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Beneficial Insects for Crop Protection

Getting to know the beneficial insects in your fields, and helping them work for you

Agricology

Salticidae eating. Photo credit: Tom Iwasyszyn

Front cover image: Seven-spot ladybird. Photo credit: Racheal Travis, Royal Entomological Society

About this guide

Many of the insects you see in and around your fields are quietly working in your favour, pollinating crops, helping with nutrient cycling and pest control, and other supporting services. Some insects can cause a lot of damage either directly or indirectly (e.g. virus transmission) to crops; however, insects are an integral part of natural ecosystems and generally work to help us. There are diminishing options for effective insecticides and growing concerns about adverse environmental side-effects. Alongside this, there is a worrying trend of decreasing insect abundance, changes in distribution, and reduction in the diversity of insect species in the UK, largely understood to be caused by habitat loss and fragmentation, agricultural intensification, climate change, pollution, and the spread of invasive species.[1] We can be the solution rather than the problem - understanding and supporting the beneficial insects already living on your farm and attracting others from within the wider environment has never been more important.

This guide focuses on the insects and other arthropods that protect crops by feeding on pests, also known as beneficial insects. It explains which insects they are, what they do, and what you can do to give them the best chance of doing their job.

What is an insect?

Maybe you've never considered it before, but the first step in using something to your advantage is to understand it. This guide is all about beneficial insects that help to protect crops, but not everything mentioned in the guide is technically an insect - some really helpful critters, such as spiders, aren't insects at all. Throughout this guide we will use the term 'insect' to cover all these helpful arthropods (see below), for simplicity.

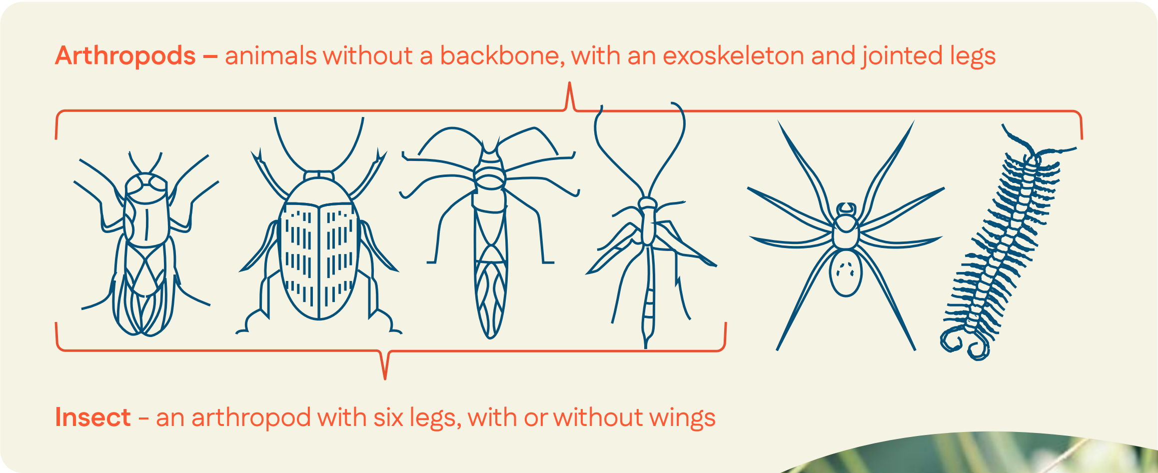


Photo credit: Rothamsted Research

How do insects work?

The basics of insect biology are extremely different to our own and understanding a little about this can help us to understand their activity and behaviours, and therefore methods of pest control.

Mouthparts

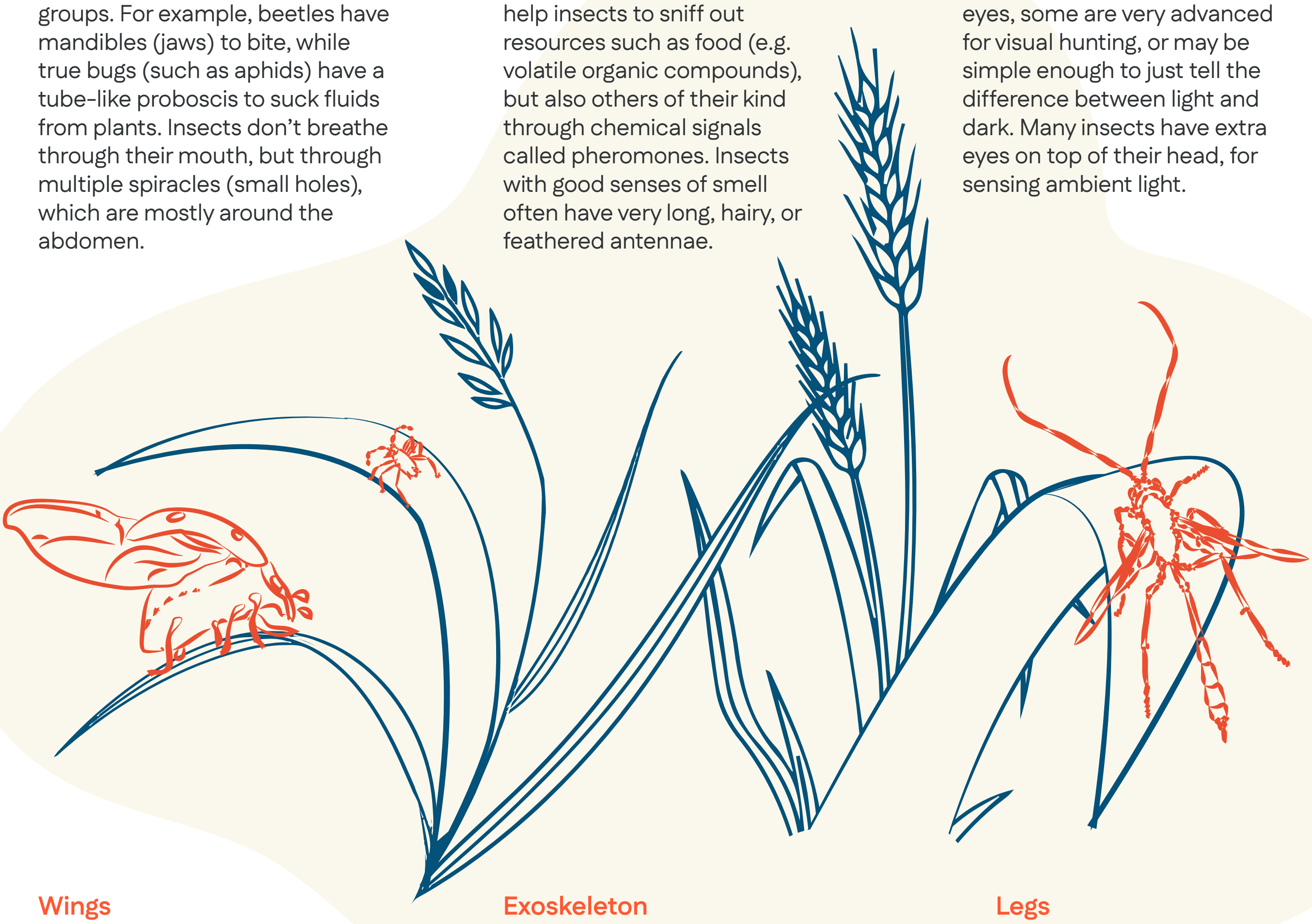
These vary widely across insect groups. For example, beetles have mandibles (jaws) to bite, while true bugs (such as aphids) have a tube-like proboscis to suck fluids from plants. Insects don't breathe through their mouth, but through multiple spiracles (small holes), which are mostly around the abdomen.

Antennae

These mobile appendages help insects to sniff out resources such as food (e.g. volatile organic compounds), but also others of their kind through chemical signals called pheromones. Insects with good senses of smell often have very long, hairy, or feathered antennae.

Eyes

Most insects have compound eyes, some are very advanced for visual hunting, or may be simple enough to just tell the difference between light and dark. Many insects have extra eyes on top of their head, for sensing ambient light.



Wings

Insects may or may not have wings. All insects that fly have two pairs of wings, except for flies. For beetles, their forewings have been modified to protect their hind wings from getting damaged and, for flies, their hind wings are modified into small rod-like structures (halteres) that provide stabilisation during flight. Some insects have generations that are winged and some are not, such as aphids, that have dispersive generations.

Exoskeleton

Being hard on the outside makes a huge difference to how these creatures move, breathe and grow. During growth, insects can regrow and repair damaged limbs by moulting their exoskeleton. However, for most insects, once they reach their adult stage, they no longer grow and therefore don't moult or replace their exoskeleton or any damaged limbs. For example, an adult beetle does not moult and does not grow any more. Spiders continually moult, even when they reach their adult stage.

Legs

They can be wider for better digging, longer for fast running, have fringed hairs for swimming, very grippy claws and wide sticky feet for climbing, and even notches for stridulation-making sounds through rubbing body parts together.

Insects are cold blooded 'poikilotherms' which means they are affected by temperature. Their activity can either depend heavily on the weather, or they can use strategies such as basking, or warming themselves with flight muscle activity.

A bug's life

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
			asexual reproduction (parthenogenesis)								sexual reproduction			
Pest	Aphid (host alternating) *(Aphididae)*	egg	nymph	adult	adult/ nymph	adult/ nymph	adult/ nymph	adult/ nymph	adult/ nymph	adult/ nymph/ mating	adult/egg	egg	egg	Incomplete metamorphosis
		sexual reproduction												
	Cabbage stem flea beetle (Chrysomelidae: *Psylloides chrysocephala*)	larvae	larvae	larvae/ pupae	larvae/ pupae	pupae	adult	adult	adult	adult/ mating/ egg	egg	egg/larvae	larvae	Complete metamorphosis
		sexual reproduction												
Beneficial	Pirate bug *(Anthocoridae)*	adult (dormant)	adult (dormant)	adult/ mating/ egg	adult/ mating/ egg	nymph	adult	adult	adult	adult	adult	adult (dormant)	adult (dormant)	Incomplete metamorphosis
	Ladybird *(Coccinellidae)*	adult (dormant)	adult (dormant)	adult/ mating/ egg	egg/larvae	larvae	adult	adult	adult	adult	adult	adult (dormant)	adult (dormant)	Complete metamorphosis

Most insects lay eggs but, depending on their subsequent development, they can be distinguished into two groups. Some undergo complete metamorphosis (holometabolous), such as a ladybird, whereby they have a larval stage that does not resemble the adult. The larvae will grow and will then pupate and emerge as an adult ladybird beetle. Others undergo incomplete metamorphosis (hemimetabolous), such as a pirate bug, that hatch into a nymph that resemble the adult and will continue to grow and moult until they reach their adult form.

Many beneficial insects have larval stages with completely different needs to adults and, in some cases such as hoverflies, are even more useful (from a pest management perspective) before they are fully grown!

Friend or foe?

Pests tend to get all the press as we notice them when they are problematic to us, but there are many insects that are beneficial to humans, they take a vital place in natural systems and indirectly help us by supporting other valuable species (e.g. as a food resource). We define pests in farmland as an organism that is damaging to crops or livestock, either directly by feeding damage or by spreading disease.

There is no precise technique to differentiate between a pest and beneficial insect, but generally, pests are herbivorous, can reproduce quickly in large numbers, and are often very mobile so are able to move to new areas. Beneficial insects that eat crop pests however are predators; they tend to reproduce less, and some have short lifespans and life cycles. This can be problematic when you consider traditional control methods – pest insects can recover populations much more quickly than our beneficial insect friends.

Ecosystem services

The natural processes that help us thrive

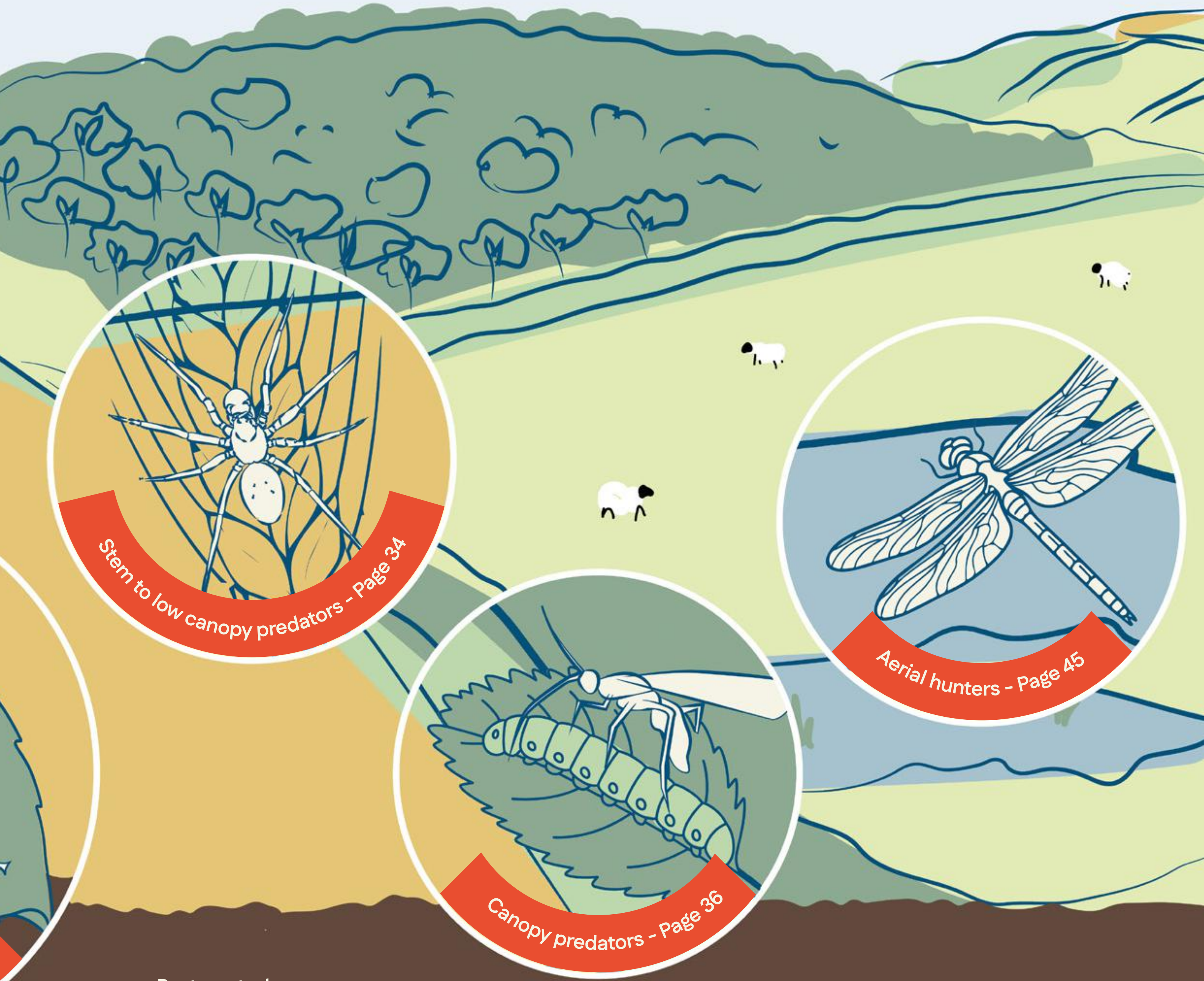
The ecosystem is simply the world around us, and all life fits into it in a specific way - what ecologists call a niche. Beneficial predatory insects have adapted to make use of the niche afforded by abundant fast breeding pests. This benefits us directly by protecting crops. But insects also help us indirectly by their roles in soil health, plant reproduction, bioindicators, and feeding other wildlife.

Nutrient cycling

The importance of well-structured and nutrient-rich soils to crop growth and yield is apparent, however, the activities of insects that contribute to soil structure and nutrient cycling are less obvious. These unseen workers of the insect world take dead plant and animal matter, and enrich the soil, improving soil porosity and water capacity, storing carbon and reducing greenhouse gas emissions. Earthworms have even been proven to play an important role in supressing toxigenic plant pathogens.[2]

Pollinators

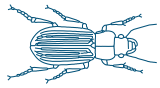
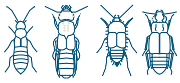
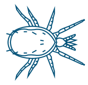
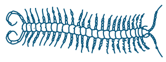
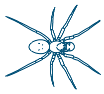
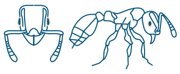
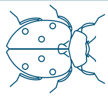
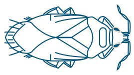
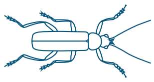
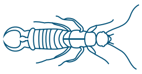
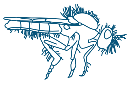
Pollinating insects get a lot of press, and deservedly so – it has been estimated that the insect pollination of crops in the UK has an equivalent value of over £430 million each year,[3] and pollinated crops account for 18% of UK consumption.[4] This is not just bees – butterflies, moths, different types of flies, wasps, bugs, and beetles all help flowering crops to yield.



