Written evidence submitted by Norwich Research Park (INS0023)

House of Commons – Science, Innovation and Technology Committee

Insect decline and UK food security

Introduction

This response has been produced by Norwich Research Park, one of the largest single-site concentrations of research in plant and microbial science, food, genomics and health in Europe. The Park brings together four independent, internationally-renowned research institutes – the John Innes Centre, Quadram Institute, Earlham Institute and The Sainsbury Laboratory – with the University of East Anglia and the Norfolk and Norwich University Hospitals Foundation Trust.

Given our interest climate change and food security, insect population declines are highly relevant to our research given the vital roles they play within our food systems. This is a joint submission prepared collaboratively by scientists from the John Innes Centre, Earlham Institute, The Sainsbury Laboratory and the University of East Anglia.

1. **The current evidence base for insect abundance in the UK, and the gaps in scientific understanding that require further research;**

Key Points:

- The UK has a strong evidence base concerning invertebrate populations and relevant abiotic factors;
- These data show worrying trends on desirable and benign insect species; and
- They also show negatively impactful trends with pest and invasive species.

Recommendations:

- The UK should ensure that its historic and valuable monitoring schemes are sustainable into the future; and
- The UK should draw together its datasets and enhance population-level genetic monitoring to enable more powerful and sustained analysis of the UK's invertebrate population against clearly defined expectations and measure of success to maintain our natural capital and food security.

The UK has a long-established and robust evidence base concerning insect abundance, diversity and distribution. These data are complemented by good quality evidence concerning relevant biotic and abiotic factors impacting insect populations, e.g. climate, land use and farming practices, that permit nuanced analysis of population trends and interactions in the context of changing environments. For example, the Rothamsted Research Insect Survey has been running since 1964 and represents a valued and unique dataset on aphids, larger moths and many other migrating insects. Data from this survey support decisions by industry (eg chemical management of aphids), policymakers and researchers, and its value is internationally recognised with information made available to organisations in the Netherlands amongst others. This survey is managed as a BBSRC-funded National Capability demonstrating the value of these publicly funded monitoring programmes.

We also benefit from our history in the natural sciences, with most studies exploring insect and invertebrate populations having been undertaken in the UK and Europe, and when combined with a strong amateur natural science tradition, we are fortunate enough to be able to draw upon a diverse and longstanding evidence base for the UK. There are citizen science schemes recording a variety of invertebrates including bees, hoverflies, social wasps, butterflies, dragonflies, spittlebugs, and others – despite this there are gaps, particularly for important but ‘non-charismatic’ insects such as parasitoid wasps.

In addition, as a result of our island geography we have fewer species present than mainland countries, and a greater understanding of the presence and impact of invasive species. Taken together we have a broad and deep pool of data to draw from.

On data collection, we would welcome greater support for these recording schemes to ensure their long-term sustainability up to and including recognising some as national capabilities – there is a wealth of knowledge on the trends we explore here that could be lost without the passionate individuals that run such schemes, for the most part on a voluntary basis. One of the UK’s greatest biodiversity assets is its rich tradition of natural history – this needs to be supported into the future!

The data themselves present a worrying situation for many beneficial or benign species. Butterfly counts show large declines in numbers and range for many species, with similar trends for key pollinators, such as bees. For example, data generated by our national recording schemes shows stark evidence of this decline in both bees and hoverflies (Figure 2 of Powney et al. 2019) (https://www.nature.com/articles/s41467-019-08974-9). There are, however, nuances to this situation: the most recent survey by Butterfly Conservation points out that those species “restricted to particular habitats such as flower-rich grassland, heathland and woodland clearings” have been particularly negatively affected, whilst more generalists, that can “breed in the farmed countryside and in urban areas”, are much less affected have fared much less badly. Likewise some bumble bees are clearly doing better than others. Understanding these nuances will be critical to our approaches to reversing their decline.

That said, it would not be an exaggeration to state that the situation is more serious than perceived for UK’s insects and invertebrates. In addition, this information shows concerning trends for pest species with economically impactful changes in distribution, abundance and behaviour threatening UK agriculture and, by extension, food security. For example, trap monitoring data shows aphid species are now emerging around three weeks earlier than before, impacting farmers and growers who must adjust their planting times to avoid emergence of pests and, more impactfully, their associated diseases. Managing these issues is a major driver for plant breeders as they work to support early growth and resilience in UK crops around insect-transmitted diseases such as barley yellow dwarf virus in cereals and beet yellows in sugar beet.

