Unravelling the Ecology of Non-native Species to inform strategy

Helen Roy and many more
Non-Native Species

Henosepilachna argus

Species introduced (aided by humans) outside native range
Invasive Non-Native Species

Non-Native Species that threatens biodiversity, ecosystems or the way we live

Harmonia axyridis
Non-Native Species in Europe

The problem: rate of invasion of alien species is increasing, and so are the associated costs to society, the economy and biological diversity.

INNS cost Europe

>12 billion € / year
(based on documented impact of 125 IAS out of over thousand considered as invasive in Europe)
Hottentot fig...home and away
Hottentot fig...home and away
INNS cost Europe

>12 billion € / year

(based on documented impact of 125 IAS out of over thousand considered as invasive in Europe)
No saturation in the accumulation of alien species worldwide

Hanno Seebens et al.

ARTICLE

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DOI: 10.1038/ncomms14435

Abstract

A major problem in invasion biology is the prediction of future invasions and the saturation of alien species in existing communities. Here, we estimate the likely number of alien species that will invade different parts of the world in the next few decades. We find that the total number of alien species that will invade the world is currently growing exponentially. This is due to a combination of increasing human-mediated transport and climate change, which are driving the invasion of new regions. Our results suggest that the number of alien species invading the world will continue to grow until at least 2100, with an estimated number of 15,900 species by that time. This is significantly higher than previous estimates, which predicted that the number of alien species would saturate by the year 2050. Our results highlight the urgent need for further research on the impacts of alien species on native ecosystems and the development of effective strategies to mitigate their negative effects.

Methodology

We used a combination of expert judgement and statistical analysis to estimate the number of alien species that will invade the world in the next few decades. We also considered the effects of climate change on the invasion process and the impact of human-mediated transport on the distribution of alien species.

Results

Our results show that the number of alien species invading the world is currently growing exponentially. This is due to a combination of increasing human-mediated transport and climate change, which are driving the invasion of new regions. We estimate that the total number of alien species that will invade the world is currently growing by approximately 19% per year. Our results suggest that the number of alien species invading the world will continue to grow until at least 2100, with an estimated number of 15,900 species by that time. This is significantly higher than previous estimates, which predicted that the number of alien species would saturate by the year 2050.

Conclusions

Our results highlight the urgent need for further research on the impacts of alien species on native ecosystems and the development of effective strategies to mitigate their negative effects. We also emphasize the importance of integrating invasion biology with climate change and human-mediated transport research to better understand the drivers of alien species invasion and to develop effective strategies to prevent their negative impacts.
25% of first records during 2000–2005 were of species that had not been previously recorded anywhere as alien.
Global threats from invasive alien species in the twenty-first century and national response capacities

Regan Early¹, Bethany A. Bradley², Jeffrey S. Dukes³,⁴, Joshua J. Lawler⁵, Julian D. Olden⁶, Dana M. Blumenthal⁷, Patrick Gonzalez⁸,⁹, Edwin D. Grosholz¹⁰, Ines Ibañez¹¹, Luke P. Miller¹², Cascade J.B. Sorte¹³ & Andrew J. Tatem¹⁴,¹⁵,¹⁶

Invasive alien species (IAS) threaten human livelihoods and biodiversity globally. Increasing globalization facilitates IAS arrival, and environmental changes, including climate change, facilitate IAS establishment. Here we provide the first global, spatial analysis of the terrestrial threat from IAS in light of twenty-first century globalization and environmental change, and evaluate national capacities to prevent and manage species invasions. We find that one-sixth of the global land surface is highly vulnerable to invasion, including substantial areas in developing economies and biodiversity hotspots. The dominant invasion vectors differ between high-income countries (imports, particularly of plants and pets) and low-income countries (air travel). Uniting data on the causes of introduction and establishment can improve early-warning and eradication schemes. Most countries have limited capacity to act against invasions. In particular, we reveal a clear need for proactive invasion strategies in areas with high poverty levels, high biodiversity and low historical levels of invasion.

Early et al (2016) Nature Communications DOI: 10.1038/ncomms12485
Global trade networks are the key to distribution of invasive non-native species.

Scientists at the Centre for Ecology & Hydrology (CEH) have conducted an analysis of invasive non-native species occurrence in 48 countries to show that global trade networks play a key role in the distribution of invasions across Europe.

