Institution:	**Keele University**
Unit of Assessment:	**A5 (Biological Sciences)**

a. Overview

Keele is a research-led institution with commitments to excellence in both research and education enshrined in the Strategic Plan. Research is organized into five multidisciplinary Research Institutes that promote excellence in focused areas through their support infrastructure and environment. RIs nurture researchers at all stages of their careers, providing strong and effective mentorship to create leaders for the future. Keele has made effective use of HEFCE Capital Funding to support research excellence by improving the environment and infrastructure, for example through campus-wide WiFi and support for ECRs and PGRs. As a result, Keele has grown significantly since 2008, with total research income up by 53% per year and average income per FTE up by 77% to £65K per annum. In addition, doctoral awards have increased by 60% since 2008 and now stand at 1.3 per FTE per year. These figures do not fully reflect recent increases in PGR numbers (up 75% since 2009-10) who will not complete until the next REF period but will dramatically increase doctoral award rates. This growing community is supported by dedicated administrative staff and by Research and Enterprise Services. Significant improvements in research profile, culture and ethos are evidenced by staff esteem indicators, embedding of RI and PGR symposia, and vibrant seminar and external visitor programmes. There is strong institutional support (including financial) for external Fellowship applications including UKRC, EU Marie Curie and Leverhulme Early Career schemes. Importantly, Keele has embedded mechanisms for allocation of research time, workloads and staff appraisal to facilitate research activity amongst staff with significant teaching and administrative loads. Significantly, Keele has recently gained the European Commission HR Excellence in Research Award.

One of Keele's leading RIs is the Institute for Science and Technology in Medicine (ISTM), which was established in 2004 to consolidate the breadth of biomedical research. In 2008, more than 50% of submitted activity achieved quality ratings of 4* or 3*, with ~ 70% of publications rated 4* or 3*. Since then, ISTM has expanded by 145% and research income has grown by 25% per annum. This growth is driven by a “bench to bedside” approach to basic, applied and translational studies and underpinned by strategic appointments in the Medical School (ranked 2nd in Medicine, Sunday Times) and School of Life Sciences (ranked 8th for Student Satisfaction in 2012) to strengthen the multidisciplinary base. Keele is committed to the support and strengthening of ISTM, both by recruiting promising young academics and by supporting commercialization of novel technologies. Since RAE2008, several companies have been spun-off to commercialize technologies, 12 patents have been filed or granted and Keele’s RES have engaged broadly to license our technologies.

ISTM provides a thriving, multi-disciplinary research environment that is well-placed to strengthen its profile over the next 5-10 years. It brings together biologists, engineers, physicists and chemists in nine focused themes across basic sciences, translational studies and clinical applications. Interaction and collaboration within and across themes actively fostered. ISTM is led by a Research Director, supported by a Deputy Director, Research Institute Manager and Senior Management Committee. Staff contribute to 5 MSc programmes, namely Biomedical Engineering, Cell and Tissue Engineering, Biomedical Blood Science, Bioscience/Neuroscience Research Training (with International Placement) and Molecular Parasitology and Vector Biology. The latter is a joint enterprise between, and accredited by, Keele, Manchester and Salford, and is one of very few programmes of excellence in this area in the UK. All programmes have been running for many years and continue to enjoy strong recruitment both nationally and internationally. One of the themes within ISTM is the **Centre for Applied Entomology and Parasitology (CAEP)** and this coherent research grouping is being submitted to the Biological Sciences Panel.

b. Research strategy

CAEP is an established research centre at Keele University, founded in 1994, and was specifically praised for its research coherence and organizational structure during RAE2008. It currently comprises approximately 50 members including 4 professors, 3 professors emeritus, 1 reader, 5 senior lecturers, 6 lecturers, 6 post-doctoral research assistants, 18 PGR students and 8 technicians. Research in CAEP is linked by its relevance to parasites and pathogens and their insect vectors and human or animal hosts. It brings together multidisciplinary interests in entomology, parasitology, genetics, molecular biology, chemistry, biochemistry, immunology,

structural biology, ecology and chemical ecology to form an internationally competitive research focus. CAEP has an ethos of local, national and international collaboration and effective strategies to engage staff at all levels in scientific discussion and communication.

CAEP conducts research in three broad areas. First, on the biology, transmission and pathogenesis of malaria, leishmaniasis and trypanosomiasis, which are responsible for significant mortality and morbidity in the developing world. This research emphasises the development of novel strategies for controlling these diseases and/or reducing their impact. It includes all aspects of modern vector control, including engineering genes for refractoriness to malaria in *Anopheles gambiae*, identifying new targets in both mosquito and vertebrate stages of *Plasmodium falciparum*, understanding the molecular basis of mosquito olfaction, and elucidating the relevance of mosquito population structures to novel control strategies. It extends to understanding *P. falciparum* gene expression within red blood cells and the post-adhesive effects of *Plasmodium*-infected cells on the human vascular endothelium during infection, with the goal of identifying new malaria treatments. Research on sandflies and leishmaniasis covers two areas. (a) understanding and exploiting the chemical communication of the sandfly vector of visceral leishmaniasis in South America. This research, which has a strong translational dimension, is currently investigating the effects of synthetic sex pheromones in novel lure-and-kill strategies to control sandflies and limit disease transmission. Ultimately, this is of vital importance to understand the epidemiology of vectorial capacity and transmission of leishmaniasis to man. (b) research on *Leishmania* focuses on the elucidation of novel molecular trafficking pathways to identify new drug targets and subsequent characterization of validated drug targets such as *N*-myristoyltransferase (NMT). Comparative studies extend to the related protozoan parasite *Trypanosoma brucei*, including the use of *T. brucei* as a model to study the functions of genes implicated in human genetic disorders.