Pest control

The focus of this guide is those insects that protect our crops by eating and supressing crop pests. These are called "natural enemies" and provide "biological pest control" or "biocontrol". The beneficial insects in this guide are the enemies of pests, evolving alongside them in a natural balanced system. Biological (pest) control is not only sustainable in terms of reducing control costs and negative impacts of chemical inputs, but it is also effective. An experimental reduction of 10% of natural enemies resulted in yield losses calculated at around £111-£175 per hectare (ha) for barley, £37-£74 for oilseed rape (OSR), and £0.50-£8 for wheat.[5] Natural enemies are estimated to account for at least 50% of pest control in crop fields,[6] a contribution valued at over $13 billion per year in the USA alone.[7]

ID at a glance guide

	Size	Shape	Predation
Carabid beetles	4 mm to 3 cm		Slugs, snails, pest beetles, caterpillars, grubs, aphids, and weed seeds
Rove beetles	1 mm to 3.5 cm		Larvae and eggs of pests in the soil, flies, moths, bugs, slugs, snails, and aphids
Harvestmen	5 cm to 7 cm		Soft bodied small insects, grubs, flies, and aphids
Predatory mites	0.2 mm to 0.5 mm		Thrips, whitefly, spider mites, leaf beetles
Centipedes	3 mm to 6 cm		Insect larvae, springtails, mites, and other small insects
Spiders	2 mm to 1.5 cm		Pest beetles, pest flies, moths, crickets, aphids, bugs
Ants	3 mm to 5 mm		Flies, moths, pest beetle larvae
Ladybirds	1 mm to 10 mm (most arable species 4 to 8 mm)		Aphids (primary prey), scale insects, whitefly, mealybug
Pirate bugs	2 mm to 6 mm		Young caterpillars, mites, thrips, aphids and moth/butterfly eggs
Lacewings	6 mm to 20 mm		Aphids, mealybugs, thrips, spider mites, whitefly, small caterpillars, insect eggs. Larvae can consume 200–300 aphids each
Hoverflies	5 mm to 30 mm		Hoverfly larvae eat aphids, scale insects, psyllids, mites and whitefly
Predatory wasps	12 mm to 20 mm (workers smaller, queens larger)		Caterpillars, flies, aphids, spiders, and any available invertebrates. UK social wasps estimated to capture ~14 million kg of insect prey per summer
Soldier beetles	7 mm to 15 mm		Adults: aphids, caterpillars, spider mites, mealybugs. Larvae: ground-dwelling invertebrates including slugs and snails
Parasitic wasps	1 mm to 5 mm (most species require magnification)		Specialist endoparasitoids. Aphidius spp. parasitise cereal and brassica aphids. Tersilochus microgaster parasitises cabbage stem flea beetle larvae. Trichogramma spp. parasitise moth eggs
Earwigs	13 mm to 15 mm		Aphids, woolly apple aphid, pear sucker, rosy apple aphid, codling moth eggs. Generalist nocturnal predator
Robber flies	3 mm to 30 mm		Diverse but notably predate flies, butterflies and moths
Dagger/balloon flies	1 mm to 12 mm		Aphids, other flies and smaller insects including a variety of pests
Long-legged flies	1 mm to 9 mm		Thrips, midges, aphids, fly larvae
Dragonflies damselflies	3 mm to 8.5 cm		Several flying insects such as mosquitoes, midges, flies and gnats. Have been known to catch moths, butterflies, bees and wasps

Peak activity												Key habitats (max 3)	Page
J	F	M	A	**M**	**J**	J	**A**	**S**	**O**	N	D	In-field strips, cover crops, field margins	28
J	F	M	A	**M**	**J**	J	**A**	**S**	**O**	N	D	Cover crops, reduced tillage, field margins	30
J	F	**M**	**A**	M	J	J	**A**	**S**	**O**	N	D	Cover crops, undersowing, field margins	31
J	F	**M**	**A**	**M**	J	J	**A**	**S**	**O**	N	D	Reduced tillage, organic amendments, mulching	31
J	F	M	A	**M**	**J**	J	**A**	**S**	**O**	N	D	Reduced tillage, organic amendments, mulching	32
J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	D	Cover crops, field margins, companion cropping	33
J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	D	Reduced tillage, field margins, in-field strips	35
J	F	M	**A**	**M**	**J**	**J**	**A**	**S**	**O**	N	D	Flower-rich field margins, hedgerows, overwinter cover in dense vegetation	36
J	F	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	N	D	Flower-rich field margins, hedgerows, beetle banks	37
J	F	M	**A**	**M**	**J**	**J**	**A**	**S**	**O**	N	D	Flower-rich field margins, hedgerows, overwinter cover in dense vegetation	38
J	F	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	D	Flower-rich field margins, beetle banks, in field strips	39
J	F	M	A	**M**	**J**	**J**	**A**	**S**	O	N	D	Field margins with thick vegetation, hedge banks, undisturbed grassland for nesting; flowering plants for adult sugar sources	40
J	F	M	A	M	**J**	**J**	**A**	S	O	N	D	Flower-rich field margins, hedgerows, umbellifers; cover crops and dense vegetation for larvae	41
J	F	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	N	D	Flower-rich margins with umbellifers (cow parsley, hogweed, wild carrot); field margins and beetle banks as overwintering sites	42
J	F	M	A	**M**	**J**	**J**	**A**	**S**	**O**	N	D	Dense field margins, hedgerows, tussocky grass; reduced tillage to protect overwintering females in soil	44
J	F	M	**A**	**M**	**J**	**J**	**A**	**S**	**O**	N	D	Grassland, woodland, hedgerows	45
J	F	M	**A**	**M**	**J**	**J**	**A**	S	O	N	D	Field margins, grassland, hedgerows	46
J	F	M	**A**	**M**	**J**	**J**	**A**	S	O	N	D	Field margins, grassland, hedgerows	46
J	F	M	**A**	**M**	**J**	**J**	**A**	**S**	**O**	N	D	Ponds, waterbodies, hedgerows	47

Diversity

Bringing greater resilience

Biodiversity is key to effective natural biological pest control in fields. It is not enough to rely on a single predator species – having a diverse community of beneficial insects, each bringing different skills, tolerances and activity periods, makes pest control more resilient and effective.

Greater diversity does not simply mean more natural enemies doing the same job. Different insect groups attack pests in different ways, at different times, and in different parts of the crop - and together they can achieve significantly more than any single group working alone. A field study in Germany demonstrated that when both flying and ground-dwelling natural enemies were present in winter wheat, cereal aphid populations were suppressed by 172% more than in the controls, compared to just 70% when only flying enemies were present, and 18% with ground-dwelling predators alone.[8] This is the additive and sometimes synergistic effect of combining different natural enemy guilds.

A diverse community of beneficial insects - each bringing different skills, tolerances, and activity periods - makes pest control both more resilient and more effective. This diversity can constitute different species within the same group (e.g. several species of ground beetles), but it is more powerful when it comprises insects from different groups within different habits as they are able to fill in each other's gaps; covering different pest life stages, different zones within the crop, and different activity periods and climatic tolerances.

Specialists and generalists

Natural enemies can be broadly divided into specialists (species that are tied into one prey or habitat), and generalists, which are more adaptable, feeding on a range of prey across overlapping habitats. We need both for effective pest control, but they work differently.

Specialist natural enemies such as parasitic wasps that target a single pest species, are excellent at tracking pest populations closely and can match the pest's life cycle. However, they tend to be slower to build up numbers and require the pest to be present before they can do their job. Generalist predators on the other hand can survive on alternative prey or even plant or fungi material (e.g. ladybirds eat pollen in the absence of suitable prey) when the target pest is scarce, meaning they are already present and active when pest colonisation begins. They form a 'first line of defence' against incoming pests. Having both in the landscape means that you retain both a pest reduction effect (driven primarily by specialists) and a pest stabilisation effect (provided by generalists maintaining low background levels of pests between outbreaks).[9]

Activity across the crop

Pests can occur in all parts of a crop; from the roots to the fruiting heads. Therefore, it makes sense to have beneficial insects situated at every section of the crop; from the soil surface to the canopy and beyond.

At the soil surface, ground beetles and rove beetles patrol at night, hunting for eggs, small larvae, slugs, and

Ant. Photo Credit: Linda Seward

Photo credit: Rothamsted Research

fallen aphids. Spiders build tiny sheet webs between plant stems and in the crop canopy, intercepting small flying insects including aphids. In the mid-canopy, parasitic wasps methodically search for their host insects, while lacewing larvae actively roam the foliage hunting for aphids. Above the crop, hoverflies and ladybirds are highly mobile aerial predators that can respond rapidly to aphid outbreaks, flying in from field margins, hedgerows, and beyond.

Cooperation is in fact more common in nature than competition is, and insects are a key example of this in action. They have evolved to exploit slightly different niches, which has an additive effect for crop pest control. Canopy level predators searching out prey can knock pests to the ground, where they are consumed by ground active predators. Studies suggest that up to 90% of cereal aphids may be knocked to the floor by weather, predator, or parasitoid activity.[10] Where pests have a larval stage in the soil, soil-active beneficials can intercept them there, and any adults that escape their clutches may be caught in spider webs or taken by aerial predators.

Activity periods

Different pests threaten different crops at different times of year, and the beneficial insects that control them have correspondingly varied activity periods. Oilseed rape crops illustrate this well, they are attacked by a wide range of insect pests from the beginning of the growing season until the very end of the crop life cycle, but various natural enemies are also present throughout the seasons. In autumn, when OSR crops are at risk from cabbage stem flea beetle (CSFB) attack, ground beetles are active and feed on CSFB eggs and early larvae. Through the winter, many ground beetles and spiders remain active in mild conditions, providing low-level pest control when few other natural enemies are available. In spring, parasitic wasps emerge and seek CSFB larvae, weevils and pollen beetles to lay their eggs. By early summer, hoverflies and ladybirds are at peak activity, arriving in response to growing aphid populations. Later in summer, lacewings and a later generation of parasitic wasps contribute to late-season pest control.

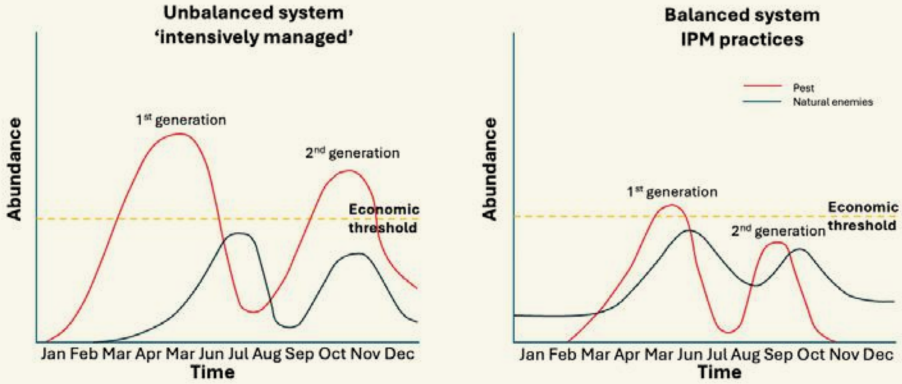
Tolerances

We are living in an increasingly variable climate. Insects are very sensitive to the ambient climate and as a result their numbers can vary from year on year. Perhaps you have noticed years where your crops are teeming with ladybirds, yet the next year they are sparse – this is largely due to the weather and aphid availability at ladybird larval hatching. With a diversity of beneficial insects, if one group has a bad year, another group can fill in the gap. Some groups cope better with drought, some with wet weather, and while a spring breeding group may be hit by cold weather in March, another group might benefit from a following good April.

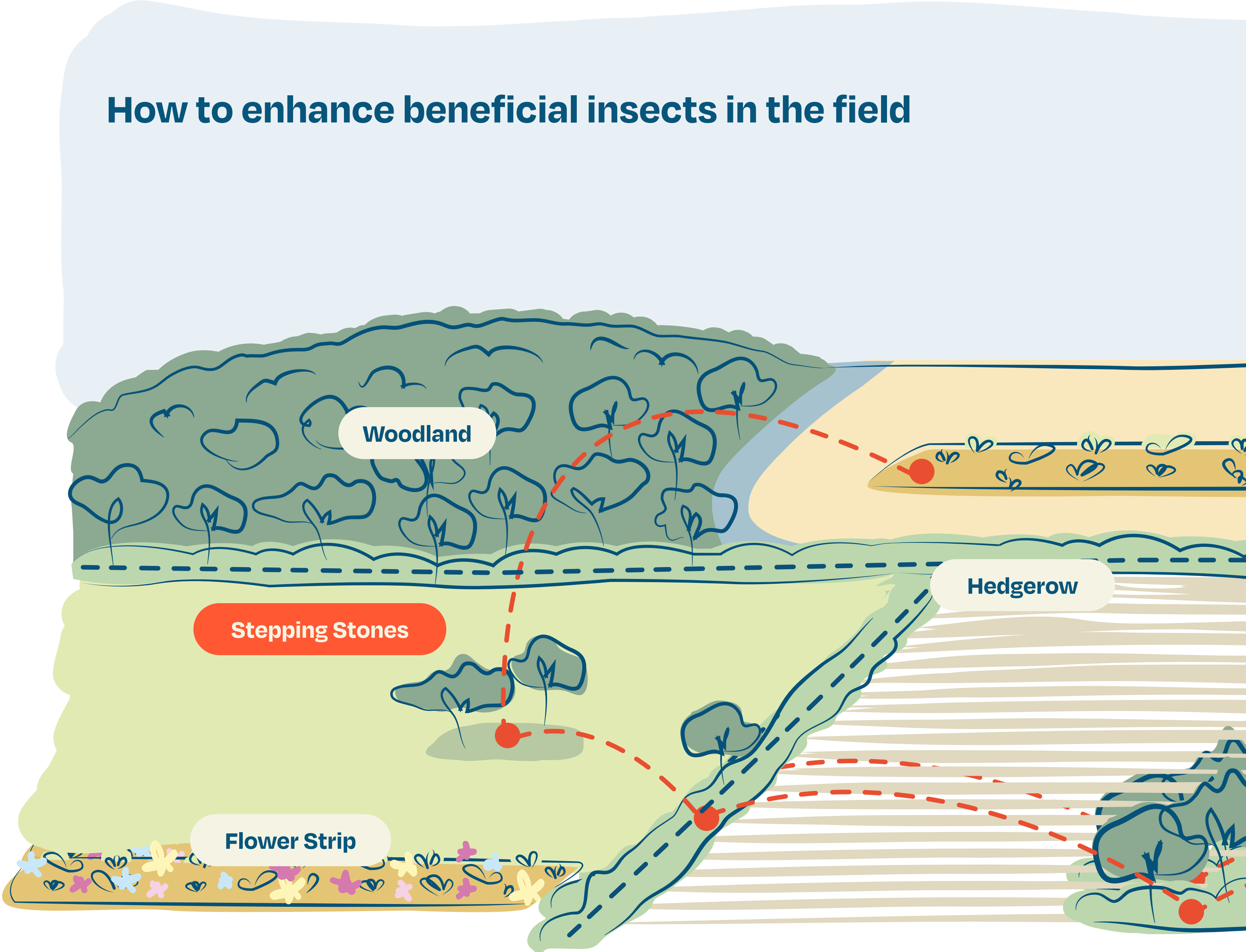
Research across European farmland has shown that landscapes supporting a greater diversity of natural enemy species deliver more consistent pest suppression across years, regardless of variable weather.[11]

The lag effect of the response of beneficial insects (e.g. predator/parasitoid) to an insect pest outbreak in crops in an unbalanced versus balanced farming system

This example details the outbreak of a pest that has two generations per year and shows how resource provisioning in a balanced system enables beneficial insects to respond quicker and reduce pest numbers before the economic threshold is reached.