The CEH team of Dr Daniel Chapman, Dr Beth Purse, Professor Helen Roy and Professor James Bullock looked at more than 420 non-native plant pest species – including 173 invertebrates, 166 pathogens and 83 plants – to show that invasion was strongly linked to agricultural imports from countries in which the focal species were present.

The scientists used sophisticated statistical models to consider trade in all agricultural products, as well as live plants, forest products, fruit and vegetables and seeds. This showed that invasion was more strongly linked to the structure of global trade networks than to other possible ways in which the species could be spread, such as by airline routes or simply through geographic proximity.

Documenting invasions in Britain - GBNNSIP
Scorecard 2017 for Great Britain

• 1506 established non-native plants
• 469 established non-native animals
• 273 established non-native species designated as having negative ecological or human impact:
  – 101 (6.7%) established non-native plants
  – 172 (36.7%) established non-native animals

Roy et al. (2014) Biological Invasions; Roy et al. (2017) Tracking changes in the introduction and distributions of non-native species in Great Britain. Final Report - Defra
B6 Invasive Non-Native Species

UK Biodiversity Indicators 2017

![Image of diverse wildlife including birds, butterflies, bees, and plants]

Bar chart showing the number of species in different habitats and time periods:
- **Freshwater**
- **Marine (Coastal)**
- **Terrestrial**

Data for Great Britain.

Logos of CEH (Centre for Ecology & Hydrology), JNCC (Joint Nature Conservation Committee), and NERC (Natural Environment Research Council).
Horizon scanning for invasive alien species with the potential to threaten biodiversity in Great Britain

HELEN E. ROY¹, JODEY PEYTON¹, DAVID C. ALDRIDGE², TRISTAN BANTOCK³, TIM M. BLACKBURN⁴, ROBERT BRITTON⁶, PAUL CLARK⁷, ELIZABETH COOK⁸, KATHARINA DEHNEN-SCHMUTZ⁹, TREvor DINES¹⁰, MICHAEL DOBSON¹¹, FRANÇOIS EDWARDS¹, COLIN HARROWER¹, MARTIN C. HARVEY¹², DAN MINCHIN¹³, DAVID G. NOBLE¹⁴, DAVE PARROTT¹⁵, MICHAEL J. O. POCOCK¹, CHRIS D. PRESTON¹, SUGOTO ROY¹⁵, ANDREW SALISBURY¹⁶, KARSTEN SCHÖNROGGE¹, JACK SEWELL¹⁷, RICHARD H. SHAW¹⁸, PAUL STEBBING¹⁹, ALAN J. A. STEWART²⁰ and KEVIN J. WALKER²¹

¹Centre for Ecology & Hydrology, Wallingford OX10 8BB, UK, ²Aquatic Ecology Group, Department of Zoology, University of Cambridge, Cambridge CB2 3EJ, UK, ³British Bugs, 101 Crouch Hill, London N8 9RD, UK, ⁴Institute of Zoology, Zoological Society of London, Regent’s Park, London NW1 4RY, UK, ⁵Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, Stellenbosch, South Africa, ⁶University of Bournemouth, Poole BH12 5BB, UK, ⁷Aquatic Invertebrates Division, Department of Life Sciences, The Natural History Museum, Cromwell Road, London SW7 5BD, UK, ⁸Scottish Marine Institute, Oban, Argyll, PA37 1QA, UK, ⁹Centre for Agroecology and Food Security, Coventry University, Priory St, Coventry CV1 5FB, UK, ¹⁰PlantLife, Uned 14, Llys Castan, Parc Menai, Bangor LL57 4FD, UK, ¹¹APEM Ltd., The Technopole Centre, Midlothian EH26 0PJ, UK, ¹²Department of Environment, Earth and Ecosystems, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK, ¹³Marine Organism Investigations Killaloe, Co Clare, Ireland, ¹⁴British Trust for Ornithology, Thetford
GB Top 10 – Asian hornet

*Vespa velutina*

Terrestrial predator

Native to China

Arrived in pottery consignment Bordeaux, France in 2004
Asian hornet – arrived September 2016

Eradicated in 2016 and 2017
GB Top 20 - Argentine ant

*Linepithema humile*

Ecosystem engineer
Engaging people in surveillance and monitoring
Alien Alerts

- Biological record
- Database
- Expert verifier
  - Yes: Record verified?
  - No: Stakeholders informed
- Stakeholders informed
- Action
Asian Hornet Watch

Learn more about Asian hornet and help detect it by recording suspected sightings.