Secondly, cross-cutting research seeks to understand the biology of agriculturally important insects, both as vectors of disease and as beneficial insects. This translates fundamental understanding into novel control strategies that optimise biosecurity and pest management. Research on the biology and chemical ecology of thrips, which are economically important pests and disease vectors in crops worldwide, has high translational impact and has resulted in multiple patent, licensing and spin-out activities. Other research on chemical communication among ants and other beneficial social insects addresses the importance of cuticular hydrocarbons in nest-mate recognition systems and in society (forensic entomology). Collaborative work on chemical ecology and bee foraging has allowed timely research on honey bee health and colony collapse.

Thirdly, research on fish disease covers the effects of parasites and pathogens on host immunology and the impact of environmental stress factors in the progression of parasitic, bacterial and viral infection. This aspect of research is strengthened by colleagues with expertise in structural biology and apoptosis. Within structural biology, research focuses on collaborative structural and functional studies which emphasise the innate immune and inflammatory responses and host-pathogen interactions across a diverse range of species, including humans. Specific projects include the potential for immune modulation in warm-water fish by feeding of glucans, structural biology of fish immune and acute-phase proteins, infection-mediated disruption of fish reproduction and the impact of pollution and apoptosis on fish immunity. In addition to on-site aquaria, this research also undertakes field trials at fish farms and production units in the UK and Poland and has extensive collaborations with industry. Expertise in this area is translated into 'Keele Water' to undertake health checks to comply with the Freshwater Fish Disease Act 1983.

CAEP research achievements include: *Drijfhout*: (i) showed that hydrocarbons on blowflies can be used to age larvae to estimate post-mortem intervals, (ii) responsible for major advances in understanding how nest-mate and species recognition cues are used in insect communication. ***Eggleston***: (i) developed site-directed genetic engineering protocols for *Ae. aegypti* and *An. gambiae*, (ii) improved transgenic protocols in *An. gambiae* through germline-specific expression of viral integrases, (iii) demonstrated that anti-malaria transgenes can significantly reduce *Plasmodium* infections in *An. gambiae*, (iv) established that *An. gambiae* larvae express atypical defensin genes that lack the expected acute-phase response. ***Hamilton***: (i) demonstrated the activity of a synthetic sandfly sex pheromone under field conditions in Brazil, (ii) first city-level cluster randomised trial to determine the potential of synthetic sex pheromone to reduce canine visceral leishmaniasis in Brazil,(iii) identified the sex pheromone in the Old World sandfly vector of cutaneous leishmaniasis. ***Hoole***: (i) first to utilise *in vivo* and *in vitro* studies to unravel interactions