How to enhance beneficial insects in the field

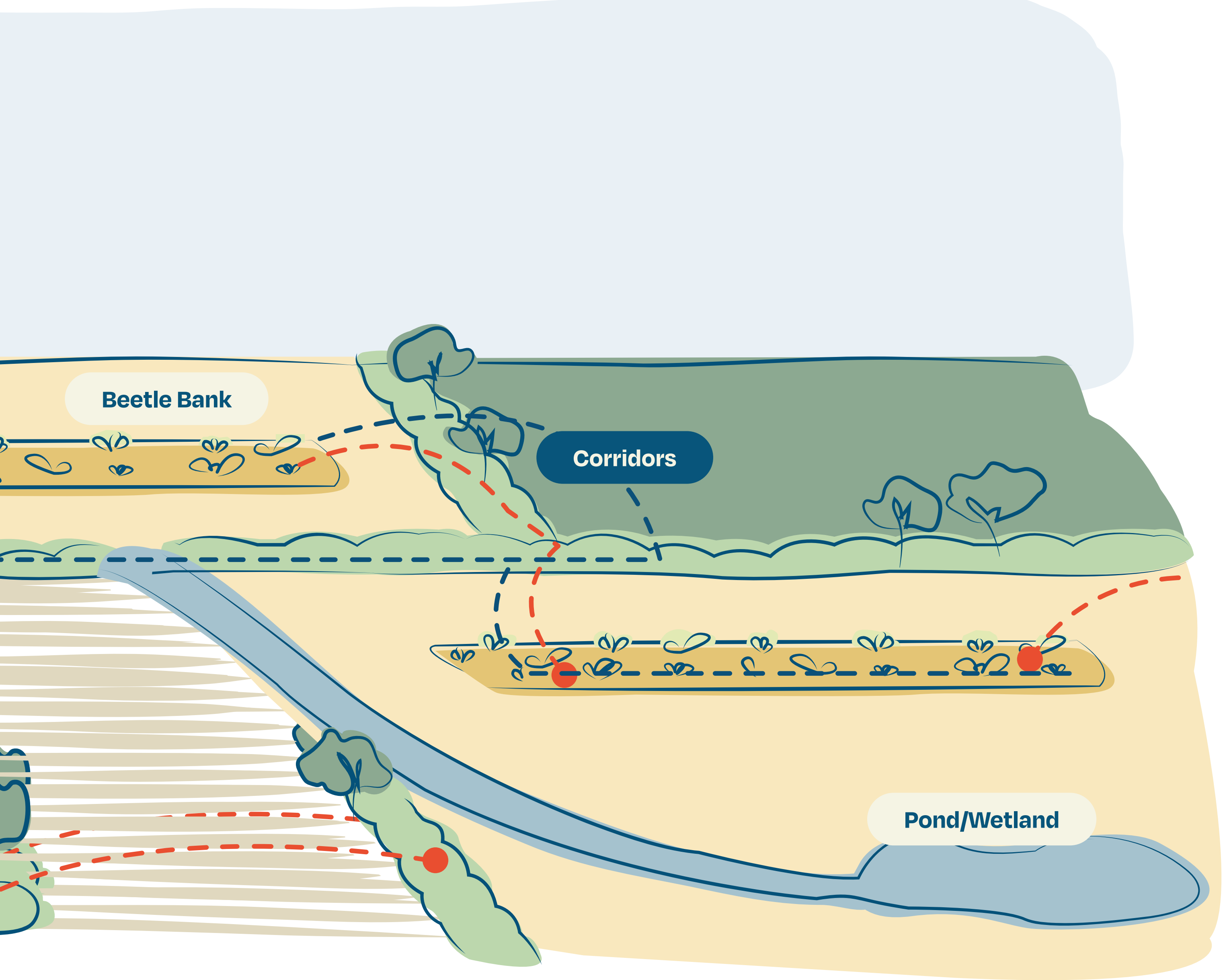


Conservation biocontrol

Conservation biocontrol is a key ecosystem service and a central pillar of Integrated Pest Management (IPM). There are different types of biological control. Classical biocontrol attempts to manage primarily invasive pests by importing and releasing non-native natural enemies for long-term establishment. Augmentative biocontrol involves releasing commercially produced biocontrol agents to temporarily boost their numbers in a targeted area. Conservation biocontrol, by contrast, involves making positive changes to the environment to increase the abundance and activity of the natural enemies already living on and around your farm.

This guide focuses on conservation biocontrol because supporting the natural enemies already present on our farms is the most important part of the picture. Conservation biological control works by primarily improving resources for natural enemies through habitat enhancement, and (in conventional systems) reducing natural enemy mortality through careful pesticide management.[12] These habitat and management changes are practical, largely low-cost, and compatible with productive farming. Together, these changes help your farm's existing community of predators and parasitoids to thrive. In organic, biodynamic and permaculture systems, manipulating farm habitats to support and enhance populations of naturally occurring predators and parasites that eat crop pests is fundamental to pest management strategies.

To identify what we can do, it helps to think about it in terms of three scales: farm scale, field scale, and the nitty gritty scale of everyday management.



Farm scale: creating landscape that works for beneficial insects

Insects may be tiny, but they need habitats at a landscape scale! They must be able to move between overwintering refuges, feeding areas, and the crops where pest control is needed. How they do this depends on how they travel.

Corridors work best for ground dispersive species; these are relatively continuous habitats such as field margins or beetle banks that run unbroken across and between fields. Scattered habitat patches act as stepping stones to move between resources for flight dispersive species, especially those with a limited range, or those that need different resources for different life stages. These semi-natural habitats include a wide range of features (Table page 14).

These semi-natural non-crop habitats offer something the cropped area cannot - stability. Unlike the cropped area (regularly disturbed by cultivation, spraying, and harvest), semi-natural habitats provide somewhere to overwinter, shelter from adverse weather, undisturbed breeding sites, and a supply of alternative prey and floral resources, when crop pests are not around. Pollen and nectar are essential for some groups of natural enemies and important supplementary food for many others.

How much semi-natural habitat is enough? Researchers have shown that having around 20% of the farmed landscape as semi-natural habitat supports effective biological control.[13] Below this level, natural enemies tend to concentrate at field edges and do not get into the main crop.[13, 14] For farms in simplified arable landscapes, this may feel a long way off. A realistic mid-point target of 8-10% has been shown to deliver measurable benefits for natural enemies, pest control and farm profitability.[12, 15]

Habitat feature	What it provides	How to maximise their benefits
Habitat provision on un-cropped land		
Hedgerows	Shelter microclimate, habitat structure, floral resources, alternative prey	Stagger cutting 1/3 of hedges across areas of the farm to ensure pockets of flowers and structure over time
Beetle banks	Shelter microclimate, habitat structure, floral resources, alternative prey	Banks provide a range of microclimates, more important in open landscapes. Stagger mowing across 2nd/3rd year
Grass field margins/ buffer strips	Tussocky grasses and flower stems provide overwinter shelter, microclimate, alternative prey	Stagger mowing to leave tussocks overwinter. Large strips, wavy edges between mown sections help create variety of structure
Wildflower margins/in-field strips	Habitat structure, floral resources, alternative prey	Choose native flowers and local seed where possible
Ditch maintenance	Refuge habitat for moisture loving insects	Manage sections of ditches on rotation to minimise insect disturbance
Ponds/ wet areas/ waterbody creation	Breeding and refuge habitat for water-loving insects	Create new ponds rather than dredging old ponds- insects can move. When pulling out vegetation, leave it on the side for several hours to allow insects to escape
Fallow land	Refuge habitat, alternative prey	Weedy plants are good for insects
Natural area retention (e.g. woods, grassland)	Refuge habitat, alternative prey	Native vegetation and scrub can be a source of insects to spill over into fields
Crop management		
Diverse cropping/ rotations	Crop diversity supports insect diversity. Predators will move between crops to hunt	Diversity of crop cultivars can also help, and provides insurance on potential pest or disease outbreaks
Under sowing / companion crops	Diversity of structure supports multiple predators active in the same space. Root structure and moisture support ground predators	Maximise structure, and minimise bare soil
Cover cropping	Refuge habitat, alternative prey. Root structure and moisture support ground predators	Choose contrasts in cereal and broadleaf crops to improve the soil
Over-winter stubbles	Stems provide structure and microclimate for overwintering	Leave a variety of stubble heights if possible
Organic matter input	Organic matter and soil structure help soil predators	Livestock integration can create a variety of soil surface habitat structure
Reduced tillage	Reduction of physical damage to soil predators, and increase in soil biota over time	Trust the process, first year might see an increase in slugs. Pair with other habitats to support predators moving in
Mulching	Shelter, microclimate for soil predators	Use organic materials, and avoid over compacting
Low herbicide use	Herbicides can restrict feeding and breeding of predators	Some weeds are non-competitive. Control problem weeds with rotations
Low pesticide use	Pesticides can be used in an IPM strategy as a last measure, use only if crop damage exceeds a threshold	Use different mode of actions when possible, once habitat is in place and beneficial insects are abundant, try going pesticide free

Photo credit: Khrizmo/ iStock

Photo credit: Rothamsted Research

Field scale: making the crop more welcoming for beneficial insects

Once beneficial insects are present in the wider landscape, we need them to move into and across the crop area - to both suppress pest occurrence below threshold levels and to respond to pest outbreaks. This requires making the crop habitat more welcoming in terms of structure and resources.

Companion cropping and undersowing can shift pest-predator balance, increasing parasitism and predator abundance while reducing pest numbers.[16] These practices introduce structure, alter microclimates, and provide shelter and alternative food resources for generalist predators, while disrupting host-finding by the pests. Cover crops, while mostly acting as a non-crop habitat, can also encourage ground active invertebrates and their larvae, which can persist into the next crop. Carabid and rove beetles, for example, have an annual breeding cycle with larvae active in the soil.[17] In-field wildflower strips and hedgerows have also been shown to reduce pest density and increase beneficial insects.[18, 19]

Research on a Buckinghamshire commercial farm showed that converting just 3% of field-edge areas to wildflowers, grasses and other non-crop plants, maintained or enhanced yields across a 5-year rotation while boosting beneficial insect populations, demonstrating that habitat creation need not reduce whole-farm productivity.[20]

Management practices for beneficial insects

Habitat creation will only deliver its full potential if farm management does not undermine it. Broad spectrum insecticides, including the widely used pyrethroid lambda-cyhalothrin, harm beneficial insects to varying degrees.[21] Recovery of beneficial insects after pesticide applications is slow, and repeated use can collapse their communities. In OSR crops, research has shown that there is no spray window in which some natural enemy group is not active, making insecticide timing mitigation difficult.[22] Where insecticide use is deemed as being necessary, applying in the evening (when fewer flying beneficials are active), and leaving unsprayed field refuges can reduce impact. Herbicides can affect invertebrates too; glyphosate has been shown to significantly inhibit the hunting and mating behaviours of wolf spiders.[23, 24]

Soil cultivation physically disrupts the habitat of ground-active predators, destroys overwintering nests, and buries cocoons of parasitoid wasps, making it more difficult for adults to emerge. Reduced or minimum tillage (till) preserves soil structure and surface debris, benefiting ground beetles, rove beetles, spiders, and earwigs. Weed cover and surface chaff of no-till systems also create a sheltered, diverse habitat that supports predators such as the slug eating violet ground beetle.[25]

These interventions complement each other. Combining overwinter refuges, reduced tillage and flowering resources within fields create year-round habitats for the predators and parasitoids that control pest populations naturally.

Supporting beneficial insects for crop protection is a journey, and your path will depend on your farm landscape and your goals. Different steps will have different impacts, some bigger than others - but each step is a move in the right direction. Our case studies show that progress might not always be smooth, but you can get there – and there are many farmers making the same journey.

Flower enriched grass margins. Photo Credit: Martin Lines

Case study:

Papley Grove: Creating productive habitats

Martin Lines has inspired many as the founder and voice of the Nature Friendly Farming Network. Martin's home farm, Papley Grove, is a 165 ha predominantly arable farm in Cambridgeshire, growing commodity crops of winter wheat, winter and spring barley, winter beans and OSR. It is here that he has developed his pragmatic approach to farming with nature, not against it. Papley Grove has become a haven for beneficial insects, and all the wildlife that comes along with them. Along the way, Martin has seen the crop protection delivered by beneficial insects and is continually tweaking his management to maximise the benefits. Papley Grove has become a practical demonstration of investing in habitat not being a cost to productivity, but rather contributing to it.

The journey to insect appreciation

Papley Grove began as a fairly conventional, edge-to-edge arable farm. The farm was enrolled in Countryside Stewardship around 2003 as I took greater ownership of day-to-day management, starting with grass margins to protect watercourses and planting new hedgerows. Later, we moved to Higher Tier Stewardship, particularly with a view to increasing habitats for farmland birds.

With the advice of RSPB experts, we set out to provide habitats for different birds across the farm - which included more grass margins, flower enhanced margins, and pollen and nectar mixes.

This soon made a difference to the birds we saw across the farm, sparking visits from ornithologists, and subsequently, entomologists. It was those entomologists that began to shift my way of thinking. They got very excited about the life they observed on the bumper of the four-by-four after we drove around the fields! I thought it was normal, but they told me it wasn't. I started to learn more about the significance of the insect life, both on the farm and within the wider landscape... and got thinking about the importance of our habitats, not just for nature restoration, but as an asset on the farm that helps with production.

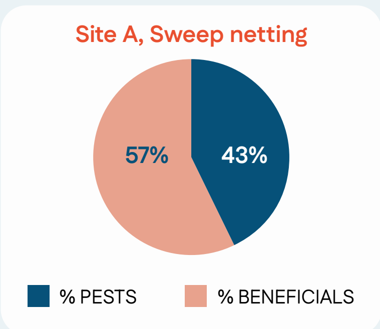
The real lightbulb moment came for me when I was late spraying winter beans (because of a spell of windy weather) that had huge numbers of black bean aphids on them. I went to check the crop before spraying and found something unexpected. I walked into the crop close to one of the field margins, and there were no aphids on those beans, only ladybirds, lacewings and other insects I've learnt about since. But when I walked up the top end of the field where there was no habitat, there were masses of aphids! As I got further down the field, there was an army of creepy crawlies starting to eat the pests, so I didn't spray. The beans did well, we didn't have a yield impact.

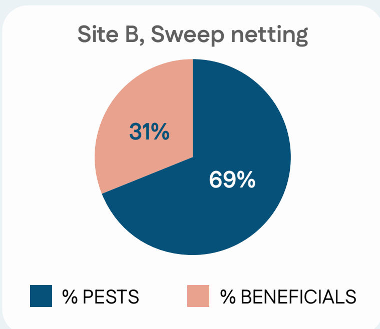
Ever since then, I've viewed insects as creatures that we can work with and as generally being beneficial for the farm. Following a similar approach to what we've done with encouraging birds onto the farm, I started thinking about what beneficial insects specifically needed and how best to provide resources for them.

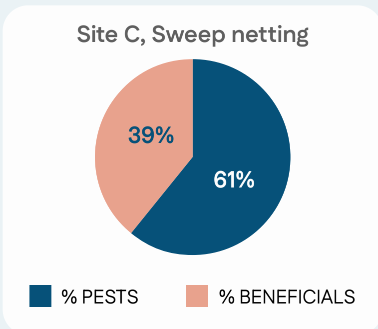
A further learning opportunity came through the ASSIST project (Achieving Sustainable Agricultural Systems), a UK research initiative that ran replicated trials comparing arable fields with in-field habitat strips and margins, margins alone, and no margins, across several farm sites. This was conducted at Home Farm, that I contracted on. Here we observed a clear spillover effect: pest control visibly improved in cropped areas adjacent to the experimental in-field strips, and after the project ended, I decided to apply this practice more widely at Papley Grove.

Papley Grove has since participated in other research. In a PGRO26 trial examining trap crops for controlling pest weevils and bruchid beetles, we had less weevil notching and bruchid damage than any other farms in the trial (see below). This was found to be more associated with our farming system as a whole than the trap crop itself.

Sweep-netting during the trial revealed a notably high ratio of beneficial to pest insects at Papley Grove compared with the other sites (see Site A below). The range of beneficials measured on the farm included soldier beetles, ladybirds, parasitic wasps, wasps, damselflies, spiders, harvestmen, lacewings, robber flies and hoverflies. These outweighed pests such as aphids, flea beetles, pollen beetles, weevils, and plant bugs.[26]







I am a keen ambassador for insect mediated IPM and am continually trying to innovate and learn about it. Papley Grove has been insecticide-free for over 13 years now and, while I sometimes observe small patches of outbreaks (e.g. BYDV), I see the potential impact of insecticide use on the system I've built as being not worth the risk. If my agronomist reports aphids, my first question is "how many lacewings and ladybirds were seen alongside them?"

You must look for both, it's all in the balance. So for me, it was really important to learn what the beneficials needed and not put things in the landscape in our flower margins that would cause degradation of yield, but rather improve it. I was then able to stop using products - knowing that the habitat or the resource for the habitat is there and recognising that I've got to invest in nature to pay me back rather than invest in products.

Key practices at Papley Grove

Optimising the farm landscape

Like many farmers of my generation, my father and grandfather removed hedges and filled in ditches to maximise productive areas. I've spent years replacing those lost habitats, but with a modern farm in mind. Rather than simply restoring the old features, I have designed a farm landscape built around what I call "fixed assets of nature": permanent wildlife corridors along field edges and within fields. I then made use of the Sustainable Farming Incentive (SFI) to put in variable measures such as using cover crops, companion crops and herbal leys. In this way Papley Grove has a fixed network of wildlife corridors and a variable series of stepping stones. We're building efficiency in our farming while I'm building efficiencies into habitats and nature, joining the two together.

Photo Credit: Martin Lines

Top tips:

- Look at your fixed assets of hedges and ditches, make them efficient for your farming style by taking out odd corners, moving gateways, straightening watercourses, and retaining or building new habitat that fits with modern farm equipment.
- Use funded options through Countryside Stewardship or SFI to establish both permanent features and flexible rotational habitat measures. Stacking options across fixed and variable elements gives you more coverage for less cost.

