







Surveillance and Monitoring: Insect Declines and Sensor Science

James Bell

Rothamsted Insect Survey







AFBI, 21st November 2019

The RIS: A Brief Introduction



- Operates both suction-trap and light-trap networks throughout UK which collect aphids, moths and other insects
- Hosts world's most extensive terrestrial invertebrate time series for academic study and policy development (1964-)
- Major role in reducing overuse of insecticides through 'aphid alerts' for targeted interventions
- Curates 100+ million insect samples into archive for genetic and whole organism research
- Detect and explain trends for policymakers, growers and conservation organisations



Suction Trap Network







37 traps. Red pins = longer running traps

Light Trap Network



insectsurvey.com Pests Aphid Bulletin | In... Rothamsted Inse... 0 X X insectsurvey.com insectsurvey.com 🖻 🕸 ⁴⁶ . 63% 🖨 09:53 Ш Cereals North England ROTHAMSTED Select your area Insect Survey RESEARCH 000000 The Insect Survey increased from last week 10 year mean reached The Insect Survey is host to a nationwide network of or exceeded light-traps and suction-traps that collect invaluable -57 number of aphids caught this week data on the migration of moths and aphids. 00 percentage of 10 year mean decreased from last week 000 00000000 0000000 000000 3 27 1 - Newcastle 000 •• • 1 - York 0000000000 21 2 000000000 1 - Preston 000000 Aphid Data The Aphid Bulletin is based on data from a network Moth Data of sixteen suction traps. The traps are emptied daily during the 'aphid season' and the aphids identified design/build 2018 🙄 design/build 2018 😳 design/build 2018 宽

Insect Declines

RESEARCH ARTICLE

More than 75 percent decline over 27 years in total flying insect biomass in protected areas

Caspar A. Hallmann , Martin Sorg, Eelke Jongejans, Henk Siepel, Nick Hofland, Heinz Schwan, Werner Stenmans, Andreas Müller, Hubert Sumser, Thomas Hörren, Dave Goulson, Hans de Kroon

Published: October 18, 2017 • https://doi.org/10.1371/journal.pone.0185809

Article	Authors	Metrics	Comments	Media Coverage				
*								
Abstract	Abstract							
Introduction	Global declines in insects have sparked wide interest among scientists, politicians, and the general public. Loss of insect diversity and abundance is expected to provoke cascading effects on food webs and to jeopardize ecosystem services. Our understanding of the extent and underlying causes of this decline is based on the abundance of single species or taxonomic groups only, rather than changes in insect biomass which is more relevant for ecological							
Materials and methods								
Results								
Discussion								
Supporting information	functioning. Here, we used a standardized protocol to measure total insect biomass using Malaise traps, deployed over 27 years in 63 nature protection areas in Germany (96 unique							
Acknowledgments	location-year combinations) to infer on the status and trend of local entomofauna. Our analysis estimates a seasonal decline of 76%, and mid-summer decline of 82% in flying insect biomass over the 27 years of study. We show that this decline is apparent regardless of habitat type, while changes in weather land use, and habitat characteristics cannot explain this overall							
References								
Reader Comments (25)	decline. This yet unrecognized loss of insect biomass must be taken into account in evaluating declines in abundance of species depending on insects as a food source, and ecosystem functioning in the European landscape							
Media Coverage (42)								
Figures	incloning in the	e Europour fundocupo.						
	Figures							



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EXPRESS Home of the Daily and Sunday Express

NEWS

SHOWBIZ & TV SPORT COMMENT FINANCE OBITUA

PLOS ONE Submit by December 12 , 2019

UK WORLD POLITICS ROYAL NATURE WEATHER SCIENCE WEIRD HISTORY Super-moth INVASION: Mutant insects to attack crops as numbers **EXPLODE**

AN INVASION of super-moths which attack crops including cabbages and cauliflowers are expected to arrive in Britain from eastern Europe.

