

Institution: Royal Holloway, University of London
Unit of Assessment: A5: Biological Sciences
Title of case study: Conservation of the stag beetle, <i>Lucanus cervus</i>
1. Summary of the impact <p>Research on the population biology of the stag beetle at Royal Holloway has created impact on the environment (species conservation through an increase in available habitat and in known breeding sites), impact on public policy (production of a species action plan and an EU Directive and the management of woodland habitats), and impact on society (change in public understanding). Using a 'Citizen Science' approach, over 250 volunteers have engaged with this research in population surveys and over 1,000 have helped to create breeding sites. The research has helped to implement conservation policy decisions in the UK and EU and has produced many public information guides. It also has resulted in a radically revised Joint Nature Conservation Committee (JNCC) national Biodiversity Action Plan (BAP) for the species. Furthermore, the research has created impact on practitioners (through enhancement of teaching practices) and brought practical conservation biology into schools, improving the teaching of the National Curriculum at KS2 and 3.</p>
2. Underpinning research <p>The stag beetle, <i>Lucanus cervus</i>, is Britain's largest insect and one of its rarest. It is recognised as a flagship species for the purpose of conserving biodiversity in England and Wales. Larvae feed on buried rotting wood, up to 1m deep in soil over a 7 year period. The adult stage lasts 3-4 weeks, making estimates of population size and distribution difficult to obtain. A nationwide survey of its occurrence was initiated by the People's Trust for Endangered Species (PTES) in 1998 (The 'Great Stag Hunt'), with analysis by Prof Alan Gange. Results showed that the species appeared to be in decline and almost nothing was known about its autecology. Hence a programme of research aimed at understanding its biology, and to develop reliable, non-destructive monitoring methods was commissioned. This began at Royal Holloway in 2000 led by Prof Gange, employed at Royal Holloway since 1992. Much of the research was conducted by Dr Deborah Harvey, a PDRA at Royal Holloway since 2006.</p> <p>Gange was involved in the co-ordination and analysis of successive 'Great Stag Hunts' in 2002 and 2007. Gange and Harvey have been members of the stag beetle focus group led by the PTES, and the London Wildlife Trust Stag Beetle Species Action Plan Group, and have driven the agenda for research into the bionomics of this rare beetle. One of the main findings of the surveys was that this is a predominantly urban insect in Britain with many records from gardens [1].</p> <p>An analysis of size variation in the beetle [2] showed that mating success constrains male size and, contrary to many insects that display elaborate male armature, provides a relatively rare example of stabilising selection. A detailed biochemical analysis was conducted to find compounds to which beetles are attracted. Adults are remarkably responsive to a chemical, alpha-copaene, found in high concentrations in ginger roots. The discovery that a readily available household substance can be used to attract stag beetles was exploited in developing a successful nationwide trapping/recording project, involving 250 public volunteers [3], enabling the first monitoring of population trends.</p> <p>It also was discovered that, unusually, larvae stridulate and the unique noises produced can be recorded with sensitive sound equipment and used as an in-situ detection mechanism. Collaborative work with the Department of Electronics at the University of York developed an inexpensive and efficient series of non-disruptive detection mechanisms based on chemical responses of adults and noise production by larvae [3].</p> <p>Gange and Harvey co-ordinated a European survey of stag beetle occurrence, involving 50 researchers in 41 countries. In total, over 10,000 records were assembled and analysed [4]. This showed that distinct differences in habitat preferences, size variation and diet occur, suggesting the presence of sub-species and showing that local conservation action plans will be the most effective strategy for this insect. Work with this consortium produced the largest and most</p>

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comprehensive distribution analysis of any insect across the European continent [5]. The underpinning research has led to an action plan for conservation of the species in the EU (see [9] below) and a UK campaign to increase the breeding sites for this insect (see [10] below). The quality of the underpinning research is demonstrated by the award to date of 10 peer-reviewed grants (£72K total), the publication of 4 peer-reviewed papers and 5 international and 5 national invited research presentations.