Photo Credit: Martin Lines

Stepping stones and corridors

In-field strips

Research and farmer experience demonstrates that the beneficial effects of margins and other natural features diminish with distance to the crop, with a zone of influence ~100 metres (m). At Papley Grove the fields are large, so working on a boom width of 30 m, I put in 6-m-wide habitat strips at 90 - 120 m intervals across the fields.

One practical challenge I noticed was that in-field strips often get flailed off at the end of the season, removing the structural habitat insects need to overwinter and complete their lifecycle.

Grass edges are left uncut, providing permanent overwintering structure and a buffer for any spray drift whilst allowing the flower strips to be managed as required.

My solution was to design margins with 1 m edge of tussocky grass on either side of the flower-mix.

Field Margin. Photo Credit: Martin Lines

Habitats built over time, opportunities for overwintering

In-field strip. Photo Credit: Martin Lines

Top tips:

- Use native seed mixes where you can as insects associated with native plants and locally sourced seed will establish and thrive better on your land. Green hay from a local donor site can work well, if available.
- Be patient, some seed mixes need 5 years to fully establish and show their value.
- Design strips with a permanent structural element (such as a tussocky grass edges) alongside any managed flower mix - this retains overwintering habitat even when the flowering area is cut back.

Photo credit: Liana Ruchka/ iStock

Cover crops

I established cover crops to minimise bare soil and keep a healthy soil ecosystem over winter. I didn't implement this specifically for insects, however I saw increases in beneficial insects associated with the cover crops that I attributed to the habitat structure the cover crops provide. If I look at the cover crops in the autumn, they're full of spiders and cobwebs - the flying insects, your aphid protection, then land on them. So instead of spraying, let cobweb nets over your cover crops help provide the protection – it's about thinking of the structure you want to put in place.

When it comes to terminating the cover crops, I use a roller crimper rather than herbicides, where practical. Research has shown that roller termination is less disruptive to the ground-dwelling and lower-canopy predators that have built up through autumn and winter. This doesn't reliably kill weeds such as black grass, so I do still use some glyphosate, for now. Drilling into a standing or recently crimped cover crop in autumn ('drilling green') is a technique I've found effective for maintaining continuous soil cover and keeping the soil ecosystem active over winter.

In-field habitats, sensitive cultivations

Top tips

- Don't drill green in the spring through a mat of volunteers or blackgrass - you may lose up to 80% of yield on cereals due to chemical (allopathic) suppressive effects.
- Think carefully about cover crop species relative to your following crop: if you're going into a broadleaf break crop (rape, beans etc.) then use a cereal-based cover crop. Going into a cereal, use a broadleaf-based cover crop to give the soils a variety of root structures.
- Consider the full season: how long will the cover crop be growing for? How large do the roots need to be? Will it be grazed? These questions affect species choice and management timing.

Photo Credit: Martin Lines

What would I tell people starting their own journey?

Talk to others - go to events, attend farm walks and find a nature-friendly neighbour, especially one farming similar soils and landscape. Find out what works for them, then look at what you've got – can any of it be managed differently? And ask: what is the practical benefit to your business? If cutting your margin management in half helps insects but also halves your mowing cost, that's a straightforward win. Then try also to understand what habitats in your system are necessary to support your production?

If you see a problem, don't just reach for a quick fix – consider first if the system itself can be adjusted to fix it and whether natural processes can be better supported to supress pests and diseases. Start small, in a part of the field out of sight if it helps, and build your confidence up from there.

Now is the best time to start - take soil samples, take pictures, and work with experts along your journey. Keep records from the beginning so that, in 5 years' time, you can see how far you've come.

Be curious - turn your sprayer off on a section of crop and see if that product is really working for you.

Dragon Fly. Photo Credit: Martin Lines

Agroforestry system on Hope Farm. Photo Credit: Georgie Bray

Case study:

Hope Farm: Farming for wildlife

Georgina Bray is the Farm Manager of Hope Farm, a 181 ha arable farm situated in Cambridgeshire, and has been working there since 2018. Hope Farm was purchased back in 2000 by the Royal Society for the Protection of Birds (RSPB) with the overarching aim to demonstrate that nature and farming can work together and turn a profit, similarly or better than an intensively managed farm. During this time, biodiversity monitoring has been a key ingredient to understand what effects these new nature-focused aims have on a once intensively managed arable farm. Hope Farm is a real-life example that demonstrates growing productive crops can work for wildlife simultaneously with minimal impacts on productivity.

Committed from the beginning

From the outset in 2000, our mission has been to grow profitable crops, try to manage the farm in a way that works for wildlife, and collect the data to see if these two priorities work hand in hand. Our approach required help from research, conservation, and the farming community, to understand how we could make changes to our management which slowly lead to the transition of the whole farm system. Whilst it's incredibly useful having the data to look back on, from my perspective it's so much more than that. The farm is alive and breathing. You stand in a field and can hear everything from grasshoppers buzzing in the flower margins, to birds singing in the hedgerows and crops. It's great to be part of a story to show that the integration of farmland habitats doesn't need to be at the detriment to farming profits, but I also feel lucky to be on a farm that feels like a healthy ecosystem.

IPM has changed from when Hope Farm was first purchased to now, as our understanding has grown along the way. At the start, we set baselines to measure the impact of small changes within a relatively conventional arable farm, hoping to see the return of farmland species that were in trouble. We have a dataset that shows how many species have benefitted, but its only in the last decade really that our research has measured the impact of our cropping management on beneficial insects.

There were lots of pesticides that worked really well to keep all pests and diseases at bay but, over the years, their effectiveness diminished.

Initially, we worked with a local contractor who was relatively intensive. We, as the RSPB, weren't experienced arable farmers and although our agronomic decisions were based on lots of external guidance, the management was still quite intensive looking back. In about 2015 we saw the world of agriculture was changing, with stronger focus on soil and natural pest control. In discussions with others and a later change in contractor to MT Lines & Partners, we made strides to manage for long term resilience in our cropping system. We were able to go insecticide-free in 2018, which was probably an easy move as we'd spent a long time building a pest control army in our habitat network across of the farm beforehand. The changes we had to make to improve our soil was another matter!

Although we had a bumpy start transitioning away from deep cultivations and higher-end use of fertilisers and pesticides, we are making progress in every rotation. It's great looking back from where we were a decade ago to now even though year-to-year progress is far from linear.


Photo Credit: Georgie Bray


Hedgerow and grass margins. Photo Credit: Georgie Bray

Hope Farm wildlife-focused practices

Diversifying crop rotation

We initially followed the same 3-year rotation before the RSPB purchased the farm, growing wheat in the first and second year, with OSR grown in year three. This simple 3-year cropping cycle was continued for 5 years, though we now grow 6 different crops on the farm including herbal leys, winter beans, spring and winter barley, winter wheat and OSR. Increasing the diversity of our cropping cycle has likely helped boost the abundance and diversity of beneficial insects, whilst reducing the risk of any one particular crop.

In-field wildflower strips

We put in-field strips in the crops to help boost biodiversity and provide natural pest control as they attract several types of beneficial insects. However, for us, the initial establishment wasn't rosy, and we've learnt that taking more time to have the right drilling conditions and seedbed pays dividends in future years. When planting flowering strips you need to think about access and when to mow (to help control annual weeds), as well as the timing and balancing the soil conditions.

Companion crops

Companion crops have been great for diversifying the living roots in the field, enhancing the soil resilience to support the crop, and disguising it from potential pests. We used a companion and a trap crop in an IPM trial run by ADAS and Rothamsted, to improve OSR establishment despite pest pressure from CSFB. The combination did a great job of hiding the OSR at its most vulnerable stage, with four times more larvae in the trap crop compared to the OSR + companion, so we have continued this system ever since.

Wildflower margins

Flower margins take a bit of planning and management to get going, but when they're established, you have an incredibly diverse plant community flowering at different times of year. Monitoring has recorded masses of invertebrates in our margins and we're providing food for birds right next to their nesting sites in the hedgerows too.

Beetle banks

We have a beetle bank on Hope Farm which is historic and encourages several beetle species, amongst other invertebrates. From our perspective, it's low maintenance and easy to establish with the right grasses as well as including other wildflower species for more resources.

Herbal leys

We have a couple of fields down to herbal leys which have been brilliant for us where we needed some longer-term roots to help restructure the soil and get on top of weeds. We also graze sheep and cut for hay, which helps to manage the green biomass each year. As soon as the sheep came on farm, the Starling flock was like a homing missile to that field, feeding on the insects associated with the livestock.

Cover crops

We incorporate cover crops to improve soil structure, reduce nutrient loss over wet winters, and help suppress weeds and other crop pests. Cover crops were again a learning curve, but we have got a lot better at growing them with guidance from a few agricultural advisory groups. Timing around drilling after harvest is key, when the soil has still got some moisture but whilst there's still plenty of warmth. Timing around terminating the cover crop is also a bit of an art as we need to get on as early as we can on the heavy ground, so the cover crop dies off ahead of spring drilling, without compacting the soil by travelling too early. Having cover crops in the ground has been good for the soil, but we've also noticed wildlife coming into the fields with cover crops rather than just using specific habitats planted around field edges. We were sweep netting for invertebrates in cover crops a few years ago and they were full of life. Walking across these fields, there are tonnes of birds using them too with everything from Reed Bunting and Skylark to Snipe and Grey Partridge.

Scrub areas

By leaving some awkward corners largely unmanaged, we have created some scrubby areas which include blackthorn, brambles, cow parsley and messy grass vegetation. These areas provide great nesting and feeding sites for several bird species and attract countless insects. Blackthorn can get a bit of a bad rep, but in March the parasitic wasps and loads of other insects buzz around the hedgerows with any Blackthorn in flower, providing vital pollinator food before the margins have come into flower for the year.

Pond establishment and restoration

Hope farm has 7 ponds that are managed for biodiversity, where we have been rotationally clearing some of the vegetation to open up and improve light access and opportunities for wildlife. They are real hot spots on farm for our aquatic insects, and other species.

Selecting for disease tolerant varieties

Since we stopped the use of insecticides, we take care in selecting disease tolerant crop varieties (e.g. KWS Feeris, a barley yellow dwarf virus-tolerant barley). There are more opportunities now to grow crops that negate the need for insecticide use, particularly in the warmer months when beneficials are going to be more active and work as a food source for farmland birds. For us, it's a no-brainer to try and select tolerant varieties rather than using a spray.

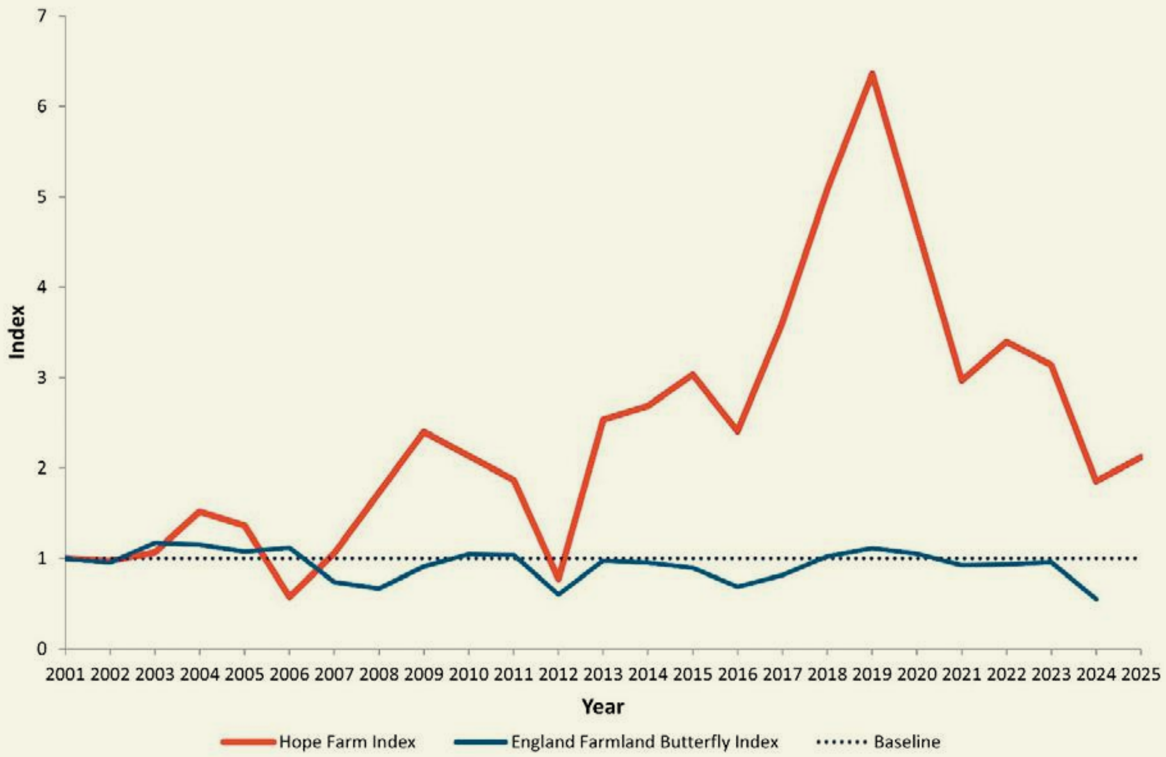
The results speak for themselves

Since Hope Farm was bought by the RSPB a focus has been on both migratory and resident farmland bird species.

Whilst many of the original changes were based around farmland bird ecological needs, with a 200% increase in breeding birds, we look at delivering for nature as a whole and how we can encourage beneficial insect species too.

Butterflies form part of the annual, standardised monitoring programme which consist of weekly farm walks from April to September each year used to calculate a butterfly index, derived from UKBMS.[27]

Since 2001, it is evident in the Hope Farm Butterfly Index that there has been an increase in both the abundance and number of species present on the farm. Whilst not directly linked to beneficial insects in relation to pest regulation, butterflies are good indicators of a healthy and biodiverse habitat. Although we've seen less butterflies on the farm compared to recent years, in line with national declines, we still have a long-term trend increase of around 200% above our baseline, whilst nationally we are unfortunately still seeing widespread declines.



Butterfly Index for Hope Farm (red) and the average England Farmland Butterfly Index.

Oilseed rape. Photo Credit: Georgie Bray

Collecting and retaining the right data is crucial in understanding if the implemented changes have a beneficial effect on both the wildlife and productivity of the farm. Several birds are intrinsically linked to insects and so the things we are trying to do to benefit our beneficial insects as well as our insectivorous birds can often work together.

What advice would I give to farmers starting on their own 'farming for wildlife' journey?

We have been making changes incrementally since 2000, slowly adding complexity based on evidence we have at the time. I'd advocate slow changes that suit the individual farm situation. Begin by thinking about what you already have on farm and how you can enhance those habitats. A great start point is the Farm Wildlife 6 Key Actions, which we work from at Hope Farm, and brings together advice from 12 conservation organisations. It really helps to work out a clear plan with plenty of detail online if you want to read up further.

Consider if you can make more of field boundaries where you expect lower productivity anyway, question what could be done with features such as ditches, hedges, and margins. Diversity in management might help to promote diversity in habitat and therefore species with a bit of a strategic but experimental approach. By thinking how different habitats can easily fit on your farm, it will give you a strategy on how to help facilitate changes for biodiversity.

Invertebrate sample from hedgerow. Photo Credit: Georgie Bray

Field margin on Hope Farm. Photo Credit: Georgie Bray

Field margin on Hope Farm. Photo Credit: Georgie Bray

Key groups of beneficial insects and farming practices to encourage them

Ground active predators

Carabid beetles
Carabidae

Also known as ground beetles, these predatory beetles are well adapted to the changing conditions of farmed land, and many species have adapted to thrive preying on agricultural pests.

Carabids are mostly generalist scavengers. The hyenas of the beetle world, they eat pretty much any food resource they come across in cropped areas; from slugs to aphids.

Most of their activity is on the soil surface and topsoil layer, they can dig well or crawl down soil cracks. They have been shown to reduce the number of slugs mainly by consuming the eggs and juveniles,[28, 29] though larger species such as the Violet Ground Beetle (*Carabus violaceus*) can attack adult slugs.

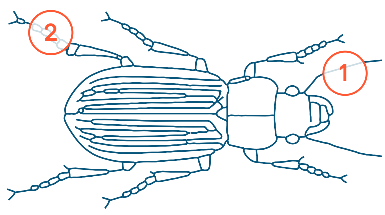
Many crop pests have a larval or pupal stage in the soil – carabids have been shown to reduce eggs and larvae of the cabbage root fly by 90%,[30] and emerging wheat blossom midge by 81%.[31]

Most of their predation of aphids happens when they fall on the ground, however some species, such as the Hairy-Templed thatcher (*Demetrias atricapillus*), are good climbers and venture to the canopy to hunt. Carabids will also eat weed seeds (favourites include dandelion and dog violet), and their presence can reduce weed seed stock in the soil by up to 90%.[32]

Carabid larvae are also important for crop protection. Carabids lay eggs in the soil in late spring or early autumn (depending on species), where they hatch into larvae. Carabid larvae are voracious predators, needing more protein than adults for growth. The larvae are also active for more of the winter.

