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POSTNOTE

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UK Insect Decline and Extinctions

Overview

- There have been documented declines in insect species and populations. Generalist species are less likely to decline than more specialised species. The impacts of this on ecological processes are poorly quantified.
- The UK has unparalleled data from long-term monitoring, but it is limited by gaps in what is measured and how. There are few long-term data sets with abundance data.
- Drivers of decline, such as habitat loss, are common across insect groups and can interact to cause combined pressure on populations. However, environmental changes can benefit some species while negatively affecting others.
- Interventions, such as habitat creation, may play a role in halting declines, but the scale and types need careful consideration.

Insects provide vital goods and services for wildlife, food production and human health, and their decline threatens important natural processes. Despite some insects being in long-term decline, a few species are showing stable or increasing trends. Insects can respond to interventions quickly. This POSTnote will summarise the evidence for insect declines in the UK, the drivers of trends, and interventions to support the recovery of insect populations.

Background

Insects play a pivotal role in natural processes that support other living organisms, and human health and well-being (POSTnote 281). Adult insects have six legs and usually one or two pairs of wings and are the most diverse group of animals.[1–4] Roles include pollination (POSTnote 348 and 442), pest and weed regulation, decomposition, nutrient cycling, and provision of food for wildlife and humans (Box 1). They can also be agricultural pests or transmit disease (Box 2).[5–18] Insects are key indicators for monitoring ecosystems (POSTnote 312).[9,19,20]

Concerns about insect decline attracted wider attention following studies showing large declines in insect abundance and biomass.[21–23] Recent media attention has claimed unprecedented declines in insects across the globe leading to an 'insectageddon'[24] causing the "collapse of nature".[25] These claims were largely based on a review of scientific articles from across the globe.[26] However, this study has been criticised as the evidence it reviewed was predominantly from North America and Europe, which may have skewed the conclusions. It also excluded studies that reported stable or increasing populations by only selecting those showing a decline.[27–31] As such, the trends for global insect populations remain largely unknown but could be underestimated.[32,33] However, studies in Europe found insect abundance or biomass declined between 38% and 75%.[21,34–38]

Limitations of UK Insect Decline Data

An ideal dataset for understanding insect decline would include insects from a wide range of ecosystems, using samples collected in a standardised way.[3,39,40,20,33] Globally, data on

Box 1: Economic Importance of Beneficial Insects

Insects have economic, social and cultural value.[2,9,41–43] A decline in insects may negatively impact ecosystem services,[44,45] and could be costly.[46] Currently, there is limited evidence for the quantitative value of ecosystem services provided by insects, but some examples are emerging. The economic value of pollination to UK crop production is approximately £500 million a year.[47,48] Dung beetles are estimated to be saving the UK cattle industry £367 million each year and £37.42 per cow through reducing flies and increasing nutrients in the soil.[49] Natural pest control (by ground beetles and parasitoid wasps) of widespread aphid pests is worth up to £2.3 million per year in South East England wheat fields alone.[46,50] Freshwater insects in their larval stage, such as dragonflies or mayflies, can also filter water, remove pollutants and provide food for bats[17], birds[51] and fish (such as salmon and trout[52]). This supports recreational activities, including angling (which contributed £1.46 billion to the English economy in 2015[53]). Insects also have social and cultural value.[54] Some studies have attempted to quantify the value the public place on insects; for example, a study found that people were willing to pay approximately £43 per household per year to support bee protection policy; equating to £842 million per year[55] when scaled up to 31 million taxpayers.

insects are limited because of the large number of species.[1,3,56] The UK has more data than many countries due to its long-term recording schemes, natural history collections, citizen science engagement and insect research community.[57,58] Emerging labour-efficient methods can help data collection through remotely monitoring larger areas, such as bioacoustics[59–62] and BioDAR[63–65] (see POSTbrief 36).[66] New identification methods such as DNA analysis may prove more reliable in the future (see POSTbrief 36).[67–74] New methods still require expert interpretation. Current data are limited by gaps in what is measured and how, including:[3,40]