Although we have robust data able to meet the requirements of the diverse and complex users across agriculture, food producers and conservationists, it could be greatly enhanced through support to draw these valuable resources together to provide a continuous, national-level analysis of key species, broader environmental conditions, and other factors impacting invertebrates and related activities at all scales. This analysis would need to be pinned to a multitude of critical success factors for our invertebrates but would enable more robust policy- and decision-making in these and associated areas, eg agricultural policy and practice, conservation, mitigating climate change, more than repaying any investment made in such a National Capability. If accompanied by clear routes to inform management and/or commercial opportunities, such as Innovate UK funding, this resource would be enormously impactful.

When considering knowledge gaps, our understanding of the genetic diversity of UK insect and invertebrate populations is poor. We know that genetic diversity impacts the spread, virulence and impact of pathogens, and regularly use this information to explore plant-microbe interactions across our institutes, but do not hold similar information concerning insects. The study of insects has historically taken an evolution and natural systems focus, but technology advances and falling costs now mean it is possible to broaden our understanding to explore the genetic diversity of UK invertebrate populations, and the impact of this diversity on the trends we see across the UK.

We also live in a time of biodiversity genomics: the Wellcome Trust funded Darwin Tree of Life project (DToL), has made great progress in the past 4 years in the task of providing reference genomes for all eukaryotic species in the UK. This work has been spearheaded by the sequencing of insect species. There are now over 500 complete sequences from the project, the vast majority of which are insects. These sequences provide the ideal foundation from which to expand our understanding of our invertebrate populations at the genetic level.

Such genetic data should not only focus on aspects of compatible insect-plant interactions, but also provide opportunities for fundamental science exploring key questions such as how it is that most insects are specialized or have some restrictions of plant host range, and why it is that most plants are resistant to most insect pests. What are the genetic components involved in non-host resistance of plants to insects and can this knowledge be used to obtain full resistance of plants to insect pests? What is the genetic diversity in under threat insect populations?

Studies have demonstrated the value of exploring insect resistance through genetics[1], but this field is emergent, particularly when considering insects demonstrating more complex population genetic diversity than clonal aphid populations.

We believe that expanding existing National Capabilities and/or creating new continuous genetic resources exploring the UK's insect populations is a necessity for the efficiency and effectiveness of our long-term management of our insects and invertebrates and, by extension, our food and natural environment.

2. **The effects of pesticides, such as neonicotinoids or other agricultural control methods on insects including pollinators and their impact on UK food security;**

Key Points:

- Neonicotinoids were highly effective in controlling insects, but their availability and simplicity of use, especially as seed treatments meant there was little development of alternate approaches;
- We still do not fully understand the medium- to long- term impact of prolonged neonicotinoid, or indeed any pesticide, use on insect populations; and
- However, until effective and efficient alternative control methods are in place to replace neonicotinoids, our food security will be at greater risk.

Recommendations:

[1] E.g. Genetic Resources of Cereal Crops for Aphid Resistance - PMC (nih.gov)

- Research, growers, agroindustry, food producers and government should prioritise the development and deployment of alternate methods of control for pest species previously managed through neonicotinoids; and
- The UK should look to grow its agroeconomics expertise and knowledge to ensure that our understanding of the behaviours and fiscal impact of policy changes are well-considered.

Neonicotinoids are an effective form of pest control. For example, the sugar beet yields were regularly 30% lower before their use which, if repeated today, would render the industry unprofitable[2]. However, when considering the impact of removing a chemical control, crop yields are a very narrow prism through which impact is commonly defined. We do not know, for example, what the impact of removing neonicotinoids (and other insecticides) has been on early insect food sources, impacts from alternate chemical usage etc. and the subsequent impact, either good or bad, arising from these changes making it difficult to state whether alternatives are safer and/or better for the environment.

The wider impact of neonicotinoids on non-target species resulted in their banning and, with studies demonstrating that neonicotinoids impact a wide range of insect functions, including the ability to find food, it seems critical to find alternatives that are more targeted and less persistent in the context of collapsing insect populations.

The challenge facing us is the legacy of the effectiveness of neonicotinoids with the development of alternative control methods greatly slowed as neonicotinoids lowered the priority in this area. This has created an acute need for the development and deployment of alternate methods of control that are both as effective as neonicotinoids and that do not repeat the same issues as before. The issues around developing alternate control approaches arising from neonicotinoids are not unique with fungicides and herbicides[3] also negatively impacting the broader environment, further increasing the benefits of exploring novel control approaches as a priority.