ID: Classic beetle shape with:

1. Simple thin antennae
2. Simple legs with 5 feet segments



Improving field centres for carabids

Research has shown that non crop habitats such as field margins and beetle banks are valuable refuges for carabid beetles. This is true for some species, yet the main predatory species such as the Rainbeetle blackclock (*Pterostichus melanarius*) overwinter in fields, and larvae are more abundant in field centres than margins.[17] Measures that improve the quality of productive areas – such as reduced tillage, cover crops, companion crops and undersowing – have greater potential to increase carabid abundance and persistence over time. This is due to the soil improvements, creation of microclimates, and enhanced alternative prey that are supported by regenerative farming practices.

Key facts

Predation: Slugs, snails, pest beetles, caterpillars, grubs, aphids, and weed seeds

Number of species in the UK: Around 360

Size range: 4 mm – 3 cm

Activity: Mostly nocturnal

Occurrence: All year, except in freezing temperatures. Peak in May/June and September/October

Dispersal: Mostly ground active, but most species are capable of flight

Optimal habitat: Healthy undisturbed soil for larvae (reduced tillage); crop diversity; cover crops; undersowing/companion cropping

Rainbeetle blackclock. Photo credit: Rothamsted Research

Rainbeetle blackclock
Pterostichus melanarius

Size:
13 - 18 mm

Preferred habitats:
Crop centres, field margins

Particularly abundant in sugar beet and wheat

Occurrence:
Autumn breeding, larvae active in winter

Dispersal:
Running on the soil surface and digging. Mostly nocturnal

Predation:
The most abundant carabid of arable crops. It has been shown to respond to outbreaks of slugs and aphids,[33] and have a suppressive effect on a range of pests including pest beetles, caterpillars, and pest flies

Sienna flat beetle
Trechus quadristriatus

Size:
4 mm

Preferred habitats:
Fields, margins, grassland

Active in topsoil layer

Abundant in OSR

Breeding:
Late autumn

Dispersal:
Active flyer, can form swarms. Walking and digging in soil or mulch

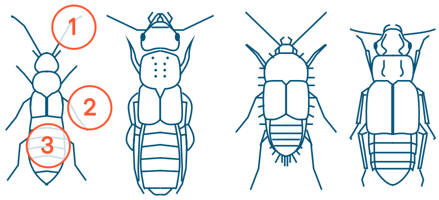
Predation:
This tiny carabid is active in the topsoil layer, where it consumes larvae of pests such as the Cabbage root fly and CSFB

Sienna flat beetle. Photo credit: Rothamsted Research

Rove beetles
Staphylinidae

ID: Variable shape with:

1. Simple thin antennae
2. Simple legs, long or short
3. Reduced wing cases exposing long flexible body segments



An abundant and diverse group of primarily soil active beetles. They have long flexible bodies, with reduced wing cases – yet rove beetles are able fliers and fold their wings into the small cases in an astonishing feat of origami.

Most rove beetles are generalist predators, however, some have adapted to feed on fungi or plant matter. Whilst over 50% are active in topsoil layers and mulch, some species are active climbers. One study showed that while rove beetles only ate 9.5% of aphids present in a wheat crop, they displaced 35% to the ground where other predators could reach them.[35]

As rove beetles are highly dispersive insects, non-crop habitats across a farm landscape are important. Adult beetles can overwinter in the field, yet many overwinter in margins and move into fields to forage. Mating generally occurs in spring, with larvae active late spring. Rove beetle larvae look very similar to carabid larvae and are likewise soil active predators.

Soil conditions matter for this group, particularly high organic matter content and moisture. Rove beetles are unusual in that tillage has neutral effects on adults, who are highly dispersive and recolonise quickly, however tillage does reduce numbers of young rove beetles,[36] so this resilience depends on the availability of refuge areas nearby.

Key facts

Predation: Larvae and eggs of pests in the soil, flies, moths, bugs, slugs, snails, and aphids

Number of species in the UK: Over 1,000

Size range: 1 - 35 mm

Activity: Nocturnal

Occurrence: Arable fields, grassland, field margins

Dispersal: Flight

Optimal habitat: Cover crops, undersowing, companion cropping, organic matter addition

Devil's coach horse beetle
Ocypus olens

Size:
20 - 35 mm, rarely 40 mm

Preferred habitats:
Disturbed habitats, arable, grasslands, field margins, beetle banks

Breeding:
Adults live multiple years, autumn breeding, larvae developing in the soil, emerging early summer

Dispersal:
Flight

Predation:
Various ground active invertebrates, especially slugs and snails. One study detailed a female devil's coach horse beetle eating 20 small snails in 22 days, eating almost its own weight daily[37]

Devil's coach horse beetle.
Photo credit: Tom Iwasyszyn

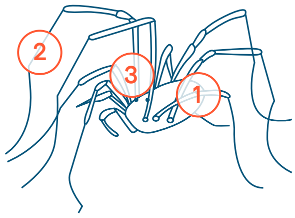
Harvestmen. Photo credit: Ryan Hink / iStock

Harvestmen

Opiliones

ID: 8 legs and:

1. Single body segment
2. Thin long legs, 2nd pair often longer
3. Single pair of eyes in middle of body



These arachnids belong to the same class as spiders, but, on closer inspection, are quite different. They do not have fangs so can eat solid food and cannot make webs.

Harvestmen are still valuable predators in crop systems, killing and eating small insects but also scavenging on dead insects and plant matter. They have been shown to be effective predators of flies and aphids[38] and may be especially useful in moist areas where they thrive. Harvestmen are short lived (usually a few months, with overlapping generations) which may make them useful in supporting other predators.

Key facts

Predation: Soft bodied small insects, grubs, flies, and aphids

Number of species in the UK: 31

Size range: 5 - 7 cm

Activity: Nocturnal

Occurrence: Grasslands, field margins, dense crops

Dispersal: Walking

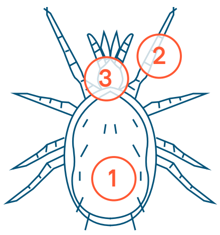
Optimal habitat: Dense vegetation, undersowing, cover crops, reduced tillage

Predatory mites

Acari

ID: Arachnid shape with:

1. Single body segment
2. With 8 short legs (6 legs as nymphs)
3. Distinct head may or may not have eyes



Mites are tiny arachnids, and while some species are crop pests, many are beneficial. They represent one of the largest groups used in biological control of fruit and vegetable crops.

Many commercially available for use in canopy pest control are non-native species bred specifically for augmentative biocontrol. However, many beneficial species exist naturally in soil, whereas most are generalist predators. Soil active species have been proven to limit numbers of (moulting) thrips, corn root worm larvae, harmful nematodes, and plant pathogenic fungi.[39]

Key facts

Predation: Thrips, whitefly, spider mites, leaf beetles

Number of species in the UK: Unknown

Size range: 0.2 - 0.5 mm

Activity: Day active and nocturnal

Occurrence: Short life cycle - can be around 40 days from egg to nymph to adult. Seasonal occurrence varies

Dispersal: Walking

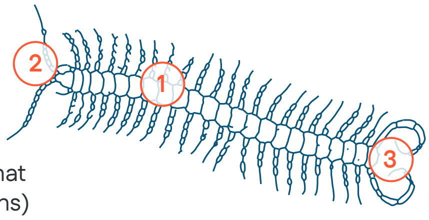
Optimal habitat: Soil structure and organic matter, cover crops, intercropping and undersowing

Predatory mite. Photo credit: Inzyx / iStock

Centipedes
Chilopoda

ID: Long body with:

1. 1 pair of legs per bodysegment (millipedes have two)
2. Distinct head with long simple antennae
3. Large forcipules, which are modified legs hat inject venom into prey (harmless to humans)



Universally carnivorous, long bodied, multi legged invertebrates found in the soil. Often mistaken for millipedes (which are decomposers).

Centipedes are generalist predators and will eat a range of pest insects. However, their specific contribution to crop pest control has not been well documented. The most common group of species in arable fields are wire centipedes (*Geophilomorpha*) that are eyeless and have 35 to over 100 pairs of legs.

Key facts

Predation: Insect larvae, springtails, mites, and other small insects

Number of species in the UK: 57

Size range: 3 - 60 mm

Activity: Nocturnal or in soil

Occurrence: Moist environments, soil leaf litter

Dispersal: Walking

Optimal habitat: Soil structure, reduced tillage, mulching

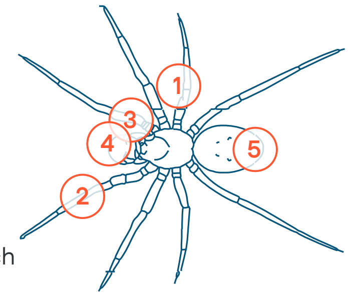
Hunting centipede.
Photo credit: Ray OReilly / iStock

Below: Living mulch habitat. Photo credit: Matt England

Spiders
Aranae

ID: Arachnid shape with :

1. 2 body segments
2. 4 sectiones legs, long or short
3. 8 eyes (which may not be obvious)
4. Sharp fangs for injecting venom into prey (UK species are not harmful for humans)
5. Little appendages called spinnerets which can shape to a variety of purposes



Spiders are important predators in arable crops, though many people are unaware of the large contribution they make to crop pest control or the variety of hunting strategies they have.

Spiders are generalist predators, and are able to respond to the pests prevalent in a crop area, coordinating their activity with peak vegetation, and pest numbers.[40] Spiders also are extra efficient at pest control, as they have been shown to routinely kill and discard prey that they do not deem optimal food. Webs also catch pests exceeding what the architect can eat, even when abandoned. It has been estimated that spides may kill up to 50 times what they actually consume.[23]

Key facts

Predation: Pest beetles, pest flies, moths, crickets, aphids, and pest bugs

Number of species in the UK: 650 - 750

Size range: 2 mm - 1.5 cm

Activity: Range nocturnal to day active

Occurrence: Ground to crop canopy

Dispersal: Walking or ballooning

Optimal habitat: In-crop structure, field margins, in-field strips, grassland and scrub, reduced tillage

Spotted Wolf spider
Pardosa amentata

Size:
5 - 8 mm

Preferred habitats:
Wide range of open habitats, grasslands, gardens and fields

Breeding:
Females carry egg sacs, and care for young. Males live a single season, while females may live for several

Dispersal:
Walking

Predation:
One of the most abundant spider predators in agriculture. Wolf spider females have been observed to eat 1 prey item per day, and have been shown to control harmful cereal aphids (*Metopolophium dirhodum*, *Rhopalosiphum padi* and *Sitobion avenae*)[41]

Spotted Wolf spider.
Photo credit: Binnerstam / iStock

Key groups of beneficial insects and farming practices to encourage them

Stem to lower canopy predators

Stem to canopy spiders

Spiders in crops may either be hunting spiders or web weaving spiders. Hunting spiders are ambush or stalking predators, such as jumping spiders, or zebra spiders (*Salticidae*) which have a large primary pair of eyes and dark striped pattens. They are agile hunters, jumping, with a silken tether, to capture even fast-moving prey.

Orb web spiders (*Araneidae*) build the classic spiral webs amongst tall vegetation, where they sit on a retreat area waiting for prey. They usually have a large abdomen and may be strikingly coloured. Other spiders such as cobweb or tangle web spiders (*Theridiidae*) build simpler or irregular three-dimensional webs, with particularly sticky lines.

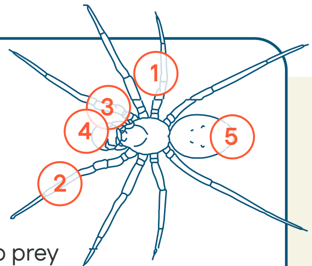
Money spiders or sheet web spiders (*Linyphiidae*) are small spiders that have a skillset all of their own. They are able to get around by 'ballooning' – being pulled in the wind by a strand of web. In this way they are able to colonise crops rapidly, and as such are a major controller of pest aphids. They are also selective, with one study showing more webs built in areas of pest outbreaks.[42]

The key habitat requirement for spiders is structure – to enable them to hunt by web or ambush. A review of diversification of crop habitats found that 33% of studies showed different structured areas (e.g. non-crop strips) increased spider abundance. However, areas combining different structures in one area (e.g. undersowing) showed increased spider abundance in 80% of studies.[43] For ground active spiders this can be surface chaff, or ground level vegetation density, whilst crop active spiders benefit from varied stem structure.

Non-crop habitats are also important in disturbed habitats such as tilled fields. In-field strips are critical for recolonisation of wolf spiders walking into crops.[44]

ID: Arachnid shape with :

1. 2 body segments
2. 4 sectiones legs, long or short
3. 8 eyes (which may not be obvious)
4. Sharp fangs for injecting venom into prey (UK species are not harmful for humans)
5. Little appendages called spinnerets which can shape to a variety of purposes



Ground hunting spiders

This group includes the wolf spiders (*Lycosidae*), and funnel web spiders (*Agelenidae*). They are mostly nocturnal hunters that stalk their prey or rely on ambush from webbed hides. They have large eyes and rely on sight for capture. They may be seen with egg sacs, guarding their young even as they hunt. They are mostly medium to large spiders, with dull or camouflage colouration. They prey on anything from grasshoppers through to plant bugs, moths, thrips, flies, and pest beetles.

Dark money spider
Erigone atra

Size:
Male 2 – 2.2 mm, female 2.5 - 3.5 mm

Preferred habitats:
Disturbed habitats, crops and grasslands

Breeding:
Typical annual lifespan, breeding late summer to autumn, multiple broods

Dispersal:
Ballooning flight

Predation:
Money spiders including the dark money spider have been shown to kill up to 31 cereal aphids per m2 per day in winter wheat, reducing peak aphid density by an estimated 37%[23]

Above Right: Ground hunting spider.Photo credit: Tom Iwasyszyn
Right: Dark money spiders. Photo credit: Neil Benison / iStock

Photo credit: Matt England

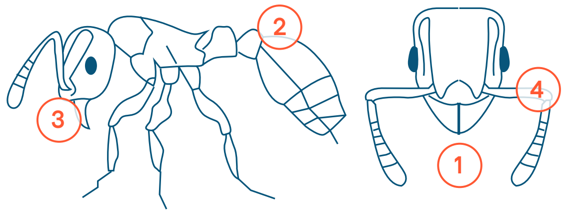
Ants

Formicidae

Familiar as hunters of sugary treats, ants are the most abundant predator on earth, equalling the biomass (weight) of humans.

Ants eat a range of insects and plant matter, and crucially they store nutrients in their colonies – meaning predation continues past individual satiation and persists through weather extremes that may kill other predators.[45] An anthill that houses a colony extends underground, where it has been shown to improve the organic matter, phosphorus, nitrogen and potassium in surrounding soil.[46]

A review of 57 studies found that ants overall improved crop yield and decreased non-honeydew producing pests.[47] The common behaviour of ants 'farming' aphids for their honeydew makes them less useful in some cereal crops. However, ants have been proven to control leafhoppers and corn borers in maize, and to be effective in fruit and vegetable crops.[46] They can compete with other predators by dominating a territorial area near anthills, but on the flip side, they can deter larger crop-damaging birds and small mammals.



ID: Simple body with pinched waist and:

1. Distinct head
2. Large abdomen
3. Large jaws
4. Antennae hinged in the middle with a clubbed end.

Key facts

Predation: Flies, moths, pest beetle larvae

Number of species in the UK: 50

Size range: 3 - 5 mm

Activity: Mostly day active

Occurrence: April to October

Dispersal: Walking to forage, flight active (usually all at once) to start new colonies

Optimal habitat: Zero tillage, field margins, beetle banks

Ant. Photo credit: Andrew Young / iStock

Key groups of beneficial insects and farming practices to encourage them

Canopy predators

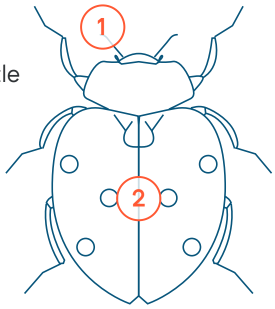
Ladybirds
Coccinellidae

One of the most iconic beneficial insects in UK farming. Ladybirds are beetles, and both adults and larvae are voracious predators that can eat an array of crop pests. Although it is easy to identify ladybirds with their characteristic red with black spot appearance, this is just the most common form. There are 47 species in the UK, ranging from the familiar red with black spots, to orange with white spots, yellow with black spots, and patterns with up to 24 spots.

The most commonly encountered ladybirds are the seven-spot ladybirds (*Coccinella septempunctata*) and the harlequin ladybird (*Harmonia axyridis*), a coloniser from Asia.

