 29 species

Identification

Adults are of variable size, 3–50 mm (typically 9–15 mm) and vary in shape from long and slender to short and stout. Likewise, colourings are variable, sometimes with yellow or orange markings on the body, similar to the markings of wasps and bees (warning signs). They are relatively rare on farmland.

Life cycle

The number of generations per year varies from one to several, depending on the species.

Benefits

The larvae predate the larvae of other insects, either in the soil or in decaying wood. Adults are agile flyers, capable of catching other insects on the wing and spiders. They are found in most types of uncropped land on farmland. Two species are considered important for biocontrol.

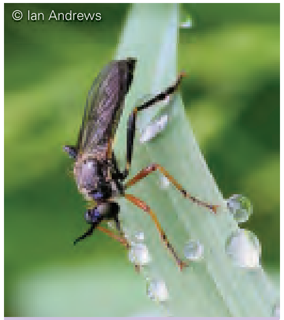
Status

Unknown

How to encourage

Robber flies favour open, sunny habitats, comprising grassland and shrubs or hedgerows.

*Robber fly (*Dioctria baumhaueri*) with prey*



*Robber fly (*Dioctria rufipes*)*

Long-legged flies (Dolichopodidae) – 287 species

Identification

Adults are small, 1–9 mm, with long slender legs. They generally have metallic green bodies, although they can be yellow, brown or black. The wings are opaque or with dark areas towards the tips.

Life cycle

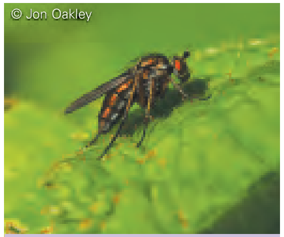
Larvae develop in the soil, on dead organic matter or in crevices on trees and are predatory or are leaf miners. The number of generations per year is unknown. The adults are strong flyers.

Benefits

Larvae may predate small soil-inhabiting insect pests. Adults are very common in field margins and crops, predating small invertebrates including pest aphids, midges, thrips and other fly larvae or adults or only feed on floral resources. Six species are important for biocontrol.

Status

Unknown



*Long-legged fly (*Dolichopus *sp.)*

*Long-legged fly (*Poecilobothrus nobilitatus*)*

How to encourage

Techniques to encourage long-legged flies include:

- providing field margins with a diverse range of flowering shrubs and herbaceous plants
- avoiding cutting in the summer
- preventing pesticide drift into margins

Balloon and dagger flies (Empididae) – 208 species

Identification
Balloon and dagger flies are distinguished by their small round head, large eyes and humpbacked thorax. Shapes vary from slender to robust and they vary in size from tiny to large (1–12 mm).

Life cycle
The life cycle of these flies is poorly understood. There is probably one generation per year.

Benefits
Larvae are predatory on other insects in the soil or dead wood or are aquatic.

Adults are typically predatory, with strong, piercing mouthparts and predate aphids, psyllids, whiteflies, coccids, midges, thrips and mites, although their contribution to pest control has not been quantified.

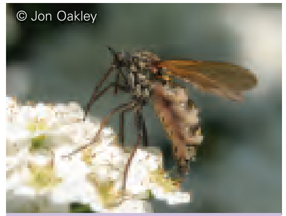
Adults of some species feed on pollen and nectar but their contribution to pollination is unknown.

Six species are considered important for biocontrol.

Status
Balloon and dagger flies are very abundant in field boundaries and some crops.

How to encourage
Techniques to encourage balloon and dagger flies include:

- providing field margins with a range of flowering shrubs and herbaceous plants
- avoiding cutting margins in summer
- preventing pesticide drift into margins



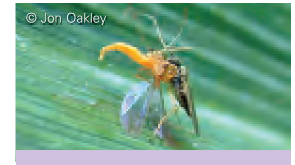
Balloon and dagger fly (Empis entomophthora)

Balloon and dagger fly (Empis sp.)