Research and technology development to address these issues have progressed, but alternatives are still unable to demonstrate the efficacy or cost-effectiveness necessary to replicate the control provided by neonicotinoids. An integrated pest management (IPM) approach seems to be much more appropriate. For example, biocontrol options are most effective in controlled (ie greenhouse) environments that do not reflect varied and complex agricultural practice. Given the need to avoid the issues presented by neonicotinoids, we believe that a single control solution is highly unlikely present itself necessitating the creation of toolkit of control options utilising the latest technologies and research available.

An IPM approach is in place in many crop/pest situations but a suite of options needs collaboration and support from growers, breeders, industry, policymakers, conservationists, and researchers to ensure that the complex balance of needs across the sector is fairly considered and should be designed with consideration of both traditional and novel methods and be managed so as to evolve and improve as needs dictate and options improve.

Relevant to our remits, we believe that connecting plant genetics to insect genetics will provide a diversity of control options and should be explored as a priority. We have a rich evidence base to draw from when exploring plant-pathogen interactions, and creating comparable genetic resources concerning plant-insect interactions would be enormously valuable.

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[2] Management of yellow dwarf disease in Europe in a post-neonicotinoid agriculture - Mc Namara - 2020 - Pest Management Science - Wiley Online Library

[3] https://doi.org/10.3389/fenvs.2020.00081

The impact of these resources would be underpinned by ongoing fundamental research of these challenges through organisations such as BBSRC, but, given the priority of this issue on UK food security, would necessitate initial investment to collect the information necessary to explore the population-level genomics of UK insect populations and define the priorities of users to focus research and innovation on the key challenges at this time.

This genomic focus would also align well with the changing policy context presented by the assent of the Genetic Technology (Precision Breeding) Act. UK-led research has greatly advanced the development of genetic technologies that can allow us to improve crops by making them resistant to insects or insect-borne diseases (such as Potato virus y and diverse yellows viruses that infect a range of crops), drastically reducing our dependence on insecticides in agriculture. Using genetic technologies to understand the underpinning roots of resistance will present options to provide broader resistance in crop plants alongside other options in this complex area.

In addition, we would welcome efforts to grow and improve agroeconomics expertise within the UK to ensure that policy decisions on control options are cognisant of likely economic and behavioural ramifications across all users that may impact the effectiveness of achieving desired outcomes.

3. **The extent that biodiversity initiatives, such as creating reservoir populations, are addressing insect decline and whether there is sufficient co-ordination with the UK food system;**

Key Points:

- The direction of progress for these initiatives is positive for both managed and native pollinators;
- More diverse strategies to support native pollinators and other insects would be beneficial; and
- The impact of land and other animal management in adjacent areas on insect populations must be considered when considering evolving these initiatives.

Recommendation:

- Data gathering to inform the development, delivery and monitoring of these initiatives broaden their foci to consider non-pollinating insects and organisms given their impactful role in agroecology.

We believe that direction of progress on both managed and native pollinators within the agroecology field is generally positive, but there are gaps in the information and understanding available that would allow us to form a more definite opinion.

Unlike the US, the UK does benefit strongly from a lesser degree of landscape-level monoculture and the maintenance of natural interspersed habitats such as hedgerows, crop edges, and fallow fields/rotation, and the benefits of these natural habitats have been well established. In addition, farmers are provided benefits for maintaining or restoring these types of natural habitats. Again, though, the focus often appears to be on pollinators rather than on pest-controlling species as well as other taxa (birds, mammals, non-pollinating insects, etc).

Greater parity in focus between managed pollinators such as honeybees and orchard bees and native pollinators, which we know are important to a large variety of crops such as those that are buzz-pollinated (which honeybees cannot pollinate normally), would be welcome.

We believe that the application of more diverse strategies for native pollinators than focusing just on flower strips (for example, nesting sites and other natural resources), will be critical.

For example, social wasps and hoverflies play a huge part in pest management by predating caterpillars and other pest species but receive comparatively very little funding due to their lack of 'charisma'. Similarly, there is a dearth of research on finding solitary specialist hunting wasps and parasitoids which might be useful for pest control – both in terms of attracting them to crop areas (nesting sites, etc) as well as breeding them at large scales for release (mostly parasitoids). Despite their importance, there is little data on parasitoid and solitary specialist hunting species' decline or improvement in the UK at all – as mentioned above, we lack data on non-charismatic but agriculturally important beneficial insects compared with butterflies and bees. How can we make informed decisions concerning these impactful species without this information?