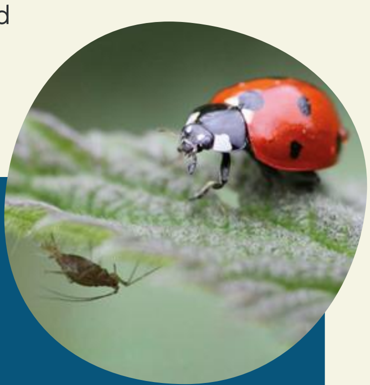
ID: Round or oval shaped beetle

1. Short clubbed antenna
2. Thorax (pronotum) are either black, white or orange and some have specfic markings



Ladybirds undergo complete metamorphosis, and their larval stage is especially voracious. Larvae from some species are commercially available for biological control (e.g. two-spot ladybird, *Adalia bipunctata*).

Keeping areas unmown to promote wildflowers and nettles provides resources for ladybirds, supporting populations ahead of future pest outbreaks in crops.



Key facts

Predation: Aphids, scale insects, mites and whiteflies

Number of species in the UK: 47

Size range: 3 – 10 mm

Activity: Mainly active in the day (March – October)

Occurrence: Spring, summer and early autumn, before the temperatures drop

Dispersal: Flying and walking

Optimal habitat: Diverse cropped arable fields, hedgerows, woodlands and grasslands

Above: Seven-spot ladybird. Photo credit: Racheal Travis, Royal Entomological Society

Seven-spot ladybird
Coccinella septempunctata

Size:
6 - 8 mm

Preferred habitats:
Field margins, beetle banks, grasslands and parks

Breeding:
Bright yellow eggs laid on undersides of leaves June - July, larvae develop until pupating to new adults in August. Adults can live multiple years and hibernate in large groups

Dispersal:
Flight and walking

Predation:
Aphids, scale insects, mites and whitefly

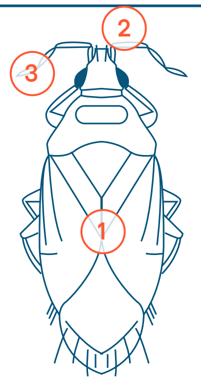
Photo credit: Matt England

Pirate and flower bugs
Anthocoridae, Miridae and Nabidae

Pirate bugs are effective predators of aphids, mites, caterpillars, and moth and butterfly eggs. They get their name due to their characteristic black and white markings and have a flattened and oval appearance with a long piercing and sucking beak. These beneficial insects can be mistaken for other pest bugs such as capsids but are in fact helping to suppress harmful invertebrate populations. They are particularly associated with apple and pear orchards but, due to their generalist nature, also help suppress pests in several arable systems.

ID: Elongated-oval and flat shape

1. Overall colour is black or brown
2. Piercing mouthparts
3. Antennae are longer than the head and have a distinctly coloured end segment



There are other bugs within the beneficial category that fall outside of the pirate bug group, however, an expert would be required to differentiate between what is regarded as a pest and beneficial within this large and diverse group of insects.

Key facts

Predation: Young caterpillars, mites, thrips, aphids and moth/butterfly eggs

Number of species in the UK: 33

Size range: 2 – 6 mm

Activity: Mainly active in the day (March – October)

Occurrence: Spring, summer and early autumn, before the temperatures drop

Dispersal: Walking and some can fly

Optimal habitat: Low-growing vegetation (e.g. field margins and undersown / companion crops), deciduous trees and shrubs and other herbaceous plants

Pirate bug
Orius vicinus

Size:
2 - 2.6 mm

Preferred habitats:
Meadows, woodlands, shrubs, gardens and arable fields

Breeding:
Adults hibernate in sheltered areas and females lays eggs on plants

Dispersal:
Flight and walking

Predation:
Aphids, spider mites, thrips, insect eggs

Above: Pirate bug. Photo credit: Tomasz Klejdysz / iStock

Lacewings
Chrysopidae and Hemerobiid

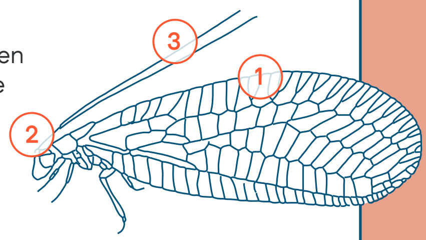
Lacewings are highly effective aphid predators. Larvae of species such as Green lacewing (*Chrysoperla carnea)* are also available commercially for augmentative biocontrol and are harmless to other beneficial insects. In the UK, there are two main groups: green lacewings (*Chrysopidae*) and brown lacewings (*Hemerobiidae*). Both brown and green lacewings can be encouraged on to the farm by providing flower-rich field areas, hedgerows and annual flowering wild bird seed mixes.[48] In addition, buckwheat strips have also been shown to attract lacewings.[49]

Lacewings can be identified by the net-like wings that are held folded over their long slender bodies. They typically have large eyes and long antennae which are used to detect prey, mainly during the day.

The larvae of these insects, also known as 'aphid lions,' are voracious predators. Adults lay their eggs individually in rows or groups on long stalks – to help prevent cannibalism from newly hatched larvae, and to be out of reach from ants and other opportunistic predators.

ID: Slender and narrow shape

1. Wings cover entire abodomen and held in a tent-like shape when resting
2. Large and often shiny eyes
3. Long thread-like antennae



Key facts

Predation: Aphids, small caterpillars, whitefly and insect eggs

Number of species in the UK: 71

Size range: 10 – 25 mm

Activity: Adults can hibernate over winter

Occurrence: Spring, summer and early autumn, before the temperatures drop

Dispersal: Larvae walk and adults walk on plants and are active fliers

Optimal habitat: Diverse habitats and shrubs. Found in gardens and parks, woodlands and hedgerows, grasslands and farmlands

Green lacewing
Chrysoperla carnea

Size:
10 - 15 mm

Preferred habitats:
Meadows, woodlands, shrubs, gardens and arable fields

Breeding:
Adults hibernate in sheltered areas and females lays eggs on plants

Dispersal:
Flight and walking

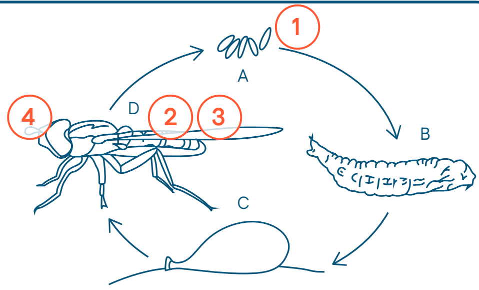
Predation:
Aphids, spider mites, thrips, insect eggs. A single lacewing larvae can consume up to 200 aphids a week

Green lacewing.
Photo credit: etc fotos / iStock

Hoverflies
Syrphididae

ID: Typical fly shape with:

1. Larvae (A) teardrop shaped, no legs
2. Adults (D) with a yellow and black striped flat body
3. Only one pair of wings
4. Eyes are large and rounded



A large and diverse group of beneficial flies that have a unique double benefit. The larvae are extremely voracious while the flies are important pollinators. Encouraging hoverflies with an array of field margins with diverse wildflowers supports both pest control and pollination simultaneously. Umbelliferous flowers such as wild carrot and cow parsley, and annuals such as phacelia, coriander and buckwheat, have been shown to encourage hoverflies, but also increase their lifespan and local abundance.[50] These insects can be mistaken as bees or wasps due to their yellow and black markings, but do not sting and are completely harmless to humans. However, due to the distinct markings and reputation of bees and wasps, several hoverflies have evolved to mimic their stinging relatives. As a result, there are many that have been given names such as the Hornet hoverfly (*Volucella zonaria*) and Bumble bee mimic hoverfly (*Volucella bombylans*) that can trick a would-be predator.

Key facts

Predation: Aphids, scale insects, psyllids, mites and whitefly

Number of species in the UK: >280

Size range: 5 – 30 mm

Occurrence: Spring, summer and early autumn, before the temperatures drop

Optimal habitat: Diverse crops arable fields, grasslands, flower-rich field margins, woodlands and hedgerows

Hoverfly larvae identification in your field

Hoverfly larvae are legless and often translucent, ranging between green, cream and brown, and can be regularly spotted in and around aphid colonies during the growing season.


Marmalade hoverfly.
Photo credit: Linda Seward

Marmalade hoverfly
Episyrphus balteatus

Size:
10 - 15 mm

Preferred habitats:
Gardens, parks, bright woodlands, field margins (particularly umbelliferous flowers)

Breeding:
Adults hibernate in sheltered areas and females lays eggs on plants

Dispersal:
Adults are active and accomplished fliers and larvae undulate (peristaltic crawling)

Predation:
Adults feed on nectar and larvae eat aphids, psyllids and mites. A hoverfly larvae can consume between 200 - 500 aphids during their development.

Wasp. Photo credit: Nigel Harris/ iStock

Predatory Wasps

Vespidae and Crabronidae

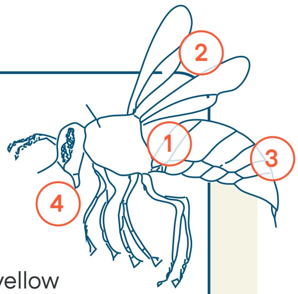
Wasps can be a nuisance around picnic tables and fruit crops during late summer, but they play an important role in the ecosystem. They are voracious predators, making a substantial contribution to pest control on farms. Each summer, social wasps in the UK capture an estimated 14 million kilogrammes of insect prey, such as caterpillars and aphids.[51]

There are more than 950 species described worldwide,[52] with only 7 present in the UK. Despite this, social wasps are especially valuable because of their large population sizes, central place foraging, tolerance to low temperatures, and a tolerance of nest manipulation.[53]

Social wasps are generalist hunters, taking whatever prey is most abundant,[54] making them particularly responsive to pest outbreaks. Adult wasps feed only on sugars from nectar, honeydew, and fruit, but they kill and chop other invertebrates to carry parts back to the nest to feed their larvae.[51] Main prey includes caterpillars, flies, aphids, and spiders, though they will take any available invertebrates. They hunt by sight, sound, and smell,[55] stinging their prey to subdue it, before using their mandibles to dismember it. Their importance goes beyond them being predators of pest insects, they are also important pollinators and bioindicators of environmental quality.

Social wasps are seasonal insects; queens emerge from hibernation in spring (April – May) to establish new nests, workers forage from late spring, being more active from June to September. Colonies are annual, dying off completely in winter with only mated queens surviving by hibernating under bark, in lofts, or other sheltered locations.

Field margins with thick vegetation, hedge banks, and areas of undisturbed grassland provide ideal nesting habitat for wasps. Maintaining flowering plants in field margins also supports wasp populations throughout their active season.[51]



ID: Sleek and hairless bodies

1. Have a distinct narrow waist
2. 2 pairs of wings
3. Most predatory wasps possess distinct banding e.g. black and yellow
4. Large chewing mandibles (mouthparts)

Key facts

Predation: Generalists, range of crop pests

Number of species in the UK: 7

Size range: 12 – 20 mm

Activity: Day active

Occurrence: Spring, summer and early autumn, before the temperatures drop

Dispersal: Flying

Optimal habitat: Field margins, hedgerows, and areas with flowering plants that provide nectar for adults. Undisturbed field margins, woodland or old stone walls for nesting

Common wasp
Vespula vulgaris

Size:
Workers are 12 – 17 mm long, queens 16 – 20 mm

Preferred habitats:
They nest underground, in tree cavities, roof spaces, and sheds

Breeding:
A single queen produces up to 10,000 workers over the summer months.[56] The colony cycle runs from spring through to late autumn

Dispersal:
Flying

Predation:
The most frequently encountered wasp species in the UK. They are generalist predators, hunting whatever prey is most abundant; including caterpillars, aphids, flies, spiders, and other small invertebrates

Soldier beetles
Cantharidae

Soldier beetles represent one of the most effective yet underappreciated groups of beneficial insects in UK agriculture. Unlike most beetles, they have soft, flexible wing cases with a smooth appearance, and are easily recognised by their elongated body shape, long antennae, and black and red or yellow colouring.

Soldier beetles are generalist predators; larvae are carnivorous, feeding on insects in the soil, while adults feed on aphids, caterpillars, spider mites, and mealybugs, turning to nectar and pollen if no insects are around.[57]

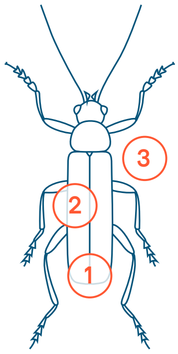
Just one soldier beetle specie (*Cantharis lateralis*) constituted more than 90% of the foliar predators in sugar beet fields in early summer, significantly reducing aphid populations.[58] Soldier beetles have also been shown to consume both Black bean aphid (*Aphis fabae*) and Peach-potato aphid (*Myzus persicae*) — two economically significant pest species in the UK.[59]

They are summer beetles, with adults emerging from the pupal state in late April to June, and dying off between June and September.[60] Cover crops, hedgerows, and flower-rich field margins (especially those containing umbellifers) will attract adults and support larval populations.

Common red soldier beetle.
Photo credit: Rothamsted Research

ID: Basic beetle shape with:

1. Soft smooth wing cases with blunt end
2. Elongated body shape
3. Black, red, or yellow colour



Key facts

Predation: Range of crop pests

Number of species in the UK: 41

Size range: 5 - 15 mm

Activity: Day active

Occurrence: Spring to autumn in ground to crop canopy

Dispersal: Flying or walking

Optimal habitat: Meadows and flower-rich field margins for feeding

Common red soldier beetle
Rhagonycha fulva

Size:
8 - 10 mm

Preferred habitats:
Hedgerows, flower-rich field margins

Breeding:
June - August

Dispersal:
Flying

Predation:
Adults actively hunt aphids while also consuming pollen and nectar

Parasitic wasps (parasitoids)

Ichneumonidae, Braconidae, Chalcidoidea

Parasitoids are tiny insects that often go unnoticed, yet they make an enormous contribution to crop protection. While they are technically wasps, these insects do not sting people, they lay eggs on or inside host insects.

Parasitoids are a group of insects whose larvae develop on or in the bodies of other insects. Unlike true parasites, which feed off a host without killing it, parasitoids always kill their hosts.[65] Parasitoids are among the most important natural enemies in agricultural systems and scientists continue to discover new species and learn how they function.

The most important families are the *Ichneumonidae* and *Braconidae* (superfamily *Ichneumonoidea*), comprising over 3,000 species in the UK.[65] These attack the larval stages of beetles, moths, flies, and other insects. Chalcidoidea, the next most important family, includes some of the smallest parasitoids (many under 2 mm), often specialising in egg parasitism. This group includes the commercially important whitefly parasitoid Encarsia formosa and egg parasitoids in the family Trichogrammatidae.

Parasitoid larvae may develop outside the host's body (*ectoparasitoids*), or inside it (*endoparasitoids*). Some immobilise the host immediately after parasitisation, while others allow the host to continue developing and feeding while consuming it.

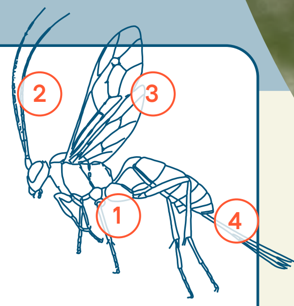
Parasitoids usually overwinter within their host, either coinciding their development with that of the host, or altering the host's development for their own purpose.

In some cases, it is possible to identify when the host has been parasitised (mummified aphids are a familiar example) but in others it cannot be detected even once it is dead.

Most species have evolved to attack only one or a few closely related pest species.[66] They have developed highly specialised venoms and ovipositors to immobilise their host and place eggs precisely within or on the host, even if the host is hidden in the soil or feeding inside a plant.[67]

ID: Sleek and hairless bodies

1. Narrow "waist" between the thorax and abdomen
2. Long antennae
3. Two pairs of membranous wings with limited veining
4. Females have an ovipositor (egg-laying tube) which can be long and obvious in some species or retracted and hidden in others



Flowering field margins with umbellifers (e.g. cow parsley, fennel, wild carrot, dill) and buckwheat provide essential food sources for adult parasitoids. These simple, open flowers are easy for tiny wasps to access.

Field margins, beetle banks or grass strips provide overwintering sites for some species and alternative hosts that help maintain parasitoids numbers when the main host is not active. For brassica aphid parasitoids, maintaining some brassica weeds in field margins or leaving brassica crop residues over winter can provide overwintering sites and early-season alternative hosts.[68]

Minimum tillage protects overwintering pupae in soil, ploughing buries parasitoids cocoons, making it difficult for the adults to emerge.[69]

Avoiding broad-spectrum insecticides such as pyrethroids is crucial as they are highly toxic to parasitoids, and applications in spring or autumn can coincide with parasitoid peak activity.

Key facts

Predation: Almost every life stage of each insect species is parasitised by one or more wasps; even parasitic wasps can be parasitised by hyperparasitoids!