Balloon and dagger fly with prey

Dance flies (Hybotidae) – 175 species

Identification
Dance flies are small (1–6 mm) and their shapes vary from slender to robustly built. They have a humped thorax and are very similar to Empididae but smaller.



*Dance fly (*Platypalpus *sp.) with orange wheat blossom midge*

Life cycle
A dance fly completes one or two generations per year.

Benefits
Adults are mostly predatory on small insects, such as aphids and midges, in cereals and oilseed rape. The larvae are predatory and live in the soil, dead wood or organic detritus. Four species are considered important for biocontrol.

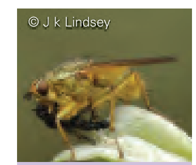
Status
Dance flies are often highly abundant along field boundaries and within fields.

How to encourage
Techniques to encourage dance flies include:

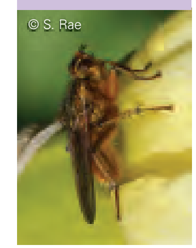
- providing field margins with a range of flowering shrubs and herbaceous plants
- avoiding cutting margins in summer
- preventing pesticide drift into margins

Dung flies (Scathophagidae) – 54 species

Identification
Colour varies from dullish yellow-brown to black and/or yellow. The shape varies from slender to robust and the size from small to large (3–12 mm). The flies have bristly bodies and legs.



Adult dung fly



Life cycle
Dung flies have a diverse range of life cycles, depending on larval feeding habitats. The number of generations per year is unknown.

Benefits
Larvae feed on plant leaves and flowers, detritus, dung or eggs of aquatic insects. Adults are predatory on soft-bodied insects, often associated with dung. Six species are considered important for biocontrol.

Status Unknown

How to encourage
Dung flies are favoured by mixed farming systems where dung is available.

Gall midges (Cecidomyiidae) – 620 species

Identification
Midges are hard to identify to species, although the family can be distinguished by their broad, round, often fringed wings. They are minute to tiny (0.5–3 mm).

Life cycle
Two to three generations per year are typical. Adults only feed on nectar or honeydew. Overwintering occurs in the soil.

Benefits
The pest midge species and those that form galls are more commonly known; however, at least five species have larvae that feed on aphids and others predate mites.

Of the aphidophagous species, each female can lay 50–150 eggs close to the aphid colony; each larvae can consume up to 80 aphids.

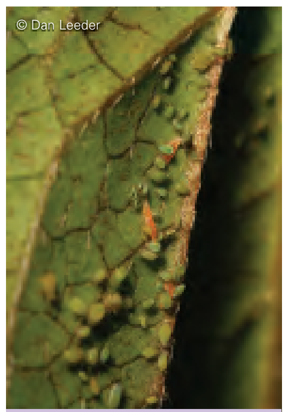
Adults of some species are also predatory.

Status
Unknown

How to encourage
Field margins with a diverse range of flowering shrubs and herbaceous plants provide a source of nectar for adults.

A few species are reared and released for biocontrol programmes in protected crops, strawberries and ornamentals; for example, *Aphidoletes aphidimyza* for aphid control and *Feltiella acarisuga* for spider mite control.

Gall midge larva feeding on peach–potato aphids



Gall midge larvae feeding on aphids

Hoverflies (Syrphidae) – 274 species

Identification
Eggs are ovoid and laid singly or in groups depending on the species.

Predatory larvae are coloured unlike other fly larvae, which are white or dirty yellow.

Pupae can sometimes be found attached to leaves.

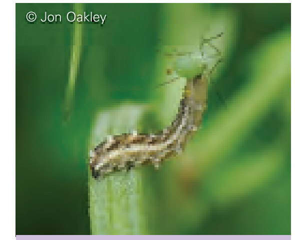
A wide range of colours is found in adults, although species with predatory larvae are black with white or yellow spots or bands similar to bees and wasps. Shapes vary from slender to stout and size varies from small to very large (3.5–35 mm). They are characterised by their ability to hover.