3. References to the research

1. Smith, M. (2007) *Great Stag Hunt III*. People's Trust for Endangered Species, London
2. Harvey, D.J. & Gange, A.C. (2006). Size variation and mating success in the stag beetle, *Lucanus cervus* L. *Physiological Entomology*, **31**, 218-226. DOI: 10.1111/j.1365-3032.2006.00509.x
3. Harvey, D.J., Hawes, C.J., Gange, A.C. Finch, P., Chesmore, E. D. & Farr, I (2011). Development of non-invasive monitoring methods for larvae and adults of the stag beetle, *Lucanus cervus*. *Insect Conservation & Diversity* **4**, 4-14. DOI: 10.1111/j.1752-4598.2009.00072.x
4. Harvey, D.J., Gange, A.C. and 46 others (2011). Bionomics and distribution of the stag beetle, *Lucanus cervus* (L.) across Europe. *Insect Conservation & Diversity* **4**, 23-38. DOI: 10.1111/j.1752-4598.2010.00107.x
5. Harvey, D.J. & Gange, A.C. (2011). The stag beetle: a collaborative conservation study across Europe. *Insect Conservation and Diversity*, **4**, 2-3. DOI: 10.1111/j.1752-4598.2010.00125.x
PDFs are available from the HEI upon request.

Peer-reviewed grants awarded to Prof Gange for stag beetle work described above include:

- PTES: £9,570 2001- 2004; *Biology and ecology of the stag beetle*
- PTES: £13,350 2002 – 2005; *Population genetics and chemoecology of the stag beetle*
- PTES: £15,000 2007 – 2013; *Stag beetle population biology: development of a Biodiversity Action Plan*
- PTES: £1,592 2008-2010; *Nitrogen metabolism in the stag beetle*
- PTES: £12,162 2009 – 20015; *Non-invasive monitoring of the stag beetle*
- PTES: £9,600 2009 – 2015; *Chemoecology of saproxylic beetles*
- British Ecological Society: £1,465 2006-2007; *Chemoecology of the stag beetle*
- Royal Society Partnership grants: total £9,000. 3 over the period 2002 – 2012; *Dining on Dead wood, Meeting the stag beetle and Monitoring the stag beetle*.

4. Details of the impact

Beneficiaries: the work has benefited populations of insects depending on decaying wood, in particular stag beetle populations. It has benefited the JNCC and the UK government by the radical revision of a Biodiversity Action Plan. The charity PTES benefited in their efforts to preserve stag beetle populations and their habitats [6]. It has benefited the general public, schools and other organisations, through their involvement in campaigns and in the installation of stag beetle breeding sites in gardens and school grounds. Furthermore, school teachers and pupils benefited, by enhanced delivery of the National Curriculum at KS 2 and 3.

Impact area 1 (Environment: Resource management): Gange and Harvey wrote the leaflet *Stag beetle friendly gardening* [7], funded by the PTES. Examples of the artificial beetle breeding sites it described ('loggeries') can now be seen in the Royal Botanic Gardens, Kew and the Wetland & Wildfowl Trust in Arundel. Thus, during the assessment period, the research has led to impact on the environment though an increase in understanding of the importance of dead wood as a natural resource, which will benefit many other saproxylic insects. Most importantly, the research has resulted in an increase in the number of potential and actual breeding sites. Through the 'Bury Buckets 4 Beetles' (BB4B) initiative, described below in impact area 3, over 1,000 potential breeding sites have been created, of which 246 have produced larvae. As the total number of breeding sites has been estimated to be 4,756 [1], this represents a 21% increase in the availability of habitat and a 5% increase in actual breeding sites. The increase in breeding sites is likely to increase the stag beetle population; the effect on population size can only be quantified in about

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10 years, due to the long life cycle of this insect.

Impact area 2 (Public Policy: Decisions & guidelines): The research of Harvey and Gange [2-4] was used as the basis for a revised Biodiversity Action Plan (BAP) by JNCC in 2010 [8]. As the JNCC advises the UK Government on nature conservation, this research had a direct impact on policy for management of dead wood habitats. The BAP listed the development of monitoring methods and population estimates as priorities by 2010, which we achieved [3, 4]. This research was also used by JNCC to submit the 'species fact sheet' (S1083) for the UK to the European Union, under EC Directive 92/43/EEC in 2008 [9].

Impact area 3 (Society: Public understanding): Harvey and Gange's research [3,4] showed that removal of tree stumps in gardens is mainly responsible for population decline, so to mitigate this and engage with the public, we developed the 'Bury buckets 4 beetles' (BB4B) project, with sponsorship from B & Q. This had its national launch in 2005 [10] and it has continued throughout the assessment period. Holes are drilled in the side of a 20 litre bucket, which is then filled with sawdust and buried, providing a habitat for larvae [11]. This scheme has informed and engaged the general public, and mobilised over 1,000 individuals to actively take part in creating habitat for the stag beetle. This capitalised and expanded on Harvey and Gange's work, which had previously engaged 250 volunteers in monitoring beetles [3]. To date, just over 1,000 buckets have been placed in a variety of locations, particularly gardens (409) and school grounds (534). Of these 246 buckets have produced larvae, which amounts to a 21% increase in the availability of habitat and a 5% increase in actual breeding sites.