- Species Info
- Record
- App Info

Asian hornet

European hornet

Giant Woodwasp / Greater Horntail

Asian hornet

*Vespa velutina*

**Flight period**

- Jan
- Feb
- Mar
- Apr
- May
- Jun
- Jul
- Aug
- Sep
- Oct
- Nov
- Dec

**Size**

- Queen: up to 30mm long
- Worker: up to 25mm long

**Legs**

- Yellow at ends contrasting with dark upper parts

**Abdomen**

- Dark brown / black with a yellow/orange band on 4th segment

**Head**

- Dark from above, orange from the front

**Antennae**

- Dark coloured
Non-Native Species Alerts

![Graph showing the number of reports received from 2010 to 2017. The graph displays the trend of reports received through different channels: Email, Online form, App, and Total. The number of reports shows a significant increase from 2010 to 2017.](image-url)
A system to address invasive alien species should be underpinned by a centralised information system collating the existing information on alien species in the Union and allowing access to information on the presence of species, their spread, their ecology, invasion history and all other information necessary to underpin policy and management decisions and allowing also the exchange of best practices.
COMMISSION IMPLEMENTING REGULATION (EU) 2016/1141

of 13 July 2016

adopting a list of invasive alien species of Union concern pursuant to Regulation (EU) No 1143/2014 of the European Parliament and of the Council

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Developing the list of IAS of Union concern on the prevention and management of the introduction and spread of invasive alien species (1), and in particular of Article 4(1) thereof,

Prioritising species for risk assessment

**Figure 1**: Selection of the proposed list of ten species for risk assessment highlighting the process leading from expert group prioritisation and finally across group prioritisation. A crude scoring process (documented in final report of ENV.B.2/ETU/2014/0016) was used to rank the species into broad risk categories and then other criteria were used to produce the final proposed list including current distribution, practicalities and effectiveness of management.

<table>
<thead>
<tr>
<th>Species</th>
<th>Proposed list of 10 species for risk assessment</th>
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<tbody>
<tr>
<td>Pterois miles (Bennett, 1828)</td>
<td>devil firefish, lion fish</td>
</tr>
<tr>
<td>Penaeus aztecus lves, 1891</td>
<td>brown shrimp</td>
</tr>
<tr>
<td>Heterotis argyrostomus (Thunberg, 1797)</td>
<td>striped red catfish</td>
</tr>
<tr>
<td>Solea parva (Bory de St. Vincent, 1817)</td>
<td>e green algae</td>
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<tr>
<td>Batrachoceridae giganteum (Nyl., 1849)</td>
<td>tanicete</td>
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<tr>
<td>Thoruss volitans (Linnaeus, 1758)</td>
<td>lion fish</td>
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<tr>
<td>Creptida ornata Goosery 1, 1824</td>
<td>Onyx slippernail</td>
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<tr>
<td>Myliobatus sallei (Rudol, 1846)</td>
<td>black striped murrel</td>
</tr>
<tr>
<td>Pseudonamia anomala Gravier, 1900</td>
<td>a sea worm</td>
</tr>
<tr>
<td>Charybdis japonica (A. Milne-Edwards, 1851)</td>
<td>Asian paddle crab</td>
</tr>
<tr>
<td>Pteraeus volitans (Linnaeus, 1758)</td>
<td>Asian Green Mussel</td>
</tr>
<tr>
<td>Potanakorba inermans (Schrenck, 1861)</td>
<td>Asian basket clam</td>
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<tr>
<td>Muraenichthys schlegeli Kliemensperger, 1872</td>
<td>offshore hydroid</td>
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<td>common kingsnake</td>
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<td>Acrothoeres tristis</td>
<td>common myna</td>
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<tr>
<td>Acrotrachis ocellata</td>
<td>Chital</td>
</tr>
<tr>
<td>Chrysemys picta</td>
<td>painted turtle</td>
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<td>Trachysurus subrubra</td>
<td>common bush tail possum</td>
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<td>Aper rufescens</td>
<td>snake bark maple</td>
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<tr>
<td>Macanthus silvestris</td>
<td>Chinese silver grass</td>
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<tr>
<td>Pteropus petra</td>
<td>Mexican weeping pine</td>
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<tr>
<td>Melococcus polydactylum</td>
<td>Himalayan knobbled</td>
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<td>Plotosus heterophyllus</td>
<td>mummichog</td>
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<tr>
<td>Breunichsia mimosaebraci</td>
<td>Nosiambique tilapia</td>
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<td>Dicrocephalus eurus</td>
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<td>Morone saxatilis</td>
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<tr>
<td>Neivilea mecopeplus</td>
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<tr>
<td>Solenopsis richteri</td>
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Minimum standards for risk assessment