Life cycle
A highly diverse group with wide-ranging life histories. Generation time is, typically, one or several per year although it can be longer. Adults are highly mobile, capable of migrating hundreds of miles.

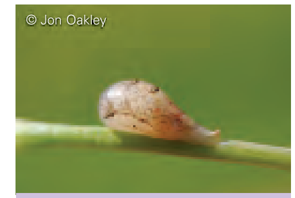
Benefits
They are highly effective predators because of their mobility and short generation time, capable of preventing aphid outbreaks. Aphids are the predominant prey of species with predatory larvae and each can consume up to 1,200 aphids. The larvae are largely nocturnal, so rarely seen on plants. Larvae of other species feed upon fungi, plant parts, detritus or are aquatic. Adults feed upon pollen and nectar of simple open flowers, usually white or yellow, such as umbellifers and daisies, and assist with pollination. Six species are important for biocontrol, two of which are very abundant.

Status
Numbers are declining, especially of those species with one generation per year.

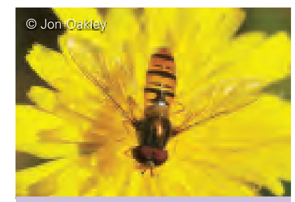
How to encourage
Adults can be attracted into a locality by planting appropriate flower-rich habitats but will only remain if suitable densities of aphid prey are available. Hoverflies feed on the flowers of annual arable plants (eg cornflower, chickweed, knotweeds and shepherd's purse) and hedgerow plants (wild carrot, cow parsley, hogweed and white campion). In addition, flower strips can be established specifically for hoverflies in and around fields containing coriander, buckwheat, phacelia or alyssum.



Hoverfly larva and pea aphid



Hoverfly (Episyrphus balteatus) *pupa*



*Hoverfly (*Episyrphus balteatus*) adult*

Lacewings (Neuroptera) – 69 species

Lacewing larva

Identification

Eggs are laid in groups, attached to vegetation. Larvae have distinct arrow-shaped brown bodies with large pincers. They sometimes attach remains of their prey to their backs as camouflage. Adults have large, translucent wings that are held roof-like above their bodies. Their wings are longer than their bodies.

Life cycle

Lacewings are capable of producing several generations per year. Eggs can develop in 6–30 days and are followed by three predatory larval stages. Larvae may also feed on extrafloral nectaries. Pupation occurs in a cocoon on plants and overwintering can occur in this stage or as adults.

Benefits

The prey of larvae and adults is usually soft-bodied insects, especially aphids, although adults may also consume nectar, yeasts, pollen and honeydew. Lacewings are capable of responding to chemical cues associated with aphids. The number consumed by each larva varies but can exceed 1,500. Their effectiveness in controlling aphid outbreaks is, however, uncertain.

Status

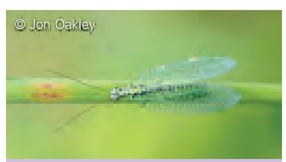
Unknown

How to encourage

Adults may be attracted by flower-rich areas and plants supporting aphids. They are known to be attracted to strips of buckwheat. There are two important families for pest control (shown below).

Green lacewings (Chrysopidae) – 20 species

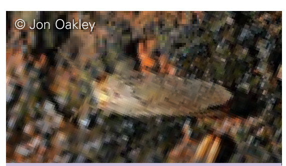
- Green bodies and golden eyes
- 20–25 mm long
- Females lay 150–600 eggs each



Chrysopa perla

Brown lacewings (Hemerobiidae) – 31 species

- Brown or grey bodies
- 6–25 mm long
- Less noticeable than green lacewings
- Females lay 600–1,500 eggs each



Hemerobius nitidulus

Sawflies, wasps, ants and bees (Hymenoptera)

This order of insects is the largest, comprising 57 families, and encompasses insects with very different life forms and biologies.