- **Methods.** Surveys that used a standardised sampling across sites, measured at systematic intervals, exist for a limited group of species and habitats.[40,75–78]
- **Time.** Limited data are available before the 1970s,[79] creating an arbitrary baseline for comparison.[40,80] Using data collected irregularly across time may lead to uncertainty.[56,81,82,33]
- **Location.** The gaps in where data are collected can lead to a bias towards some habitats such as nature reserves and agricultural systems. The trends from these systems may not be transferable to other systems. This bias has begun to be addressed through several schemes.[40,76,81,82]
- **What is measured.** Data focus on specific insect groups; such as bees,[83] rather than other groups, such as decomposers;[2,3,56,84] and more easily observed adult forms rather than caterpillars or aquatic larvae.[66]
- **The type of data** can affect the conclusions made about insect declines. For example, species richness tells us the number of species present. However, abundance (number of individuals of a species) may have a stronger link with ecosystem services than richness.[9,21,45,85–87] Without knowing the abundance and species identity, changes in communities can be masked.[88] The range of data can make comparisons across insect groups, locations and time difficult but statistical modelling can be used.[85,89]
- **Who is collecting data.** The reliance on volunteers means that there is often irregular sampling.[39,85,90] To continue collecting data, long-term investment into resources, building skills and capacity, is required to sustain volunteers, support amateurs and incentivise professional development.[40,91–97]
- **Accessing data.** Some data are fragmented (held privately by researchers, or companies like agricultural or environmental consultancies, see POSTbrief 36).[40]

Trends in UK Insects

The UK has experienced extinctions and declines in abundance, biomass and distribution of insects. Of the 2430 GB insect species assessed by Natural England, 55 have gone extinct and 286 (11%) are threatened.[98] Total aerial insect biomass declined at one of four sites since 1973.[99] Data from 3089 insect species showed that the distribution size for terrestrial insects increased during 1970–1980s but declined sharply between 2005–2015.[83] However, freshwater insects have recovered since the early 2000s.[83] Insects have also become less widely distributed by 10% on average (1970–2015).[19]

Insects may be declining faster than other groups.[100] The average abundance of insect indicator species (butterflies and moths) is decreasing while bird and mammal abundance remains stable.[19] Declines in distribution are comparable across mammals, plants and insects (4–8%).[19] However, a study found that butterfly distribution declined more than birds and plants.[34]

Declines in abundance or distribution have been seen in bees and hoverflies,[32,101] butterflies[34] and moths,[35] beetles,[102] and freshwater insects.[48,101,103,104] However, some species are increasing in biomass.[105] The data available for the most studied insect groups are summarised below.

Bees and Hoverflies

Bees and hoverflies experienced dramatic losses between the 1950s and 1980s but losses have slowed since the 1990s.[77] Of 353 wild pollinator species, 117 (33%) had decreasing distributions (1980–2013).[32] Yet, 10% of species had increasing distributions.[3297] The rest (57%) had an unclear trend.[32] Pollinators key to European crops increased by 12%, potentially supported by agri-environment schemes or the increased area of oilseed rape.[32,106,107] Since 1909, 20 bee and wasp species have gone extinct in Britain.[108]

Butterflies and Moths

Of 62 butterfly species, 19 (31%) are threatened and four have gone extinct in GB.[109] Butterfly abundance has declined for 21 species since 1976.[110] However, abundance increased for 11 species[111] (such as silver-washed fritillary with a 127% increase).[112] Of 337 moth species, 111 (33%) had increasing trends but 222 (66%) were declining, and 71 species declined by over 30% per decade (1968–2004).[100] Total GB moth abundance has decreased by 31% (1969-2016).[100,113]Moth declines occurred in coastal, urban and woodland habiats.[113] However, some evidence suggests that moth biomass may be increasing, implying that a few species are doing well.[79]

Beetles

Of 1134 beetle species in GB, 13% are threatened.[98] A significant decline in abundance of ground beetles was found in 75% of 68 species, and 34 of those species decreased by 30% each decade (1994–2008).[102] The number of species also declined.[102] However, abundance in chalk downlands, woodlands and hedgerows increased (16–57%).[102]