- Evidence for ecosystem service impacts
- Consideration of climate change
- Socio-economic impacts

1. Basic species description and overview
2. Likelihood of invasion
3. Likelihood of invasion
4. Assessment of introduction pathways
5. Assessment of impacts on biodiversity and ecosystems
6. Assessment of impacts on ecosystem services
7. Assessment of socio-economic impacts
8. Consideration of status (threatened or protected) of species or habitat under threat
9. Data limitations
10. Documents information sources
11. Provides a summary in a consistent and interpretable form
12. Includes uncertainty
13. Includes quality assurance
Thinking about pathways

a) Taxonomic groups
- Other alien species

High-impact IAS

b) Environments
- Other alien species

High-impact IAS

Just published: Guide to Pathway Terminology (European Commission)
Variation in the importance of pathways

Crossing Frontiers in Tackling Pathways of Biological Invasions

FRANZ ESSL, SVEN BACHER, TIM M. BLACKBURN, OLAFL BOYD, GIUSEPPE BRUNEL, ANA-CRISTINA CARDOSO, RENE ESCHEN, BELINDA GALLARDO, BELLA GALIL, EMILY GARCIA-BERTHOU, PIERO GENOVESI, QUENTIN GROOM, COLIN HARROWER, PHILIP E. HULME, STELIOIS KATSANEVAKIS, MARC KENIS, INGOLF KÜHN, SABRINA KUMSCHICK, ANGELIKI F. MARTINOU, WOLFGANG NENTWIG, COLETTE O’FLYNN, SHYAMA PAGAD, JAN PERGL, PETR PYŠEK, WOLFGANG RABITSCH, DAVID M. RICHARDSON, ALAIN ROQUES, HELEN E. ROY, RICCARDO SCALERA, STEFAN SCHINDLER, HANNO SEEBENS, SONIA VANDERHOVEN, MONTSERRAT VILÀ, JOHN R. U. WILSON, ARGYRO ZENETOS, AND JONATHAN M. JESCHKE

Substantial progress has been made in understanding how pathways underlie and mediate biological invasions. However, key features of their role in invasions remain poorly understood, available knowledge is widely scattered, and major frontiers in research and management are insufficiently characterized. We review the state of the art, highlight recent advances, identify pitfalls and constraints, and discuss major challenges in four key fields of pathway research and management: pathway classification, application of pathway information, management response, and management impact. We present approaches to describe and quantify pathway attributes (e.g., spatiotemporal changes, proxies of introduction effort, environmental and socioeconomic contexts) and how they interact with species traits and regional characteristics. We also provide recommendations for a research agenda with particular focus on emerging (or neglected) research questions and present new analytical tools in the context of pathway research and management.

Keywords: alien species, impact, management, propagule pressure, temporal trends

Likely pathways of arrival for EU horizon scanning species

Pathway of arrival

- RELEASE IN NATURE
- TRANSPORT – STOWAWAY
- TRANSPORT CONTAMINANT
- ESCAPE FROM CONFINEMENT
- CORRIDOR
- UNAIDED

Number of species

- MEDIUM
- HIGH
- VERY HIGH
UK Ladybird Survey
www.ladybird-survey.org
Engaging people in non-native species ecology
Surveillance and monitoring invasions

Harmonia axyridis
Impacts of harlequin ladybirds
Escape from parasitism by the invasive alien ladybird, *Harmonia axyridis*

RICHARD F. COMONT,¹,² BETHAN V. PURSE,¹ WILLIAM PHILLIPS,³ WILLIAM E. KUNIN,⁴ MATTHEW HANSON,⁴ OWEN T. LEWIS,² RICHARD HARRINGTON,⁵ CHRISTOPHER R. SHORTALL,⁵ GABRIELE RONDONI⁶ and HELEN E. ROY¹ ¹NERC Centre for Ecology & Hydrology, Oxfordshire, UK, ²Department of Zoology, University of Oxford, Oxford, UK, ³4 Archer Close, Gorse Meadow, Loughborough, UK, ⁴School of Biology, Faculty of Biological Sciences, University of Leeds, Leeds, UK, ⁵Rothamsted Insect Survey, Department of AgroEcology, Rothamsted Research, Harpenden, UK and ⁶Department of Agricultural and Environmental Sciences, University of Perugia, Perugia, Italy

**Abstract.** Alien species are often reported to have lower parasitism as compared with native species. The harlequin ladybird, *Harmonia axyridis* alien to Britain, provides a model system for investigating the evolutionary implications of escape from natural enemies (predators, parasites and pathogens) compared with native species.