The order is divided into three suborders:

Apocrita-Aculeata

- Stinging insects
- Slender-waisted
- Includes social insects, such as bees, wasps and ants
- Also includes some solitary predatory wasp species

Hornet

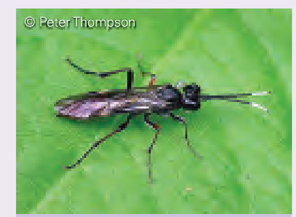
Apocrita-Parasitica

- Parasitic wasps
- Slender-waisted
- In many situations, the most important group of natural enemies

Parasitoid wasp
*(*Stenomalus micans*)*

Symphyta

- Sawflies and woodwasps, some of which are pests
- Plant-feeding
- No obvious waist



White-tipped sawfly,
Taxonus terminalis

Adult hymenoptera require proteins for egg development and most feed on honeydew, nectar or other plant secretions.

Adults of some species are carnivorous (eg ants, vespid wasps and some sawflies).

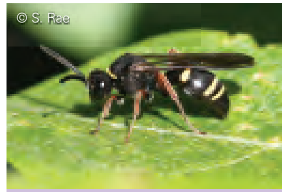
The feeding habitats of the social insects are more complicated and may involve the collection and storage of plant and animal food or culturing of fungi and other insects.

Bees, true wasps and ants (Apocrita-Aculeata)

Within this suborder there are some parasitic species but in these cases the eggs are laid near the host and the larvae attack the host from the outside.

Solitary wasps
(Crabronidae) – 118 species

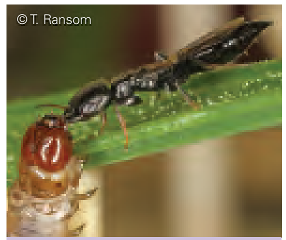
- Adult females will take other insects, including other natural enemies, to feed their young in nests
- Their contribution to biocontrol is unknown



Crabronid wasp (Nysson spinosus)

Bethylid wasps
(Bethylidae) – 22 species

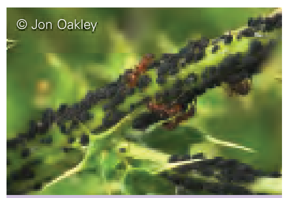
- Ectoparasites of beetle (including stored product pests), moth and butterfly larvae



Bethylid wasp

Ants
(Formicidae) – 60 species

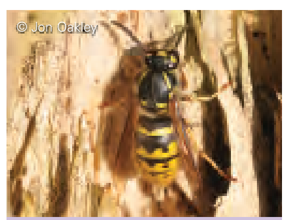
- Some species are predatory, while others ‘farm’ aphids
- Confined to uncultivated land



Black bean aphids attended by ants (Myrmica sp.)

True wasps
(Vespoidae) – 7 species

- Feed their young on other insects
- Very powerful jaws
- Notched crescent-shaped eyes, wings folded lengthwise at rest
- Eat pollen but do not have nectar-sucking mouthparts



Common wasp (Vespa vulgaris)

Parasitic wasps/parasitoids
(Apocrita-Parasitica) – over 6,000 species

Identification
Most adult parasitoid insects are small and their identification is difficult and requires magnification.

In some cases, it is possible to identify when the host has been parasitised, for example, mummified aphid nymphs and adults or by changes in egg colouration. Such changes can be used to gain an insight into the proportion of parasitised pests and whether chemical treatments are needed.

Life cycle
Given the huge number of parasitoid species, it is not surprising that there is a diverse array of different ways in which parasitoids have evolved to coexist with their hosts.