Number of species in the UK: Over 3,000 species

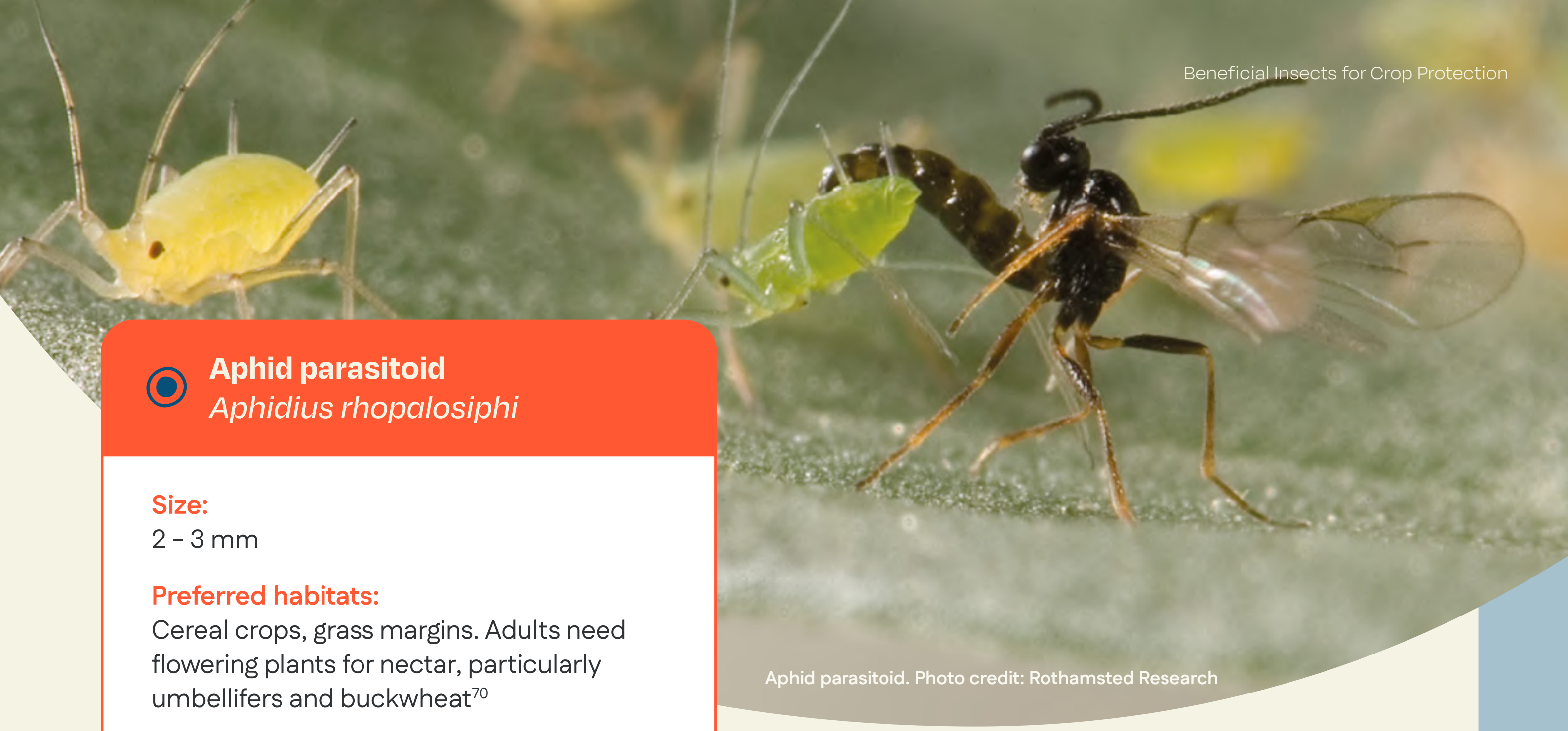
Size range: Less than 1 mm to more than 50 mm, though most are under 5 mm

Activity: Range from diurnal to nocturnal

Occurrence: Spring, summer and early autumn, before the temperatures drop

Dispersal: Flying

Optimal habitat: Flowering field margins and grasslands that can provide food sources and overwintering sites for alternative hosts. Minimum tillage protects overwintering pupae in soil



Aphid parasitoid. Photo credit: Rothamsted Research

Aphid parasitoid
Aphidius rhopalosiphi

Size:
2 - 3 mm

Preferred habitats:
Cereal crops, grass margins. Adults need flowering plants for nectar, particularly umbellifers and buckwheat[70]

Breeding:
April - October in field crops, peak activity May - July - coinciding with cereal aphid populations

Dispersal:
Flight

Predation:
Grain aphid (*Sitobion avenae*), bird cherry-oat aphid (*Rhopalosiphum padi*), and other cereal aphids on wheat, barley, oats, and rye. A single female can parasitise over 200 aphids in her lifetime (around 13 days)[71]

How to spot their work:
Look for golden-brown 'mummies' – dead aphids that have swollen and hardened after parasitism. Round exit holes appear where adult wasps have emerged

Cabbage stem flea beetle parasitoid
Tersilochus microgaster

Size:
4 - 5 mm

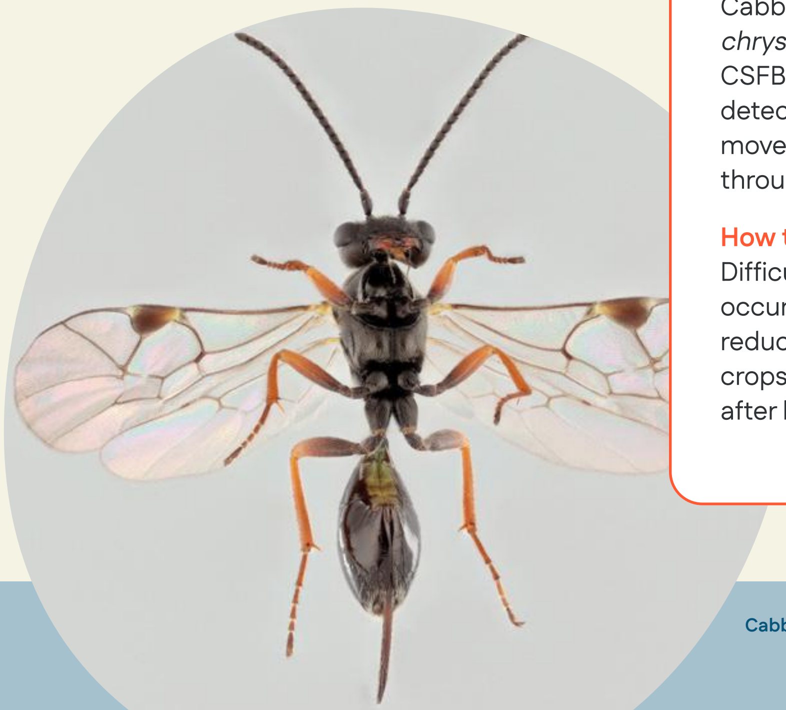
Preferred habitats:
Oilseed rape fields and brassica vegetable crops. Overwinters as pupae in soil beneath former OSR crops, so benefits enormously from minimum or no-till systems and crop rotation that returns OSR to the same area

Breeding:
Adult wasps active March - April

Dispersal:
Flight

Predation/target spp:
Cabbage stem flea beetle (CSFB *Psylliodes chrysocephala*) larvae. Adult females locate CSFB larvae mining inside OSR stems by detecting plant volatiles and possibly larval movements.[72] Female inserts her ovipositor through the stem to parasitise larva

How to spot their work:
Difficult to observe parasitism directly as it occurs inside plant stems. Evidence includes reduced emerging adult beetles from infested crops and presence of parasitoid pupae in soil after harvest



Cabbage stem flea beetle parasitoid. Photo credit: Malcolm Storey

Earwigs
Forficulidae and Labiidae

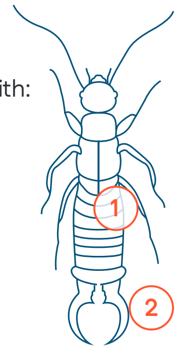
Despite their reputation, earwigs are harmless to humans and can make a valuable contribution to pest control on farmland. They are omnivorous, feeding on plant material, decaying organic matter and other invertebrates, positioning them as both potential minor pests and beneficial predators.[61]

Earwigs are mostly nocturnal; they come out after sunset to forage and hide during the day in dark places. This is why their beneficial activities often go unnoticed. However, research has shown that the European earwig (*Forficula auricularia*) is an effective predator of woolly apple aphid, pear sucker, rosy apple aphid, and codling moth eggs in orchards.

Earwigs are easily recognised by their forcep-like pincers used for defence, prey capture, courtship, and even wing folding. One quirky fact about this group is that females protect the eggs throughout the winter and feed their nymphs – a form of maternal care rarely seen in non-social insects.[62,63]

ID: Rove beetle like body with:

1. Elongated, flattened bodies
2. Distinctive pair of forceps-like pincers at the tip of the abdomen



Adults are most active in crop canopies from June to September, coinciding with peak pest activity, they then overwinter in the soil. Artificial refuges such as cardboard rolls placed near trees can significantly increase earwig abundance.[64] Broad-spectrum insecticides are highly harmful to earwigs, and spring applications coinciding with nymph migration can significantly reduce summer adult populations with knock-on effects for the following year's generation.

Key facts

Predation: Generalists, range of crop pests

Number of species in the UK: 7

Size range: 13 – 15 mm

Activity: Nocturnal

Occurrence: Ground to canopy level

Dispersal: Walking/crawling (they rarely fly)

Optimal habitat: Reduced tillage practices, woodland, suitable (artificial) shelter such as rolls of cardboard or flowerpots stuffed with straw

Earwig. Photo credit: Roger Key, Royal Entomological Society

Key groups of beneficial insects and farming practices to encourage them

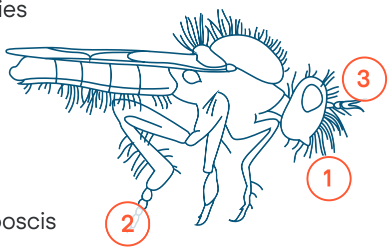
Aerial predators

Robber flies
Asilidae

As the name suggests, these flies are very adept aerial hunters and 'rob' or snatch their prey mid-flight. Robber flies are ambush hunters and will often perch in the open perches on bushes or trees waiting for their next meal. Due to their aerial prowess, they predate a large range of insects including flies, beetles, grasshoppers, moths and butterflies (sometimes even other robber flies!). Their wide prey range can include several pest species such as the Turnip moth (*Agrotis segetum*), Diamond back moth (*Plutella xylostella*) and Turnip root fly (*Delia radicum*).

ID: Long and slender bodies

1. Have a distinct 'moustache' which is a dense cluster of bristles on their face
2. Long, spiny legs
3. Short and strong proboscis (mouthparts)



They use their piercing mouth parts (proboscis) to stab their victim's exoskeleton and inject neurotoxins that paralyze and proteolytic enzymes to aid in digestion of their unfortunate prey. Some species can also mimic bees and wasps – the hornet robber fly (*Asilus crabroniformis*) is a good example – but they do not sting and are harmless to humans. Robber flies can be distinguished from the similar dagger flies by their 'moustache' of stiff facial bristles (the mystax) and their shorter, forward-facing mouthparts.


Robber fly. Photo credit: Paul Kitchener

Key facts

Predation: Diverse but notably predate flies, butterflies and moths

Number of species in the UK: 29

Size range: 3 – 30 mm

Activity: Mainly active in the day (March – October)

Occurrence: Spring, summer and early autumn, before the temperatures drop

Dispersal: Walking and some can fly

Optimal habitat: Sunny open and dry areas, especially grasslands, woodland edges and heathland

Violet black-legged Robber fly
Dioctria atricapilla

Size:
10 - 12 mm

Preferred habitats:
Grasslands and woodland

Breeding:
Adults hibernate in sheltered areas and females lays eggs on plants

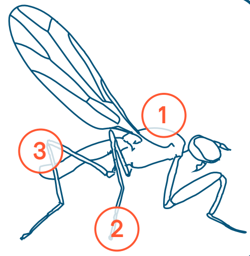
Dispersal:
Adults are active fliers

Predation:
Adults feed on a variety of small insects, especially other flies

Dagger fly. Photo credit: Linda Seward

Dagger / Balloon flies
Empididae

ID: Fly-shaped and bristly body
1. Distinct hump-backed thorax
2. Long and slender legs
3. Generally non-metalic and vary from yellow/brown to black



Similar to robber flies but generally smaller, without the mystax, and with long downward-facing mouthparts — the 'dagger' that gives them their name. They have a distinctive hump-backed thorax and a small head and large eyes.

Some of the larger dagger flies, such as Empis tessellate, can often be found in and around umbelliferous plants including hemlock, hogweed and cow parsley. Umbellifers such as wild carrot are often used in an array of wildflowers mixes and will aid in attracting these beneficial insects to the area. Reducing or avoiding cutting field margins during summer and preventing any foliar drift to the margins will encourage these insects.

Key facts

Predation: Aphids, other flies and smaller insects including a variety of pests

Number of species in the UK: 208

Size range: 1 - 12 mm

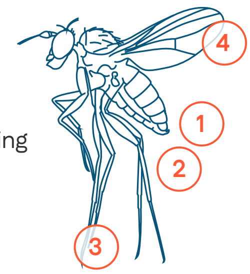
Activity: April – August

Occurrence: Spring, summer and early autumn, before the temperatures drop

Optimal habitat: Field margins and boundaries, gardens, woodlands and hedgerows

Long-legged flies
Dolichopodidae

ID: Small delicate flies
1. Metallic bodies
2. Stilt-like posture when resting
3. Very long slender legs
3. Fast and erratic fliers



There are around 287 species of long-legged flies in the UK, with the majority of these being skilled mini predators. They can be distinguished by their beautiful metallic appearance, along with their characteristic long legs. They also perch in a similar manner to a mosquito when at rest, due to their long legs! Unlike some of their larger relatives (e.g. robber flies) these flies cannot bite. Several larvae of this large and diverse group could be providing further pest suppression by consuming pest insects within the soil. For example, the larvae have been shown to eat soft-bodied insects such as aphids, thrips, midges and other fly larvae – they are regarded as key natural enemies within cereal crop (e.g. wheat and barley).[73]

Key facts

Predation: Thrips, midges, aphids, fly larvae

Number of species in the UK: 287

Size range: 1 - 9 mm

Activity: April – August

Occurrence: Spring, summer and early autumn, before the temperatures drop

Optimal habitat: Field margins and boundaries, gardens, woodlands and hedgerows

Long-legged fly.
Photo credit: Jayantibhai Movaliya / iStock

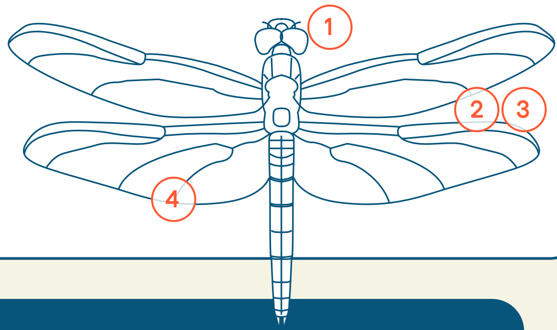
Dragonflies and damselflies
Odonata

Regarded as some of the most charismatic and iconic insect groups in the UK and Europe, this group comprises damselflies (*Zygoptera*) and dragonflies (*Anisoptera*). Damselflies can fold their wings at rest (closed over their abdomens), have eyes set apart, and are weaker fliers, their flight has a characteristic flutter. Damselflies are usually much smaller and daintier in appearance compared to dragonflies. Dragonflies rest with their wings open and, in flight, are fast and agile hunters on the wing. They can regularly be seen patrolling areas around water and hunting on the wing, catching other smaller insects with their strong legs and mandibles (jaws). Their large compound eyes provide a near 360° vision, making them very adept aerial predators of mosquitoes, midges, gnats, other flying insects.

Dragonflies and damselflies need permanent water to breed, spending most of their lives as aquatic nymphs before emerging as adults. Creating or maintaining water habitats such as ponds will help establish areas for dragonflies and damselflies to reproduce. Creating these water habitats will also increase other beneficial insects and provide further habitat to increase biodiversity, attracting several species of insects. Introducing hedgerows and other wildlife corridors will also encourage these insects into the area, as they regularly patrol these boundaries.

