Institution:	Keele University
Unit of Assessment:	A5 – Biological Sciences

a. Context

The Centre for Applied Entomology and Parasitology (CAEP) is an established research centre at Keele University, located within the School of Life Sciences. It was founded in 1994 to facilitate and support Keele's growing strength in research linked by its relevance to parasites and pathogens, their insect vectors and their human or animal hosts. In 2004, a major re-organization of research infrastructure at Keele created a series of multi-disciplinary Research Institutes. At that time, CAEP was incorporated into the Institute for Science and Technology in Medicine (ISTM), which helped to broaden and consolidate the breadth of biomedical research across the university. Throughout this time, CAEP has remained one of the strongest and most coherent research groupings at Keele. Indeed, it was one of few areas during RAE2008 that was specifically praised for its strategic focus. With strong support from the Centre, CAEP has grown significantly in research activity, funding support and infrastructure, and has continued to recruit excellent staff through appointments within both the School of Life Sciences and the School of Medicine.

b. Approach to impact

The main thrusts of research within CAEP relate to insect-borne tropical diseases, fish health and immunity, and insect chemical communication. In addition to very strong academic engagement, this research impacts on a range of non-academic beneficiaries and audiences. These include individuals, health administrators and legislators in disease-endemic countries, as well as companies, growers and producers within the aquaculture and horticulture industries. This breadth of activity has impact across several areas of importance related to specific research groups defined in REF5. In relation to Health this includes strategies for the control of malaria via both mosquito vectors (**Eggleston**, **Hurd**, **Tripet**, **Pelletier**) and parasites (**Horrocks**, **Merrick**, **Skidmore**), as well as the epidemiology and control of leishmaniasis via both sandfly vectors (**Hamilton**) and parasites (**Price**). In relation to Public Policy and Services, research within CAEP facilitates the interaction between basic science and the implementation of potential interventions for disease control in endemic areas. This includes engagement with health agencies and legislators in Brazil in relation to the use of pheromone for sand fly control, which has now been adopted by the Ministry of Health in its Vector Control Manual (**Hamilton**). It also includes engagement with government agencies in Mali to embed codes of practice for the release of genetically modified 'malaria refractory' mosquitoes (**Eggleston**, **Hurd**, **Tripet**). In relation to Economics, this includes the commercial exploitation of Macrogard in strategies for improved fish health and immune-stimulation in the aquaculture and fish-farming industries (**Hoole**, **Shrive**, **Skidmore**) and the commercialization of Thripline, a pheromone-based control agent for Western Flower Thrips, which are a major pest of glass house crops (**Hamilton**). In relation to Environment, this includes the role of pollution and immunity in fish health, as exemplified by well-established fish health checks coordinated through Keele Water (**Hoole**); the use of pheromones to reduce the environmental impact of insecticides (**Hamilton**); the chemical ecology of communication amongst social insects and butterflies (**Drijfhout, Jones**) and the forensic applications of insect chemical ecology and communication (**Drijfhout**).

CAEP has a range of strategies to promote the impact of its research and these are embedded within both the University and the Research Institute (ISTM). Strategies are fostered through effective communication of research successes locally, regionally, nationally and internationally to promote Keele's distinctive contribution and to raise external profile and reach. Examples cover a wide range of activities, from local awareness-building through Keele's website, Week at Keele newsletter, 'Discovering Excellence' brochure, Video Wall, publications database and open-access repository, and individual staff web pages, through to Keele press releases and engagement of individual researchers with a variety of media outlets. At an institutional level, Keele's research impact is managed and promoted by dedicated staff within Research and Enterprise Services (RES), including Enterprise Business Managers and Technology Transfer (IPR) experts and extends to the Commercial and Business Engagement Directorate via the Science Park. Within the Research Institute (ISTM), the positive approach to impact is evidenced through the recognition, promotion and increased research-time buyout available to individuals that achieve enhanced research impact as evidenced during annual appraisal (SPRE and PPRE). ISTM's approach is supported by a Research Institute Manager and seeks to engage with enterprise, business and