To engage with and inform the volunteer network and the general public, Harvey set up a web site in 2002 [12], which provides information for the public (2,920 queries answered since 2008) and an on-line records form for survey work (3,119 received since 2008). The site provides instant advice for those who find stag beetles on their land, such as how to relocate larvae when the habitat is excavated accidentally.

The BB4B scheme had nationwide impact through exposure on national media; it was covered by the BBC when Gange contributed to an edition of *Wild About Your Garden* (November 2009) when a bucket was incorporated into a design for a wildlife-friendly garden. Gange also appeared on BBC's *The One Show* (2009) to explain stag beetle-friendly gardening, while Harvey presented stag beetle articles on Radio 4's *Costing the Earth* (2006), BBC South Local News Bulletin (2005), *As It Happens* on CBC radio, and has been scientific advisor for *Springwatch* (2009), Chris Packham's *Animals Guide to Britain* (2010), and *Hudson's Monarch*, a film on stag beetles that won the Wildscreen award in 2010. Numerous newspaper and magazine articles include *The Independent's* Gardening Column (2005), *Good Lives*, *The Guardian* (2005 and 2011), *BBC Wildlife magazine* and the *Daily Telegraph* (2010) and *The Times* (2010).

The finding that stag beetles respond to ginger volatiles resulted in over 44,000 hits to the story in a Google search. This research was covered by virtually all the national papers, the BBC science web site and was promoted heavily by the British Ecological Society (BES). Indeed, Harvey was nominated by the BES and awarded the accolade of presenting the prestigious Charles Lyell Award Lecture at the British Science Festival in October 2011 [13].

Impact area 4 (Practitioners: Educational practices): The research sponsored through the Royal-Society partnership grants was highlighted by *Planet Science* as a "big success" in contributing to public understanding and has been used to help teachers deliver the National Curriculum using field-based projects [14].

The research team have presented 66 beetle 'roadshows' to school children. They have written educational materials to accompany the buckets, which have been distributed to teachers and used to help deliver the National Curriculum. Harvey has produced a range of stag beetle education materials, aimed at KS2-3 [15], including an information booklet and 40 worksheets of curriculum based activities. The school stag beetle work with the PTES has formed the basis of the Royal Horticultural Society's 'Meet the stag beetle' in their campaign for school gardening [15].

5. Sources to corroborate the impact

6. The PTES website <http://www.ptes.org/index.php?cat=118> corroborates our claims of impact on

public policy and public engagement through the PTES. For further details, please contact the Chief Executive who chairs the stag beetle focus group or the Conservation Officer who deals with all beetle enquiries and liaises with the external organisations mentioned above.

7. Stag beetle friendly gardening leaflet, published by PTES shows how the impact on the environment was achieved:

http://www.ptes.org/files/273_stag_beetle_friendly_gardening_leaflet.pdf

8. Biodiversity Action Plan from JNCC based on Gange and Harvey's research and notes the need for monitoring:

<http://jncc.defra.gov.uk/speciespages/425.pdf>

9. Species fact sheet submitted by JNCC to the EU is part based on the research of Gange and Harvey: <http://jncc.defra.gov.uk/pdf/Article17/FCS2007-S1083-Final.pdf>

10. PTES website for the bury buckets 4 beetles campaign (BB4B) shows when the campaign was launched, and that it is ongoing, and indicates the extent of the campaign:

<http://ptes.org/?page=211>,

11. Leaflet developed by Royal Holloway and PTES giving information on the BB4B scheme showing how the public was involved in doing the monitoring and engaged in the science:

http://www.ptes.org/files/270_bb4b_id_guide_and_form.pdf

12. The stag beetle info web site shows how the public is informed about the science:

<http://stagbeetle.info/>

13. Link to British Science Association Festival Charles Lyell lecture, and which commended Harvey for "outstanding skills in communication to a non-specialist":

<http://www.britishecologicalsociety.org/blog/2011/05/20/bes-member-to-deliver-prize-lecture-at-british-science-festival/>

14. Planet Science featured article on the "big success" of the Royal Society-sponsored log pile scheme at Cookham Dean School:

http://stagbeetle.info/wp-content/uploads/2013/08/RS_rspg_10.pdf

15. The RHS Campaign for School Gardening, which has links to the KS2 and KS3 leaflets:

<http://apps.rhs.org.uk/schoolgardening/article.aspx?PageId=1063>