1. Alien species often report to perform better than functionally similar species native to the invaded range, densities, and a tendency to become invasive. The escape hypothesis (ERH) explains the success of invasive alien species by reduced mortality from natural enemies (predators) compared with native species. The harlequin ladybird, *Harmonia axyridis*, a species alien to Britain, provides a model system for investigating the evolutionary implications of escape from natural enemies (predators, parasites and pathogens).

2. Pupae of *H. axyridis* and the native ladybird, monitored for parasitism between 2008 and 2011, in England in areas first invaded by *H. axyridis* between 2008 and 2009. In addition, a semi-field experiment was established to test parasitism of adult *H. axyridis* and *C. septempunctata*.

3. *Harmonia axyridis* pupae were parasitised at a much lower rate than conspecifics in the native range, and both pupae and adults were parasitised at a lower rate than *C. septempunctata* pupae in the same place and time. *H. axyridis* (2–7%) was found to affect the parasitism rate of *C. septempunctata* (18%) and adult *H. axyridis* (2–7%).

4. Our results are consistent with the general prediction that the prevalence of parasitism is lower for introduced species than native species. This may partly explain why *H. axyridis* is such a successful IAS.

**Keywords.** *Coccinella septempunctata*, enemy releasing alien species, parasitism, natural enemies.
## Ten years of invasion in Britain

<table>
<thead>
<tr>
<th>Prediction</th>
<th>Evidence</th>
<th>References</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eurytopic nature of <em>H. axyridis</em> will contribute to rapid spread</td>
<td>The range of host plant associations and widespread distribution of <em>H. axyridis</em> in the UK reflects the eurytopic nature of this species although coniferous woodlands may negatively affect the spread of <em>H. axyridis</em>.</td>
<td>(Brown et al., 2008b, Brown et al., 2011a)</td>
<td>+</td>
</tr>
<tr>
<td>Climatic adaptability of <em>H. axyridis</em> will give it a competitive advantage over some of the more niche-specific native ladybirds</td>
<td>Climatic conditions have not been a barrier to the colonization and spread of <em>H. axyridis</em> in southern Britain, but are speculated to have limited its abundance in northern England and in Scotland. There are clear discrepancies between the observed and predicted (climate model) distributions of <em>H. axyridis</em>, it is apparent that climate is an important factor in determining the spread of this species but alongside other interacting biotic and abiotic factors.</td>
<td>(Purse et al., 2014, Comont et al., 2012)</td>
<td>+/?</td>
</tr>
<tr>
<td>Maritime climate of Britain will allow <em>H. axyridis</em> to breed throughout the summer, with no requirement for a summer dormancy</td>
<td>Continual breeding of this species is apparent and at least two generations of <em>H. axyridis</em> have been observed each year since arrival. Multivoltinism contributes to the rapid rate of population growth of <em>H. axyridis</em> each year and consequently spread.</td>
<td>(Brown et al., 2008b, Roy et al., 2011a)</td>
<td>+</td>
</tr>
<tr>
<td>Phenotypic plasticity will allow <em>H. axyridis</em> to successfully and regularly extend its breeding season to September, October, and even into November</td>
<td>Phenotypic plasticity displayed by <em>H. axyridis</em> enables local adaptation at temporal and spatial scales, increase in autummal melanisation may have accelerated the spread of <em>H. axyridis</em>. Further work required to elucidate the importance of phenotypic plasticity in the invasion success of <em>H. axyridis</em>.</td>
<td>(Michie et al., 2010, Purse et al., 2014)</td>
<td>?</td>
</tr>
<tr>
<td><em>H. axyridis</em> will spread across the entire British mainland by 2008</td>
<td>The first record of <em>H. axyridis</em> in Scotland was in 2007. However, there are relatively few records in Scotland and its distribution and breeding there is limited.</td>
<td>(Roy et al., 2011a, Brown et al., 2008b, Brown et al., 2011a)</td>
<td>+</td>
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**Ecological Entomology** (2015), 40, 326–348

DOI: 10.1111/een.12863

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**Invited Review**

**Ten years of invasion: Harmonia axyridis (Pallas) (Coleoptera: Coccinellidae) in Britain**

**HELEN E. ROY** and **PETER M. J. BROWN**

Centre for Ecology & Hydrology, Natural Environment Research Council, Oxfordshire, U.K.
Going global…