Box 2: Pests and Invasive Non-Native Species

While other insects are in decline, there are concerns that pest species (native and invasive) such as weevils,[101] aphids,[112] and cabbage stem flea beetles[110] may be increasing (POSTnotes 303, 394, 439), with negative impacts on crop yields.[114,115] Climate change and emerging resistance of pests to insecticides[116] amplifies this increase[117] (POSTnote 597). Although some invasive species can create opportunities (such as increased pollen availability), others pose risks (such as increased predation, see POSTbrief 36).[118] The impact of the invasive species depends on the abundance and the role it plays in the system. For example, some invasive plants are readily taken up by native pollinators but these interactions are poorly understood and risks could be overlooked with limited knowledge.[118] Invasive predators tend to exert strong top-down pressure on insects.[44,119,120] For example, the Asian hornet feeds on bees.[47] Other stressors, such as disease and pesticides, can make bees more vulnerable to predation.[121,122] Risk registers include non-native species with potential economic risks, but are less effective at capturing the ecological risks.[123]

Freshwater Insects

Of 724 aquatic insect species in GB, 68 (9%) are threatened and 11 have gone extinct.[98] A recent UK study found that dragon-fly, caddis-fly and mayfly distributions decreased in the 1970–1990s, but recovered in the 2000s to above 1970 levels.[101] Species with increasing distributions tend to be generalists or have adapted to warmer climates.[124] A study in Wales found that populations of specialist caddis-flies, stone-flies and beetles were more likely to decline even if overall species richness remained stable.[88]

Drivers of Insect Trends

There are a variety of drivers behind insect decline and their impacts differ across habitat, species and time (see POSTbrief 36). There is a lack of evidence on how some of these drivers affect different insects as the impacts may have already occurred prior to sufficient monitoring.[40,99,126,127,33] Drivers may also interact with each other and increase their impact on insect populations.[41,47,128,129] For example, bees can be more susceptible to parasites and the effects of habitat loss during exposure to pesticides.[128,130] Climate change is likely to interact with multiple stressors such as habitat loss.[35,37,131,132] Wild and commercially-managed insects share drivers of decline such as loss of habitats, reduced variety in plants and exposure to chemicals (Box 3).[128,133–135] Key drivers are known to include:

- **Habitat loss, fragmentation and degradation.** Habitat loss and degradation caused by land-use change can reduce the resources for insects across their life stages (breeding sites, foraging sites, shelter from weather and predators).[47,66,136,137] Hostile environments between fragmented semi-natural habitats make it more difficult for species to move (POSTnote 300).[138] Specialist species are more vulnerable to the impacts of land-use change.[47,108] For example, some species are reliant on human-modified habitats, such as brownfield sites.[139]
- **Urbanisation** can impact habitat connectivity.[128] Pollution, including air, water and light, can impact insects but evidence on these is limited (see POSTbrief 36).[140–151] Some urban habitats, such as gardens, can support high and unique insect biodiversity but are often dominated by generalist species.[152–160]
- **Land-use intensification.** Large-scale monoculture is often accompanied by high chemical inputs, tillage and mowing.[161] This can impact insects through habitat loss, degradation and fragmentation.[23,47,162] Although monoculture of some crops provides resources for pollinators,[47] the simplification of the landscape can reduce plants[163] and nesting sites.[44] Crops only flower for a short time, whereas wildflowers offer resources throughout insect lifecycles.[41,44,136,164] This can contribute to decreased insect abundance, and changes in community composition and ecosystem service provision.[44,45,134,165,166]
- **Pesticides, fertilizers and veterinary medicines.** Chemicals are used in rural and urban environments that can have unintended direct and indirect negative impacts on non-target wildlife,[14] including insects.[47,107,135,162,167–184] In one study of wild pollinator individuals with detectable levels of chemicals, 71% had been exposed to more than one compound.[168] This increases toxicity and stress.[12,169,170] The impacts of this combined exposure remain unclear.[47] These chemicals can build up in soils and plants, and can run off into water systems, further impacting insects.[12,197–199] There is limited evidence on the impacts of pesticides on non-target insects that aren't pollinators; with most research since 2014 focussing on the impacts of neonicotinoid pesticides (Box 4).[167]
- **Climate change** can affect individual insect species both positively and negatively.[19,35,84,125,162,200–209] For example, due to a warming climate, aphids had an earlier and longer flight season and were able to reproduce more compared to previous years; becoming more abundant.[112,200] Changes in weather and temperature can alter the timings of insect lifecycles that can negatively impact fitness or prevent emergence altogether.[89,112,158,210–215] Of 130 butterfly and moth species, 39 had increasing abundance, but early emergence led to neutral or negative impacts for 91 species.[216] The range of some species has expanded northwards and upwards while others have contracted.[84,131] These changes in communities can lead to temporary increases in the number of species through the rise of novel ecosystems.[217]