academia, for example through the Senior Management Committee, annual 'Away Day' and active seminar programmes that host high-profile visiting speakers. The counterpart to this is the coherent 'research passion' shown by CAEP researchers and their willingness to engage in dissemination activities, including promotion of their own work through discussion visits and invited research talks. This engagement is intentionally broad, ranging from school outreach visits, to presentations and seminars at universities, hospitals, companies and research institutes throughout the UK and overseas. CAEP has also collectively engaged with policy makers including local members of parliament to raise awareness about novel approaches to the control of insect-borne disease. This includes hosting information-gathering visits from both Jeremy Lefroy (MP for Stafford; Chair of the All-Party Parliamentary Group on Malaria and Neglected Tropical Diseases) and Stephen O'Brien (MP for Eddisbury; Shadow Minister for Health).

CAEP has a well-defined approach to its interaction with non-academic users, beneficiaries and audiences, designed to maximise research impact. For example, **Eggleston** has pursued the potential of transgenic mosquitoes in the development of novel strategies for the control of insect-borne human disease. This has included, (i) engagement with health agencies including the World Health Organization, where he was an invited consultant in the WHO/TDR Technical Consultation on Genetically Modified Mosquitoes; (ii) engagement with government legislators in Mali over codes of practice to regulate potential releases of genetically modified mosquitoes, including the *de novo* establishment of appropriate ethical committees and outreach with local population/village elders to explain the research and facilitate individual recruitment for malaria sampling and field studies; engagement in the training of African scientists at the MRTC, University of Bamako, Mali, (iii) engagement with UK legislators on the potential use and release of transgenic insects e.g. Parliamentary Office for Science and Technology; DEFRA / ACRE) and (iv) engagement with various media outlets, including Research TV, SciDevNet, BBC World Service and MRC. **Hoole** has taken an active approach to engage users and beneficiaries in the impact of his work on fish diseases and immunity. This includes the establishment of an industry-based international training programme for young fish scientists with workshops on fish immunity (Netherlands), protein crystallography (UK; with **Shrive**), carp aquaculture (Poland) and proteomics (Denmark). This extends to engagement with policy makers including meetings and planning discussions with CEFAS (the UK Government Centre for Environment, Fisheries and Aquaculture Science), DEFRA and the European Association of Fish Pathologists that will result in a key international conference at Keele University in September 2014. In relation to his sand fly pheromone Translation Award, **Hamilton** has contributed to Wellcome Trust events (2008-13) to disseminate translation research to private and institutional funders and health industry leaders, and engaged with communities, householders, control agencies, Health Authorities and the Ministry of Health in Brazil. **Hamilton** also engaged with a FCO Innovation in Life Sciences Inward Mission to Brazil (2009) which resulted in a Keele/FAPESP institutional funding agreement that has brought **Pelletier** to CAEP and will fund a clinical post in 2014. The impact of work on thrips pheromones (**Hamilton**) has been promoted through engagement in EU networking meetings in Spain (2012) and New Zealand (2013) and dissemination to UK growers via DEFRA Hort-Link. This has led to new mass trapping approaches for thrips control and joint Industry/Keele initiatives to benefit UK/EU growers and industry. **Hamilton** also has patents covering novel methods for control of whitefly (2008) and thrips (2012), requiring ongoing oversight and maintenance of technology licence, including liaising with external IP legal experts, preparation of NDAs, and management of patent renewal costs, royalty income and disbursement. **Hurd** has played a central role in engagement with the EU through her appointment to the management team of COST Action: BM0802 Life or Death of Protozoan Parasites, with outputs including annual meetings of members, training workshops and student exchanges between laboratories. **Horrocks** established links to Nnamdi Azikiwe University in Nigeria and the UK SMEs Phytoquest and Charnwood Molecules to set up a PhD position for a Nigerian scientist at Keele, whilst **Horrocks** and **Skidmore** engaged with the enterprise agenda to secure Keele Innovation funding for novel antimalarials. **Hamilton** has engaged with the enterprise training agenda through the award of a Medici Fellowship, which helped to develop the University approach to enterprise and impact. **Shrive**, as part of the Keele Structural Biology group has helped to raise research profile by contributing structural images of proteins such as that for human CRP. These are sold widely and have appeared in Newsweek, Physicians Journal, Amersham International, Clinical Chemistry, GP Circulars, EyeNet magazine and The Immune System. Members of CAEP are frequently consulted for expert comment on major news stories (e.g.