ID: Dragonfly – Large robust insects

1. Large eyes that 'wrap' around the head
2. Two pairs of different-sized wings
3. Always rest with wings open
3. Incredibly agile on the wing



Key facts

Predation: Several flying insects such as mosquitoes, midges, flies and gnats. Have been known to catch moths, butterflies, bees and wasps (particularly the larger species)

Number of species in the UK: 42 (25 dragonflies and 17 damselflies)

Size range: 3 – 8.5 cm

Activity: Active during the day (diurnal)

Occurrence: May - August

Dispersal: Adults mainly by flight, immature nymphs swim and crawl

Optimal habitat: Ponds and water bodies, with diverse vegetation and open water areas

Damselfly. Photo credit: Caroline McHardy, Royal Entomological Society

Habitat Summary

	Carabid beetles	Rove beetles	Harvestmen	Predatory mites	Centipedes	Spiders	Ants
Habitat provision on un-cropped land							
Hedgerow maintenance	1	2	3	1	2	3	2
Hedgerow establishment	1	2	3	1	2	3	2
Beetle banks	2	3	3	1	3	3	3
Grass field margins/buffer strips	3	3	3	1	3	3	3
Wildflower margins/in-field strips	2	3	3	1	3	3	3
Ditch maintenance	2	3	3	2	3	1	3
Ponds/wet areas/waterbody creation	1	1	0	0	0	0	0
Fallow land	2	2	2	2	2	2	2
Natural area retention (e.g. woods, grassland)	2	3	3	1	3	3	3
Crop management							
Diverse cropping/rotations	3	2	2	2	2	3	2
Under sowing/companion crop	3	3	3	3	3	3	3
Cover cropping	3	3	3	3	3	3	3
Over-winter stubbles	1	2	2	3	3	2	1
Organic matter input	2	3	3	3	3	1	3
Reduced tillage	3	3	3	3	3	1	3
Mulching	2	3	3	3	3	2	3
Low herbicide use	1	1	2	1	1	3	1
Low pesticide use	3	3	3	3	3	3	3

Ladybirds	Pirate bugs	Lacewings	Hoverflies	Predatory wasps	Soldier beetles	Earwigs	Parasitic wasps	Robber flies	Dagger/balloon flies	Long-legged flies	Dragonflies damselflies
3	3	3	3	3	2	2	3	3	3	3	3
2	3	2	3	3	2	2	3	2	2	2	3
2	3	2	2	2	3	2	3	2	2	2	2
3	3	2	3	3	3	3	3	3	3	3	3
3	3	3	3	3	3	2	3	3	3	3	3
1	2	1	1	2	2	2	1	2	2	2	3
0	0	0	1	0	0	0	0	0	0	0	3
2	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3	3
3	2	2	3	2	2	2	3	2	2	2	2
3	2	3	3	2	2	2	3	2	2	2	2
3	2	2	3	2	2	2	3	2	2	2	1
2	2	2	2	1	1	2	1	1	2	2	1
2	1	2	2	2	1	1	2	2	2	2	1
3	2	3	2	2	1	1	1	1	1	1	1
2	2	2	2	2	1	1	2	2	2	2	1
2	2	2	2	1	1	1	2	1	1	1	1
3	3	3	3	3	3	3	3	3	3	3	3

Photo credit: Rothamsted Research

3= Extremely beneficial

2 = Very beneficial

1= Slightly beneficial

0= Neutral

References

1. Science Innovation and Technology Committee. Insect decline and UK food security. Second Report of Session 2023–24. https://publications.parliament.uk/pa/cm5804/cmselect/cmsctech/326/summary.html (2024).

2. Plaas, E. et al. Towards valuation of biodiversity in agricultural soils: A case for earthworms. Ecol. Econ. 159, 291-300. (2019).

3. Smith, P. et al. UK National Ecosystem Assessment: Technical Report. Chapter 14: Regulating services. UNEP-WCMC, Cambridge. (2011).

4. Breeze, T. D., Garratt, M. P. D., Senapathi, D., Willcox, B. K. & Potts, S. G. Economic Benefits of Pollination to Global Food Systems- Evidence and Knowledge Gaps: Final Report. (2022).

5. King, P., Robinson, T., Howard, C., Breeze, T. D. & Dallimer, M. Economic valuation of pest regulation benefits provided by arthropods in the UK. Ecosyst. Serv. 76, (2025).

6. Pimentel, D., Hepperly, P., Hanson, J., Siede, R. & Douds, D. Organic and conventional farming systems: Environmental and economic issues. Tech. Report. New York State Coll. Agric. Life Sci. Cornell Univ. Ithaca, N.Y. (http//ecommons.library.cornell.edu/bitstream/1813/2101/1/pimentel_report_05- 1.pdf). 5, 1–52 (2005).

7. Losey, J. E. & Vaughan, M. The economic value of ecological services provided by insects. Bioscience 56, 311–323 (2006).

8. Schmidt, M. H. et al. Relative importance of predators and parasitoids for cereal aphid control. Proc. R. Soc. B Biol. Sci. 270, 1905–1909 (2003).

9. Symondson, W. O. C., Sunderland, K. D. & Greenstone, M. H. Can generalist predators be effective biocontrol agents?. Annu. Rev. Entomol. 47, 561-594. (2002).

10. Kendall, D. A. Soil tillage and epigeal predatory arthropods. in Soil tillage in agroecosystems 297–342 (2003).

11. Letourneau, D. K., Jedlicka, J. A., Bothwell, S. G. & Moreno, C. R. Effects of natural enemy biodiversity on the suppression of arthropod herbivores in terrestrial ecosystems. Annu. Rev. Ecol. Evol. Syst. 40, 573–592 (2009).

12. Holland, J. M. et al. Structure, function and management of semi-natural habitats for conservation biological control: a review of European studies. Pest Manag. Sci. 72, 1638–1651 (2016).

13. Tscharntke, T., Steffan-Dewenter, I., Kruess, A. & Thies, C. Contribution of small habitat fragments to conservation of insect communities of grassland-cropland landscapes. Ecol. Appl. 12, 354–363 (2002).

14. Mohamed, A. et al. Securing Nature's Contributions to People requires at least 20%–25% (semi-)natural habitat in human-modified landscapes. One Earth 7, 59–71 (2024).

15. Tscharntke, T., Klein, A. M., Kruess, A., Steffan-Dewenter, I. & Thie, C. Landscape perspectives on agricultural intensification and biodiversity – ecosystem service management. Ecol. Lett. 8, 857–874 (2005).

16. Järvinen, A., Hyvönen, T., Raiskio, S. & Himanen, S. J. Intercropping shifts the balance between generalist arthropod predators and oilseed pests towards natural pest control. Agric. Ecosyst. Environ. 348, (2023).

17. Jowett, K. et al. Using a multi-scale approach to examine the effects of field margins and landscape features on predatory carabid communities in crop fields. Agric. Ecosyst. Environ. 373, 109115 (2024).

18. Tschumi, M., Albrecht, M., Entling, M. H., Jacot, K. & Tschumi, M. High effectiveness of tailored flower strips in reducing pests and crop plant damage. (2015).

19. Albrecht, M. et al. The effectiveness of flower strips and hedgerows on pest control, pollination services and crop yield: a quantitative synthesis. Ecol. Lett. 23, 1488–1498 (2020).

20. Pywell, R. F. et al. Wildlife-friendly farming increases crop yield: Evidence for ecological intensification. Proc. R. Soc. B Biol. Sci. 282, (2015).

21. Blanco-Moreno, J. M. et al. Species Sensitivity Distribution (SSD) profiles towards □-cyhalothrin for key ecosystem service provider (ESP) species across five European countries representing different pedoclimatic zones. Sci. Total Environ. 954, (2024).

22. Williams, I. H. & Ferguson, A. W. Spatio-Temporal Distributions of Pests and Their Parasitoids on the Oilseed Rape Crop. in Biocontrol-Based Integrated Management of Oilseed Rape Pests (2010).

23. Maloney, D., Drummond, F. A. & Alford, R. TB190: Spider Predation in Agroecosystems: Can Spiders Effectively Control Pest Populations. (2003).

24. Lacava, M., García, L. F., Viera, C. & Michalko, R. The pest-specific effects of glyphosate on functional response of a wolf spider. Chemosphere 262, (2021).

25. Jowett, K. et al. Above□and below□ground assessment of carabid community responses to crop type and tillage. Agric. For. Entomol. 23, 1–12 (2021).

26. Howard, B., Duffy, M. S., Vela, M. N. & Gomez, M. D. Annual report for 2022 (year 2). The combined effects of perimeter trap crops and semiochemical attractants on the management of pea and bean weevil and bruchid beetle in faba beans. https://www.pgro.org/downloads/Ekhaga2020_59Annualreportyear2PGRO.pdf (2022).

27. Defra. Butterflies in the United Kingdom and in England, 1976 to 2024. https://www.gov.uk/government/statistics/butterflies-in-the-wider-countryside-uk/butterflies-in-the-united-kingdom-and-in-england-1976-to-2024--2 (2025).

28. Jiang, L. et al. Functional response and predation potential of carabus elysii adults against the terrestrial slug Agriolimax agrestis. Insects 12, 1135 (2021).

29. Hatteland, B. A., Grutle, K., Mong, C. E. & Skartveit, J. Symondson, W.O.C. Solhøy, T. Predation by beetles (Carabidae, Staphylinidae) on eggs and juveniles of the Iberian slug Arion lusitanicus in the laboratory. B. ulletin Entomol. Res. 100, 559–567 (2010).

30. Hoarau, C., Campbell, H., Prince, G., Chandler, D. & Pope, T. Biological control agents against the cabbage stem flea beetle in oilseed rape crops. Biol. Control 167, 104844 (2022).

31. Kromp, B. Carabid beetles in sustainable agriculture: a review on pest control efficacy, cultivation impacts and enhancement. I. Invertebr. Biodivers. as Bioindic. Sustain. landscapes 74, 187–228 (1999).

32. Honek, A., Saska, P. & Martinkova, Z. Seasonal variation in seed predation by adult carabid beetles. Entomol. Exp. Appl. 118, 157–162 (2006).

33. Bohan, D. A. et al. Spatial dynamics of predation by carabid beetles on slugs. J. Anim. Ecol. 367–379 (2000).

34. Hoarau, C., Campbell, H., Prince, G., Chandler, D. & Pope, T. Biological control agents against the cabbage stem flea beetle in oilseed rape crops. Biol. Control 167, 104844 (2022).

35. Dennis, P. & Sotherton, N. W. Behavioural aspects of staphylinid beetles that limit their aphid feeding potential in cereal crops. Pedobiologia, 3, 222–237 (1994).

36. Bohac, J. Staphylinid beetles as bioindicators. Agric. Ecosyst. Environ. 74, 357–372 (1999).

37. Orth, R. E., Moore, I., Fisher, T. W. & Legner, E. F. A rove beetle, Ocypus olens, with potential for biological control of the brown garden snail, Helix aspersa, in California, including a key to the nearctic species of Ocypus. Can. Entomol. 107, 1111-1116. (1975).

38. Dixon, P. L. & McKinlay, R. G. Aphid predation by harvestmen in potato fields in Scotland. J. Arachnol. 17, 253-255. (1989).

39. Gerson, U. Pest control by mites (Acari): present and future. Acarologia 54, 371–394 (2014).

40. Samu, F. & Szinetár, C. On the nature of agrobiont spiders. J. Arachnol. 30, 389-402. (2002).

41. Nyffeler, M. & Benz, G. Feeding ecology and predatory importance of wolf spiders (Pardosa spp.)(Araneae, Lycosidae) in winter wheat fields 1. J. Appl. Entomol. 106, 123–134 (1988).

42. Harwood, J. D., Sunderland, K. D. & Symondson, W. O. C. Living where the food is: web location by linyphiid spiders in relation to prey availability in winter wheat. J. Appl. Ecol. 38, 88–99 (2001).

43. Sunderland, K. & Samu, F. Effects of agricultural diversification on the abundance, distribution, and pest control potential of spiders: a review. Entomol. Exp. Appl. 95, 1–13 (2000).

44. Öberg, S., Mayr, S. & Dauber, J. Landscape effects on recolonisation patterns of spiders in arable fields. Agric. Ecosyst. Environ. 123, 211–218 (2008).

45. Offenberg, J. Ants as tools in sustainable agriculture. J. Appl. Ecol. 52, 1197–1205 (2015).

46. Choate, B. & Drummond, F. Ants as biological control agents in agricultural cropping systems. Terr. Arthropod Rev. 42, 157 (2011).

47. Anjos, D. V. et al. The effects of ants on pest control: a meta-analysis. Proc. R. Soc. B 289, 20221316 (2022).

48. AHDB. Biology and encouragement of lacewings (a natural enemy of field crop pests). https://ahdb.org.uk/knowledge-library/biology-and-encouragement-of-lacewings-a-natural-enemy- (2021).

49. Jonsson, M., Wratten, S. D., Landis, D. A., Tompkins, J. M. & Cullen, R. Enhancing biological control by an omnivorous lacewing: Floral resources reduce pest numbers at low prey densities. Biol. Control 55, 224–229 (2010).

50. van Rijn, P. C. & Wäckers, F. L. Nectar accessibility determines fitness, flower choice and abundance of zoophagous hoverflies in arable field margins. J. Appl. Ecol. 53, 204–213 (2016).

51. Osterloff, E. What do wasps do? Natural History Museum https://www.nhm.ac.uk/discover/what-do-wasps-do.html.

52. Pickett, M. & Carpenter, J. M. Simultaneous analysis and the origin of eusociality in the Vespidae (Insectae: Hymenoptera). Arthropod Syst Phylogeny 68, 3–33 (2010).

53. Donovan, B. J. Potential manageable exploitation of social wasps, Vespula spp. (Hymenoptera: Vespidae), as generalist predators of insect pests. Int. J. Pest Manag. 49, 281–285 (2003).

54. Southon, R. J., Fernandes, O. A., Nascimento, F. S. & Sumner, S. Social wasps are effective biocontrol agents of key lepidopteran crop pests. Proc. R. Soc. B Biol. Sci. 286, (2019).

55. Lester, P. J. & Beggs, J. R. Invasion success and management strategies for social Vespula wasps. Annu. Rev. Entomol. 64, 51–71 (2019).

56. Matthews, C. British wasp guide: How to identify common species, lifecycle and why wasps sting. Countryfile.com https://www.countryfile.com/wildlife/insects-invertebrates/british-wasp-guide-how-to-identify-common-species-lifecycle-and-why-wasps-sting-in-autumn (2024).

57. Bailey, S. ENTFACT-707: Soldier Beetles. University of Kentucky College of Agriculture https://entomology.mgcafe.uky.edu/ef707 (2022).

58. Losey, J. E., Ives, A. R., Harmon, J., Ballantyne, F. & Brown, C. Early-season predation impacts the establishment of aphids and spread of beet yellows virus in sugar beet. BioControl 42, 499–516 (1997).

59. Jachowicz, N., Kramer Jacobsen, S. & Sigsgaard, L. Molecular gut content analysis reveals predator feeding preferences and potential for biological control of aphids in sugar beet fields. BioControl 70, 627–638 (2025).

60. Outen, A. Cantharidae – Soldier Beetles. https://markgtelfer.co.uk/beetles/cantharidae/.

61. Orpet, R. J., Crowder, D. W. & Jones, V. P. Biology and management of European earwig in orchards and vineyards. J. Integr. Pest Manag. 10, 21 (2019).

62. Staerkle, M. & Kölliker, M. Maternal food regurgitation to nymphs in earwigs (Forficula auricularia). Ethology 114, 844–850 (2008).

63. Boos, S., Meunier, J., Pichon, S. & Kölliker, M. Maternal care provides antifungal protection to eggs in the European earwig. Behav. Ecol. 25, 754–761 (2014).

64. Niedobová, J., Skalský, M., Ouředníčková, J. & Michalko, R. Forficula auricularia (Dermaptera) in orchards: Monitoring seasonal activity, the effect of pesticides, and the perception of European fruit growers on its role as a predator or pest. Pest Manag. Sci. 77, 1694–1704 (2021).

65. Godfray, H. C. J. Parasitoids. in Encyclopedia of biodiversity 13 (Elsevier, 2007).

66. Burke, G. R. & Sharanowski, B. J. Parasitoid wasps. Curr. Biol. 34, R483–R488 (2024).

67. Johnson, N. F. Hymenoptera. in Encyclopedia of biodiversity (ed. Levin, S. A.) 177–184 (Academic Press, 2013).

68. Geiger, F., Bianchi, F. J. J. A. & Wäckers, F. L. Winter ecology of the cabbage aphid Brevicoryne brassicae (L.) (Homo., Aphididae) and its parasitoid Diaeretiella rapae (McIntosh) (Hym., Braconidae: Aphidiinae). J. Appl. Entomol. 129, 261–265 (2005).

69. Nilsson, C. Impact of soil tillage on parasitoids of oilseed rape pests. in Biocontrol-based integrated management of oilseed rape pests. (ed. Williams, I. H.) 305–311 (2010).

70. AHDB. Monitoring and managing insecticide resistance in UK pests. Annual project reports https://ahdb.org.uk/monitoring-and-managing-insec ticide-resistance-in-uk-pests. (2024).

71. Shirota, Y. Biology of Aphidius rhopalosiphi, a parasitoid of cereal aphids. Entomol. Exp. Appl. 34, 27–34 (1983).

72. Barari, H., Cook, S. M., Clark, S. J. & Williams, I. H. Effect of a turnip rape (Brassica rapa) trap crop on stem-mining pests and their parasitoids in winter oilseed rape (Brassica napus). BioControl 50, 69–86 (2005).

73. Marchiori, C. H. Bionomic of the Dolichopodidae Family (Insecta: Diptera). Open Access Res. J. Biol. Pharm. 4, 048–059 (2022).

74. Winspear, R. Six Key Actions to Restore Nature on Farmland. Farm Wildlife https://agricology.co.uk/blog/six-key-actions-to-restore-nature-on-farmland/ 2023

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