By KATIE MANSFIELD

HOME

PUBLISHED: 17:08, Wed, Jun 15, 2016 | UPDATED: 17:14, Wed, Jun 15, 2016



RIS: Declines Science

Journal of Animal Ecology



Insect Conservation and Diversity (2009) 2, 251-260

doi: 10.1111/j.1752-4598.2009.00062.x

Journal of Animal Ecology 2015, 84, 21-34

doi: 10.1111/1365-2656.12282

Long-term phenological trends, species accumulation rates, aphid traits and climate: five decades of change in migrating aphids

James R. Bell^{1*}, Lynda Alderson¹, Daniela Izera¹, Tracey Kruger¹, Sue Parker¹, Jon Pickup², Chris R. Shortall¹, Mark S. Taylor¹, Paul Verrier¹ and Richard Harrington¹

¹Department of AgroEcology, Rothamsted Research, West Common, Harpenden AL5 2JQ, UK; and ²SASA, Roddinglaw Road, Edinburgh EH12 9FJ, UK

Journal of Animal Ecology	BRITISH Ecological Society
Journal of Animal Ecology 2017, 86, 337-347	doi: 10.1111/1365-2656.12622

The long-term population dynamics of common wasps in their native and invaded range

Philip J. Lester*,1, John Haywood², Michael E. Archer³ and Chris R. Shortall⁴

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Rapid declines of common, widespread British moths provide evidence of an insect biodiversity crisis

Kelvin F. Conrad^{a,*}, Martin S. Warren^b, Richard Fox^b, Mark S. Parsons^a, Ian P. Woiwod^a

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CHRIS R. SHORTALL, ALISON MOORE, EMMA SMITH, MIKE J. HALL, IAN P. WOIWOD and RICHARD HARRINGTON Plant and Invertebrate Ecology Department, Rothamsted Research, Harpenden, Hertfordshire, UK

Journal of Insect Conservation (2019) 23:369–380 https://doi.org/10.1007/s10841-019-00135-z

ORIGINAL PAPER

Check for updates

Trends and indicators for quantifying moth abundance and occupancy in Scotland

E. B. Dennis^{1,2} · T. M. Brereton¹ · B. J. T. Morgan² · R. Fox¹ · C. R. Shortall³ · T. Prescott¹ · S. Foster⁴

Received: 14 January 2019 / Accepted: 31 January 2019 / Published online: 5 April 2019 © The Author(s) 2019





State of Nature 2016

onture







Media



AGR = Annual Growth Rate (the average percentage change in abundance from year-to-year), Total % Change = The estimated change in population from 1967 to 2016. Figures in brackets are the 95% Confidence Intervals (CI) on these estimations. (Note, these graphs are on a log scale).

These graphs present expected counts and trends for 432 abundant moth species caught in Rothamsted light-traps between 1967-2016.

Aphid Trends

Total number of sites studied was 25 (9 to 48 years) between 1969-2016 - 16,447,869 individual aphids



Moth Trends

Total number of sites studied was 112 (9 to 48 years) between 1969-2016 - 7,593,437 individual moths





Moth biomass increases and decreases over 50 years in Britain

Callum J. Macgregor, Jonathan H. Williams, James R. Bell & Chris D. Thomas







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iMT

Moth populations in steady decline in Britain, study finds

Long-running survey finds 1976 heatwave boom has been followed by dropping numbers



▲ The elephant hawk-moth has declined by 11% over the last 50 years, according to Rothamsted Insect Survey data. Photograph: Callum Macgregor



Dan Blumgart

Dan Blumgart: The mechanisms behind moth declines (Envision DTP) Lancaster



Background:

- Moth populations have suffered large declines in the UK and elsewhere in Europe since the 1960s.
- Agricultural intensification is thought to be the main cause.

Questions:

- Which aspects of agricultural change have had the most impact on moth populations?
- Can agri-environment scheme field margins mitigate the decline in moths?
- How important are nectar resources for moth fecundity?