Rapid spread of *Harmonia axyridis* in Chile and its effects on local coccinellid biodiversity

Audrey A. Grez1, Tania Zaviezo2, Helen E. Roy2, Peter M. J. Brown3 and Gustavo Bizama3

Lessons from lady beetles: accuracy of monitoring data from US and UK citizen-science programs

Mary M. Gardiner2, Louis L. Allard5, Peter M.J. Brown1, John E. Losey1, Helen E. Roy3, and Rebecca Rice Smyth5

Citizen scientists have the potential to play a crucial role in the study of rapidly changing lady beetle (*Harmonia axyridis*) populations. We used data derived from three coccinellid-focused citizen-science programs to examine the costs and benefits of data collection from direct citizen-science data (data used without verification) and verified citizen-science data (verified data provided by trained experts) programs. Data collected through direct citizen science overestimated species richness and diversity values in comparison to verified data, thereby influencing interpretation. The use of citizen scientists to collect data also influenced research costs; our analysis shows that verified citizen science was more cost-effective than traditional science (in terms of data gathered per dollar). The ability to collect a greater number of samples through direct citizen science may compensate for reduced accuracy, depending on the type of data collected and the type(s) and extent of errors committed by volunteers.

Insect Conservation and Diversity

Long-term changes in communities of native coccinellids: population fluctuations and the effect of competition from an invasive non-native species

ALOIS HONEY,1 ZDENKA MARTINCOVA,1 ANTHONY F. G. DIXON,2 HELEN E. ROY3 and STANO PEKAŘ4 1Department of Biodiversity Research, Global Change Research Centre AS CR, Brno, Czech Republic, 2Crop Research Institute, Prague, Czech Republic, 3NERC Centre for Ecology & Hydrology, Wallingford, UK and 4Department of Botany and Zoology, Faculty of Sciences, Masaryk University, Brno, Czech Republic

The harlequin ladybird, *Harmonia axyridis*: global perspectives on invasion history and ecology


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SCIENCE OF THE ENVIRONMENT
SHORT COMMUNICATION

In the shadow of the condor: invasive *Harmonia axyridis* found at very high altitude in the Chilean Andes

AUDREY A. GREZ,¹ TANIA ZAVIEZO,² HELEN E. ROY,³ PETER M. J. BROWN¹ and BERNARDO SEGURA¹

¹Facultad de Ciencias Veterinarias y Pecuarias, Universidad de Chile, Santiago, Chile, ²Facultad de Agronomía e Ingeniería Forestal, Pontificia Universidad Católica de Chile, Santiago, Chile, ³Centre for Ecology & Hydrology, Wallingford, UK and ⁴Animal & Environment Research Group, Anglia Ruskin University, Cambridge, UK

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…unravelling ecology together…
**HEATHER LADYBIRD**  **Harmonia conformis**

**Identification**

Adult
- Length: 4-4.5mm
- Background colour: Black
- Patterned body
- Number of spots: 2-6 (10)
- Small palisade setae
- Other colour forms: None
- Proventriculus: Black
- Leg colour: Black
- Other features: Distinct ring around the edge of the elytra.

**Habitat**

The Heather Ladybird is commonly found on heathland, but there are also a number of coastal records from dune systems and scrub where it is found on shrubs such as Buckland, Bramble and Gorse and also on trees including silver birch and Scots pine. An increasing number of reports on the species have been associated with Sylph Cynine, a small scale insect canker beetle.

**Range**

Historically, this species has been limited to England with records in Wales and across Ireland. However, recent records from Scotland suggest it is spreading northwards.

**National conservation status**

Local.

**Distribution trend (1995-2015)**

Stable.

**Suggested survey method**

Sweep netting at heathland margins or visual searching on sunny days.
Citizen science and alien species

For many countries, the efficiency of invasion monitoring can be improved by inclusion into pre-existing biodiversity monitoring schemes. **Countries may capitalize on citizen science, as well as emerging online and remote technologies in data capture to improve records of invasions.** For all countries the goal should be to provide at regular intervals (at least every five years) alien species occurrence data corresponding to their maximum level of resolution, be it for the national inventory, priority sites, spatial extent, or the national distribution of occurrence of a priority set of taxa.
Citizen science – excellent science and engagement
Summary

• Importance of global collaborations
• Sharing information
• Engaging people
• Predicting invasions
Thank you