Box 3: Commercially Used Insect Population Trends
Bumblebees and solitary bees are managed but little is known about these populations in the UK as registration is not required.[47] Current evidence is biased towards pollinators such as honey bees.[167] Honey bee colonies and bee-keepers decreased by 31% across Europe between 1985–2005.[133] However, registered honey bee colonies in the UK grew from 90,000 in 2008 to 247,000 in 2017.[185] These figures may be inaccurate as honey bee registration is voluntary.[47] The drivers of honey bee declines are most likely economic, such as difficulty in making money from bee farming, the reduced cost of importing bees,[133,186] and high costs of treating diseases and concern over pesticide exposure.[186–188] Diseases can contribute to declining numbers[47,189] although the scale of impact on recent declines remains unclear (see POSTbrief 36).[133] The management of disease relies on good bee-keeping practice.[47,190] There is limited knowledge on how disease impacts services or wild insects.[47,167,191] Managed bees (honey[191,192] and bumble[193]) share pathogens with wild pollinators, with potential for negative impacts (bumblebees, solitary bees or hoverflies) but the direction in which the infection occurs is unclear.[191,193-196] Managed bees can also compete with wild pollinators for resources.

Box 4: Neonicotinoid Pesticides
In 2018, an EU-wide ban was applied due to poisoning and sublethal effects on pollinators[44] (which can translate to reduced reproduction or colony level failures)[218] but evidence for other insects is limited (Commons Briefing Papers SN06656).[219–224] However, risk of exposure remains, with persistent detectable levels[222] and increased toxicity[223] across environments.[171] Honey bees and bumble-bees can exhibit preferences for neonicotinoid-treated food over time, making it difficult to control their exposure.[224] Neonicotinoids can also negatively impact aquatic systems.[14,172,225,226] In response to the ban, older and less effective insecticides are being used, as are newer insecticides that have limited evidence of impact.[47,227–230]

Interventions to Support Insect Recovery

The Wildlife and Countryside Act 1981 prevents collecting or killing of a small number of butterfly, moth and beetle species.[231,232] The Natural Environment and Rural Communities Act 2006 identifies individual insect species for conservation.[233] The Habitats Directive (92/43/EEC) covers seven UK insect species. The 2014 National Pollinator Strategy[234] is being delivered with a range of stakeholders. Future policy suggestions for insect recovery have been published.[235,20] Future policy for England includes commitments set out in the 25-Year Environment Plan for the Natural Environment.[236] This includes creating or restoring 500,000 hectares of wildlife-rich habitat outside protected sites as part of a Nature Recovery Network to connect habitats across the country.[237] This enables insects to move through habitats, allowing some species to adapt to changes in climate. The Environment Bill 2019-2020 makes provisions for setting long-term biodiversity targets.[238]

Insect conservation can support other animals and demonstrate the quality of the environment.[9,19] Insects have the potential to recover faster than other animal groups due to their rapid life cycles and can even respond to small scale interventions (see Box 5). Evidence synthesis of measures to address the drivers of decline is skewed towards pollinators, but new studies are addressing this.[239]

Habitat Creation, Connection and Protection

Protecting and creating habitats for other groups (plants or birds) can support insects,[240–242] but more targeted conservation for insects would include conserving a range of habitats (semi-natural and micro).[47,243–248,20] For example, heathlands can protect important pollinator-plant interactions.[240,249] Wild pollinators[250,251] are supported by bare ground (for nests),[250] flower strips,[106,136,252,253] restored grass and heathland,[249,250,254] and nest boxes and uncropped naturally regenerated field margins.[32,251] Chalk and limestone grassland, broadleaved woodland, and natural grassland produce the greatest amount of nectar per unit area.[136]