Methods:

- Field experiments surveying moths in different treatments of field margin
- Analysis of existing RIS data measuring population trends against land-use
- Nectar-limitation experiments on captive-reared moths





•Ishbel Hayes - Flight-to-light and the decline in British moths. SW-Bio DTP with Exeter (2019-23)

But some are doing well......



Frontiers of Biogeography

the scientific journal of the International Biogeography Society

Bucking the trend: the diversity of Anthropocene 'winners' among British moths

Douglas H. Boyes^{1,*}, Richard Fox², Chris R. Shortall³ and Robert J. Whittaker^{1,4}

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Abstract

An appreciation of how some species are becoming more common despite unprecedented anthropogenic pressures could offer key insights for mitigating the global biodiversity crisis. Research to date has largely focused on declining species, while species that are becoming more common have received relatively little attention. Macro-moths in Great Britain are well-studied and species-rich, making them an ideal group for addressing this knowledge gap. Here, we examine changes in 51 successful species between 1968 and 2016 using 4.5 million occurrence records and a systematic monitoring dataset. We employ 3D graphical analysis to visualise long-term multidimensional trends in prevalence (abundance and range) and use vector autoregression models to test whether past values of local abundance are useful for predicting changes in the extent of occurrence. The responses of Anthropocene winners are heterogeneous, suggesting multiple drivers are responsible. Changes in range and local abundance frequently occur intermittently through time, demonstrating the value of long-term, continuous monitoring. There is significant diversity among the winners themselves, which include widespread generalists, habitat specialists, and recent colonists. We offer brief discussion of possible causal factors and the wider ecosystem implications of these trends.

Highlights

- Trends in abundance and occurrence are described for 51 British macro-moths that have become more common, using data from two long-term recording schemes
- We expected to find evidence of range expansion in years following high abundance, but this was supported for only six species
- Nine species showed instantaneous correlation between local abundance and range extent, likely driven by increased detectability in range margins
- Among British moths, successful species ('winners') are ecologically diverse and include habitat specialists
- Changes in abundance and range size seldom occur smoothly, frequently being non-linear and sometimes non-monotonic
- Long-term monitoring of multiple facets of rarity (e.g. abundance, range) is necessary to comprehensively assess changes in prevalence.



Figure 6. Hostplant associations of the 51 species of successful British moths examined in this study. Only ten

Conclusions

Aphids



- Not in significant decline and it's not logical to apply standard decline theory to this group
- The concept of outbreak with interannual variation is perhaps more appropriate



- Significant decline since turning point of 1980s long term linear decline -28%, but this too is variable between years
- Not all habitats are recording a significant downward trend, only in coastal, urban, moorland and woodland is this apparent.

Insect Senors

Counting Insects Using Laser Sensors





Particle Light Scattering Sensor to Detect Bioflow



Prototype II now installed in experimental suction-trap. Data transfer to webpage for real-time reporting enabled



Aphid Data Moth Data Media Impact About Contact

Live Insect Biomass Data

Welcome

In collaboration with the Centre for Atmospheric and Instrumentation Research, University of Hertfordshire, a live feed using state-of-the-art lasers is provided showing total insect biomass changes over time.

This research is supported by the Smart Crop Protection (SCP) strategic programme (BBS/OS/CP/000001) lunded through Biotechnology and Biological Sciences Research Council's Industrial Strategy Challenge Fund.



-- Live Feed -his data will be available in 2019

Receiver array Infrared LED Emitter



Candlestick Sensor



Mean Spectra: Fundamental and Harmonic Wingbeat Frequencies



File: F180524_171321_005_G_050_T_28.7_H_41.4

File: F180620 210705 100 G 080 T 29.3 H 44.3

File: F180605 121527 101 G 080 T 27.3 H 40.4.wav

Elements of the signal are distinguishable and could be combined for classification

Fundamental Frequency (wingbeat)



Dominant Frequency (loudest frequency)



Bioacoustic Index (the area under the curve)



 to construct a reasonable classification trees we need **both** frequency spectra and extracted characteristics of the audio and spectra