Relevant to this topic is discussion of broader land management and management of animals for activities. For example, the loss of wetland habitats is a large concern given their role in flood management and as one of the most biodiverse habitat types on our planet.

Taken together, we should continue to build on our initial successes with these initiatives and look to understand the impact of these policies more thoroughly beyond the quite narrow focus on pollinators, noting the interactions between pollinating and non-pollinating insects, and other organisms. This flexibility should be reflected in how we review, analyse and adapt our policies through considering the multiplicity of confounding factors that impact these areas and recognising that no one solution will be the 'silver bullet'.

4. **Whether the threat to UK food security from insect decline receives sufficient cross-government priority; and**

Key Points:

- We welcome the increased government focus on food security and recognition of the complexity of this issue across departments;
- There have been numerous NGO- and landowner-delivered activities that have managed to impactfully manage insect decline; and
- Government should recognise that these solutions are complex and require multifactor solutions, and look to ensure its priorities are flexible enough to accommodate these conditions.

Recommendation:

- Government provide the information, coordination, policy flexibility, incentives and requirements, and, where appropriate, resources to landowners and users to manage insect decline.

We consider that UK research and the views of the UK public are well aligned towards protecting pollinators and native habitats and, as a consequence, preventing insect decline. There is less of a focus on protecting other species (with the exception, perhaps, of songbirds) or studying the impacts of agriculture on other aspects of ecological systems and their function, which may well be limiting the impact of initiatives as explored above.

The most impactful work in this space is driven by NGOs and forward-thinking landholders and farmers - a very bottom-up rather than top-down approach. This is not necessarily a bad thing as overall trends appear positive in terms of research and awareness, but more direct government intervention may be necessary to fill in the gaps of less "charismatic" species where these organisations are not having an effect. This would, as mentioned above, require a flexible, appropriately resourced, and well-evidenced approach, which necessitates government support to first catalyse and then deliver.

There are good examples of this type of working in research, such as the BRIGIT programme[4], a Strategic Priorities Fund hub (via BBSRC, NERC, Scottish Government and Defra) supporting nine projects delivered across twelve organisations to address bacterial threats to UK plants. The hub provided a clear focal point and defined a core with impactful with outcomes - such a hub could not have been formed without government support and is well-placed to fulfil this coordinating and resourcing role.

5. **Additional policy initiatives and solutions needed in the UK and internationally to reduce and reverse the trends in insect decline.**

Key Points & Recommendations:

- Options for Integrated Pest Management solutions should be explored with greater focus; and
- These issues are complex and international and we should continue to work across sectors and with other countries to understand and manage them.

There is a lower level of focus on IPM - Integrated Pest Management - than on pollinator work and we see less focus in policy on non-chemical means of managing pest insects, both those vectoring diseases and those causing solely feeding damage. The importance of IPM is recognised[5], but we encourage government to raise the profile of this impactful option.

Examples of these types of controls include utilising predator insects in the field; selecting crop varieties with natural or engineered resistance to pests; or intercropping with repellent crops. There are good examples where IPM is working well in the UK and these need to be nurtured and encouraged. For example, the Voluntary Initiative was set up specifically to promote IPM and reduce the impact of pesticides. Pesticides are expensive to buy and expensive and difficult to apply so farmers are always looking for alternatives. Hence disease resistant varieties are extremely sought after and popular especially (but not only) in horticulture. Such an approach is relevant as much in the UK as in the Global South countries - particularly sub-Saharan Africa, where, for example intercropping with repellent crops has proved successful in the growing of many food crops.

We should also look to improve coordination between conservation activities and food security. For example, wheat stem rust has the potential to impact 80% of current UK wheat lines. Barberry, the host plant of the threatened Barberry Carpet Moth, can act as an overwinter host of rust teliospores providing a source of rust. Shrub removal was undertaken to remove this risk to the detriment of the moth population, but recent research activities using citizen science and in collaboration with farmers and conservationists have allowed us to better understand the barberry population in Norfolk and manage this risk without impacting conservation activities.

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[4] BRIGIT (Xylella) – Bacterial Plant Diseases Programme

[5] Pests & Beneficials - BCPC British Crop Production Council : BCPC British Crop Production Council