Sunday Times (**Merrick** and **Tripet)** and can demonstrate a strong profile of engagement with the general public, schoolchildren and teachers to address research issues. For example, **Merrick** has contributed a Science in the News article and delivered a 'Cutting Edge Science' workshop for school teachers; **Hurd** has established links with Mbarara University in Uganda to talk to medical students about parasitic diseases such as malaria and to rural school children about the control of parasitic disease; **Horrocks** has worked with the local Rotary Club to provide secondary school events during Science week. In addition, CAEP members have held prominent roles in various learned societies, helping to promote the impact of research conducted at Keele. **Hurd**, **Horrocks** and **Merrick** have sat on the Council of the British Society for Parasitology (**Hurd** was a former President) and **Eggleston** was a Council Member and Trustee of the Royal Entomological Society. CAEP, operating within ISTM and the broader University, prides itself on an agile approach to opportunities. As a coherent research grouping, with frequent interactions between members, it is flexible and can move quickly to respond to and support developments that maximise research impact. One example of this is the recent collaboration forged between **Hoole** and **Skidmore** to modify and improve β-glucan formulations for promoting fish health. The focus and priority given to this area is embedded in the appraisal process (SPRE and PPRE) and forms a core component of the promotion criteria. For example, both **Hoole** and **Hamilton** were promoted to Chairs during the reporting period partly on the strength of their enterprise and 'impact' agendas.

c. Strategy and plans

Within Keele's Strategic Plan, the third strategic aim is to 'deliver international excellence and **impact** in focused areas of research'. In line with this, the Research Strategy (2011-15) sets out plans for research to have a significant social, cultural, environmental and economic impact, and to work with external partners and collaborators to benefit society. Keele's impact strategy is thus embedded in the annual planning process for ISTM and highlights impact at the highest level, including resource needs, in a nested-hierarchy to the Executive Dean of Health and the Senior Leadership Group. At the unit level, strategies for deciding which areas of impact to focus on and support are discussed regularly by the Faculties of Health and Natural Sciences and by the Senior Management Committee of ISTM. This includes regular strategy meetings for individual research themes such as CAEP, which are reported back to SMC and debated more broadly at the annual 'Away Day'. Strategies to promote and recognize impact are embedded in both the appraisal and promotion criteria and impact activities are analyzed as part of annual review of research activity and research planning process. In recognition of the growing importance of cross-disciplinary research within European and the international community, Keele has continued to increase its European and International grant portfolio and provide support to academics on engagement in European and international research activities that raise profile and impact of research. A good example of this strategy within CAEP is the successful EU FP7 International Training Network (NEMO), co-ordinated by **Hoole**. Keele's strategic commitment to European engagement is evidenced by the recent investment in Brussels-based support. Securing representation in events, the organisation of bespoke meetings and opportunities for informing future policy on the basis of research will result in new partnerships and ensure that the impact of research is maximised. At the level of the individual researcher within CAEP, Keele University adopts strategies, managed jointly by the School of Life sciences and the Institute for Science and Technology in Medicine, to release staff time through research buyout, the employment of temporary teaching replacement staff and 'rallying round' to assist colleagues at key times in their careers. Central to this strategy are robust mechanisms for mentoring of new appointments and early career researchers. In addition, there are embedded policies within ISTM and Keele University to provide financial incentives to help maximise research impact. For example, individual staff can share in the financial benefits arising from enterprise activity and licensing. More broadly, ISTM releases 90% of all overhead income directly back to the individual researchers responsible for the external funding awards. These funds flow into T-Accounts that can be used to enhance and promote activity and impact of individual research groups and help to 'pump-prime' further activity.

d. Relationship to case studies

REF3b (Improving fish health and quality using naturally derived products) is an exemplar of our approach. It encompasses commercial engagement in the use of β-glucans, the establishment and dissemination of industry-based training programmes, engagement with policy makers and legislators and the development of multi-disciplinary approaches to product improvement.