Taking sequencing to the field





Genomic Surveillance

Cryptic species, host strains, real-time field methods



- 18 new mitochondrial aphid genomes assembled and annotated
- A LAMP assay to detect barley yellow dwarf viruses (BYDV) complete.
- PopGen analysis of BYDV vector over UK

Pests





Credits: McEvey 2017



Smart Armyworm Surveillance (SAS)

James Bell

Head of Rothamsted Insect Survey



Dr Aislinn Pearson ENTOMOLOGIST MIGRATION BIOLOGIST





Dr Subbi Subramanian ENTOMOLOGIST INSECT PATHOLOGY











The Fall Armyworm *Spodoptera frugiperda*

- Native to Americas
- Highly migratory
- >200 host plants
- African yield losses up to 20 million tonnes pa (CABI 2017)
- Estimate value of losses is \$11.5 billion pa
- Resistant to many pesticides and GM crops





© MATT BERTONE 2014



Actual monitoring across all the primary agricultural zones of Kenya

Hypothetical design







Digital Pheromone Traps: Ground distribution and reproductively active populations

- Local weather data (temp. & humidity)
- Extensively used in US and Europe for FAW
- Image detection algorithm
- Fully automated and operated remotely
- Specialists validating trap catches

The Fall Armyworm Spodoptera frugiperda The False Armyworm Leucania loreyi





Location name:Private Farm, Device:S04539 Embu (KALRO)

• Jump to date ▼ IMAGES 18.04.2019 20.04.2019 02:01:00 21.04.2019 02:05:00 17.04.2019 23:01:00 19.04.2019 02:01:00 22.04.2019 02:05:00 23.04.2019 02:05:00 $\langle \langle \rangle$ Pest by temperature chart Degree days





Jump to

Accumulated Pest Pressure







🖻 🕏 📲 👙 🔐 87% 🛢 17:36

15:14

11:43

0

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Obsidentify Farm Netw... Aislinn Moby, Dan, Dickens, Smar...

catch in the entire Kisumu.

1 JULY 2019

SmartArmyworm RRES Hi All,

FAW catches for this weekend and this morning

Saturday 29th June Mbita: 4 Embu: 1 Nakuru: 4

Sunday 30th June ICIPE Nairobi: 1 Nakuru: 1

Monday 1st July Mbita: 5 Embu: 2

TODAY +254 722 613765 ~Allan Metho Type a message





Smart Armyworm @SmartArmyworm

A smart monitoing project for #FallArmyworm in Africa. Implemented by ICIPE and Rothamsted Research, funded by the Bill and Melinda Gates Foundation.

Kenya
Joined March
Joined
Joined March
Joined March
Joined Mar

72 Following 97 Followers

Tweets & replies Tweets

Media Likes



CABI Invasives @CABI_Invasives · 2d 🗸 ▶ Watch: Fall Armyworm Life Cycle

***** #Fallarmyworm is a major #invasive pest with a voracious appetite; its ability to spread and reproduce quickly is one











App: Nondo

Automatic identification of adults and larvae through computer vision/ML

- More than 980 images were sourced
- 20 species of moth (adults and larvae) for maize
- Algorithm improved to 83% of accuracy overall rising to 95% for training images (ca. 100)













More information

https://www.plantwise.org/KnowledgeBank /datasheet/29810

IN DOUBT? ADD A PHOTO	SAVE OBSERVATION
	NEW IDENTIFICATION

IMAGE ©MATT BERTONE

Rothamsted Insect Survey





Acknowledgements

The Rothamsted Insect Survey, a National Capability, is funded by the Biotechnology and Biological Sciences Research Council under the Core Capability Grant BBS/E/C/000J0200.

I acknowledge use of photos from the internet and collaborators, particularly <u>http://influentialpoints.com/</u> under a Creative Commons Attribution 3.0 Unported License

Twitter:@Rothamsted_RIS

http://www.rothamsted.ac.uk/insect-survey