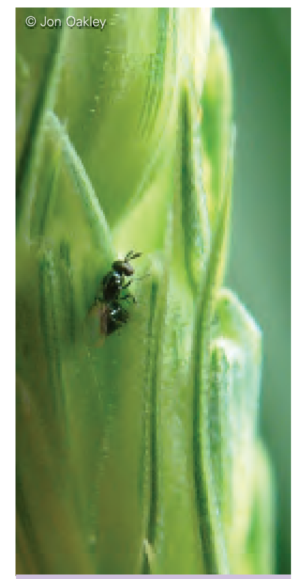
The larvae of parasitic hymenoptera are usually endoparasites (the egg is laid on or inside the host and the larvae consume it, usually killing it) and such insects are called parasitoids. There are also examples of ectoparasites, which feed outside of the host's body, and some that parasitise plants (eg gall wasps). In a few cases, there are species with plant-feeding larvae (eg Agaonidae and Cynipinae) or with predatory larvae.

Adults feed on nectar, pollen and honeydew, although females of at least 17 families also feed on their hosts, consuming body fluids. The amount and quality of adult food can, in some cases, extend the adult's lifespan and increase fecundity.

Adult parasitoids often emerge in areas devoid of their hosts, so they first locate their host's habitat using chemical and physical parameters. Once in the right habitat, the adults search systematically for their hosts using chemical cues originating from their host. This is then followed by a process to determine host suitability and acceptance.

Parasitoids overwinter within their host, either coinciding their development with that of the host, or altering the host's development for their own purpose.

Mummified potato aphid



Parasitoid wasp (Macroglens penetrans)

Parasitoid laying eggs in an aphid

Benefits

Almost every life stage of each insect species is parasitised by one or more wasps; even the parasitic wasps can be parasitised by hyperparasitoids. Each parasitoid species, typically, attacks a specific host species or closely related group of species. They have developed venoms to immobilise their host and an ovipositor that can place eggs very precisely within or on the host.

Parasitoids are important in the control of most pests, with those from the Ichneumonidae and Braconidae (superfamily Ichneumonoidea) being the most important, comprising over 3,000 species. The other common superfamily in agricultural crops is the Chalcidoidea, most of which are parasitoids, often of eggs.

Parasitoids can control the sex of their offspring and, consequently, the number of fertile females and infertile males. Some species can also produce eggs that continue to divide after laying, producing more than one larva. These attributes give them the ability to respond to their environment by controlling their reproductive output.

Parasitic wasps/parasitoids
(Apocrita-Parasitica) – over 6,000 species

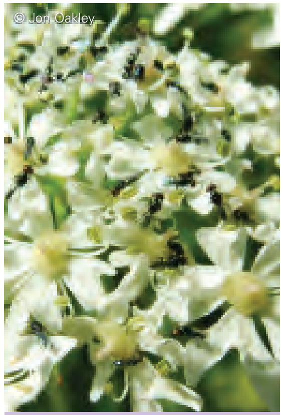
Status

Cereal pests	Number of important parasitic species (abundant)
Cereal aphids	8
Orange wheat blossom midge	4 (3)
Yellow wheat blossom midge	3
Frit fly	91 (2)
Gout fly	2
Yellow cereal fly	0
Wheat bulb fly	2
Cereal leaf beetle	3
Cereal ground beetle	unknown
Wireworm	unknown
Cereal stem sawfly	2
Leatherjackets	2
Slugs	10–20

Oilseed rape pests	Number of important parasitic species (abundant)
Cabbage aphid	3
Peach–potato aphid	2
Brassica pod midge	>20 (2)
Cabbage root fly	2
Cabbage stem flea beetle	8 (1)
Cabbage flea beetle	4
Rape winter stem weevil	4 (2)
Seed weevil	>20 (3)
Cabbage stem weevil	6 (1)
Rape stem weevil	3 (1)
Pollen beetle	9 (3)
Turnip sawfly	2
Slugs	10–20

How to encourage

Parasitoids are, in some cases, capable of providing sufficient control to prevent pest outbreaks alone, although it may be necessary to adopt specific crop management practices to ensure this occurs.



Parasitoid wasps on cow parsley

Given their small size, dependence on pests as hosts and preference for floral resources that are usually located on the top of the canopy, parasitoids are very vulnerable to the direct and indirect effects of pesticides. Only spray when thresholds are exceeded and avoid drift into uncropped areas.