The success of habitat creation is determined by its structure, resources (such as nectar, dung or food plants), the extent of fragmentation and diversity of surrounding habitats, and the absence of pressures (POSTbrief 34).[10,47,66,106,255,256,20] For example, hedgerows in a landscape can act as corridors to facilitate insect movement.[156,257,258] Habitat creation can be implemented in either urban areas (Box 5) or agricultural land. Species that have become locally extinct can be re-introduced to protected or created habitat (Box 6).

Habitat Creation on Agricultural Land

Under the Agriculture Bill 2019-20, results-based payments could be made to incentivise high-quality implementation that maximises the complexity and connectivity of habitats (POSTNote 377).[259] This could be supported by co-operative incentives that encourage peer-to-peer knowledge exchange and working at a larger scale. The evidence on the uptake and quality of implementation is limited.[260] For example, flower mixes and hedgerows may have increased since 2015 because of the Countryside Stewardship Scheme package,[47,261] but it only represents 1% of national nectar provision.[136] The benefits of these interventions are limited to a few surrounding acres and common species.[283–287] Training land managers can improve the quality of implementation.[288–290] For example, appropriate tree planting that creates diverse habitats can support insects,[291–296] but planting appropriate native trees supports more insect species than introduced tree species.[297]

Box 5: Urban Habitat Creation

Urban spaces; such as brownfield sites, ponds, road/rail verges, gardens, allotments and green roofs; support insects.[153,155–160,254,262–267] Reducing mowing can support insects but appropriate timings should be explored.[268,269] Flower mixes should be chosen carefully to support pollinators and provide breeding habitat.[136,160,270–272] However, public perception may pose a barrier to implementation. There is a concern that road or rail interventions could create an 'ecological trap' by drawing pollinators to dangerous areas, exposing them to risks from cars and pollution.[273] Another option is reducing the use of pesticides in urban areas.[47,168,171,274–276] Bee or bug 'hotel' effectiveness depends on the quality of the surrounding habitat.[47,277] Light pollution may also limit effectiveness.[135] 'Re-wilding' gardens can reduce chemicals and increase habitats such as flowers and ponds.[278–282] Rewilding could also restore processes on a larger scale (POSTnote 537).

Other Interventions for Agricultural Land

Other interventions can include organic farming,[17,47,298] diversifying crops,[41,44,47] beetle banks,[299] and reducing inputs (fertilizers, herbicides, pesticides and fungicides,[251] or livestock medical treatments[12,41,197]). Freshwater insects benefit from buffer strips that decrease run-off pollution in freshwater systems.[300] Training and education around chemical use can prevent and reduce impacts.[44] However, bans can also be effective in reducing the use of high-risk chemicals (Box 4).[44]

Integrated Pest Management gives preference to non-chemical methods to manage pests such as using crop rotations, field margins and biological control.[47,236,301–303] In 2017, the National Farmers Union developed a self-assessment tool for farmers.[304] This has been completed by 16,820 farmers and growers, covering 25% of the UK total agricultural area.[47] However, this data are not public so there is no current review being undertaken on the effects, at a farm-scale, on insects.[47]

Box 6: Reintroductions and Assisted Colonisation

Reintroducing species to habitats they naturally occupied or to habitats with continued climate suitability can reverse extinctions and increase complexity and resilience of systems.[45,305,306] For example, two UK butterfly species (marbled white and small skipper) were introduced to sites in Northern England that were outside of their existing range but had a suitable climate. Both populations grew and expanded their range.[305] This is called assisted colonisation.[305] Reintroductions that are evidence-based and supported by stakeholders are more likely to be successful. An example is the large blue butterfly, which is of global importance but was extinct in the UK in 1979 and reintroduced in the 1980s.[307] It became very abundant at a number of sites by 2014[308] and benefited other species[309] (some endangered[307]). Understanding the large blue's relationship with a species of red ant and the wider ecosystem was essential for successful reintroduction.

Endnotes:

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