Parasitoids may benefit from supplies of nectar provided by simple open flowers, such as those on buckwheat and umbellifers. Alternative host species may be needed outside the crop growing season.

Parasitoids are weak flyers and for the species that overwinter in the soil (parasitoids of pollen beetle), adopting minimum tillage and planting crops nearby to the previous year's location will improve parasitism rates.

Identification

Spiders are arachnids, not insects; they have four pairs of legs, no wings and no antennae. They have only two body regions. Harvestmen are most likely to be confused with spiders. In harvestmen, the two parts of the body are broadly joined, whereas in the spiders the body is clearly divided into two parts joined by a narrow stalk. Harvestmen have only two eyes, whereas spiders have six to eight.

Spiders and harvestmen are generalist predators and, consequently, may also capture other pest natural enemies. They provide background levels of control but the more mobile species only settle in locations with sufficient prey so exhibit some response to prey densities.

Life cycle

The generation time varies hugely between species, from short-lived species with multiple generations per year to those that produce one generation per year and live for several years. Eggs are laid in clutches inside a silk sac and emerge as spiderlings, which in some species are cared for by the female. Spiderlings pass through several moults before reaching adulthood. Some spiders are capable of dispersing over large distances by spinning a long thread on which they are carried by air currents, known as ballooning.

Benefits

Spiders are carnivorous and are unique in having a spinner near the hind end of the abdomen that produces silk. Some spiders spin webs which are used as snares. Others do not spin webs but instead lie in wait for their prey or actively hunt. Web-spinning spiders are more effective predators because their webs can continue to catch prey after they have been abandoned. Spiders and harvestmen can be an important component of bird diets.

Status

Unknown.

How to encourage

For web-spinning species, vegetation or a soil surface with a diverse architecture provide more opportunities to build webs. Leaving trash on a more cloddy surface helps retain spiders within fields in the autumn, while the presence of arable weeds provides a suitable structure in the spring and summer.

Wolf spiders occur predominantly along field margins and penetrate less than 60 metres into fields. Splitting fields using beetle banks or similar vegetative strips can help improve coverage within fields.

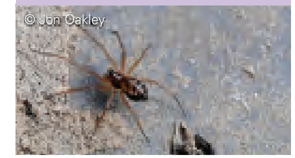
Spiders are highly vulnerable to pyrethroid insecticides.

Spiders and mites (Arachnida)

Money spiders
(Linyphiidae) – over 270 species

- Largest European family
- Highly abundant, especially cereal crops
- Small grey or black bodied spiders, 1.2–7.2 mm long
- Hunting or web building
- Drift through air on strands of silk

Above: Erigone *sp.*
Below: Linyphiid *sp.*



Wolf spiders (Lycosidae) – 36 species

- Hunting spiders, mostly at ground level but occasionally on low vegetation
- Mostly brownish, but attractively marked and clothed in dense hairs, 3.5–18 mm long
- Most abundant in field headlands
- Good runners and can jump
- Females conspicuous from May/June onwards with brown or greenish-blue egg sacs

Wolf spider
*(*Pardosa *sp.)*

Predatory mites (Phytoseiidae) – 34 species

- Highly effective predators of spider mites due to their voracity (20 spider mites per day), short generation time (1 week) and high fecundity (40–60 eggs per female)
- Some species are reared and released for biological control
- Also may feed on other small insects, honeydew and pollen, the latter boosting their reproductive capability
- More susceptible to insecticides than their spider mite prey

Adult predatory mite
*(*Phytoseiulus persimilis*)*

Further information

AHDB Cereals & Oilseeds Publications

Available at **cereals.ahdb.org.uk/publications**

G51: Enhancing arable biodiversity through the management of uncropped land: an HGCA guide (2011)

Research Review 86: A review of pest management in cereals and oilseed rape in the UK (2016)

Information from other organisations

For guidance on IPM, habitat creation and biological control, see **www.gwct.org.uk/research/habitats/farmland**

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