between metazoan parasites and the innate and acquired immune responses in fish, (ii) characterized some of the molecular pathways of apoptosis in immune cells of fish during their interaction with pathogenic viruses and bacteria, (iii) isolated and characterized the genes encoding CRP in fish and the effects of pathogenic viruses and bacteria on CRP expression, (iv) demonstrated the molecular interactions between apoptosis and viral infections in fish. ***Hoole, Shrive***: (i) first to demonstrate that CRP is an acute-phase reactant in fish, (ii) determined the joint effects of β-glucan and infections on innate immune proteins such as complement and CRP in fish. ***Horrocks***: (i) first complete bioinformatics catalogue of the network of ubiquitin and ubiquitin-like proteins in apicomplexan parasites and comparator species, (ii) first comparative study of intergenic space organisation in apicomplexan parasites, (iii) genetic and epigenetic analysis of the factors directing absolute and temporal control of a proto-typical housekeeping gene in *P. falciparum*, (iv) first demonstration that the dynamic response of a bioluminescent reporter protein following drug perturbation offers significant opportunities for scalable *in vitro* assays of antimalarial rate-of kill. ***Hurd****:* (i) demonstrated, using multiple phenotypic and biochemical markers, that malaria sporogonic stages undergo apoptosis, (ii) demonstrated that oxidative stress induces *Plasmodium* ookinetes to undergo apoptosis *in vivo* and *in vitro*, (iii) first study of the fitness costs associated with mosquitoes selected for refractoriness to malaria. ***Hurd, Eggleston****:* (i) investigation of the anti-malaria activity and fitness effects of AMPs on laboratory and field infected mosquitoes. ***Hamilton***: (i) commercial exploitation of thrips aggregation pheromone through technology license, (ii) identification and patenting of the aggregation pheromone of *Thrips palmi*, a major crop pest in Asia (ii) ***Drijfhout, Hamilton***: identification of the contact pheromone in the order Thysanoptera. ***Jones***: (i) identified the chemical co-evolution inherent in surface chemistry mimicry by butterfly caterpillars that parasitize *Myrmica* ant colonies. ***Merrick***: (i) first field study to examine expression of virulence genes and their epigenetic regulators in primary isolates of *P. falciparum*, (ii) demonstrated that Sir2a in *P. falciparum* is a histone deacetylase with pleiotropic roles in virulence gene silencing, telomere maintenance and chromosomal stability. ***Pelletier:*** (i) first functional evidence for the role of a mosquito odorant-binding protein in the reception of odorants, (ii) first genomic and molecular characterization of olfactory gene families in *C. quinquefasciatus*, (iii) first functional characterization of odorant receptors involved in the reception of oviposition cues in *C. quinquefasciatus*, (iv) first development of transgenic strategies to knockout mosquito olfactory genes. ***Price:*** (i) *in vitro* and *in vivo* validation of *N*-myristoyltransferase as a drug target against *Leishmania* and *Trypanosoma,* (ii) development of *T. brucei* as a model system to study proteins implicated in human genetic diseases, (iii) use of transgenic parasites to demonstrate on-target effects of potent inhibitors of *T. brucei* NMT and identification of two essential substrates, (iv) demonstration of the essential role of the ciliopathy-associated BBSome complex in *Leishmania* host virulence. ***Shrive***: (i) solved the structure of a microbial ligand with a pulmonary collectin, (ii) demonstrated two molecular aggregations for a pentraxin protein, (iii) demonstrated ligand binding determinants in a lung collectin and the influence of flanking residues on ligand binding, (iv) first determination of the structures of pentraxins from species other than man. ***Skidmore***: (i) pioneered the use of laser-induced fluorescence for structural determination of biologically important and medically relevant glycosaminoglycans, (ii) demonstrated the potential use of sulphated carbohydrates as inhibitors of rosetting, cytoadherence and invasion for severe *P. falciparum* malaria, (iii) first to engineer semi-synthetic, carbohydrate-based glycosaminoglycan analogue libraries as a resource in future drug discovery, (iv) developed new tools, technologies and methodologies for the elucidation of protein-carbohydrate structure-function relationships. ***Tripet****:* (i) confirmation of the role of accessory-gland proteins in inducing the switch to the mated stage in female *An. gambiae*, (ii) first report of cross-mating in the wild between *Ae. aegypti* and *Ae. albopictus* with important implications for their spatial distribution, (iii) functional demonstration of cooperative feeding in a blood-feeding arthropod through studies of the sandfly vector of leishmaniasis, (iv) experimental demonstration of conditional learning and long-term memory in *An. gambiae*, (v) experimental demonstration that host alternation constrains molecular evolution of arthropod-borne viruses, (vi) discovery of a hybrid *Triatoma dimidiata* population with increased vectorial capacity for Chagas disease in Mexico. ***Tripet, Hurd***: experimental demonstration that infection with malaria parasites reduces mosquito survival in a stress-dependent manner. ***Tripet, Eggleston***: assessment of fitness characteristics to validate transgenesis in *An. gambiae*.

c. People, including:

i. Staffing strategy and staff development

CAEP, within the frameworks of ISTM and the School of Life Sciences, has active mechanisms to support and nurture its members. Since 2008, CAEP has appointed four ECRs (**Skidmore**, **Merrick**, **Price**, **Pelletier**) each supported by generous start-up packages, specific allocation of research time, reduced teaching loads for the first three years, formal mentoring by senior staff, research supervisor training and prioritized access to both HEFCE capital funding and internal PGR funding. Of these, **Pelletier** is part of a strategic collaboration between Keele and FAPESP (Brazil), designed to strengthen basic to translational links in tropical disease research and foster future collaborations. This will be further enhanced by a medically qualified appointment in December 2013, funded by FAPESP, to facilitate translational and epidemiological research. More broadly, all members of CAEP have access to staff development programmes, dedicated research time within a workload allocation model, strong support for grant and fellowship applications (internal peer-review, ethics) and access to quality research time through the award of internal Research Fellowships. Notably, research excellence is embedded within the promotion criteria to facilitate early promotion of excellent researchers. During the census period, continued research excellence has given rise to individual promotions to Personal Chairs (**Hamilton, Hoole**), Readerships (**Tripet**) and Senior Lectureships (**Horrocks, Drijfhout**). CAEP members enjoy flexible, family-friendly working arrangements (Athena Swan), and benefit from a revised appraisal system that is designed to identify development needs and reward excellence. Achievements and excellence are highlighted locally and via 'Week at Keele' to foster a competitive research environment. Across CAEP, we have specific and collaborative expertise in insect physiology and the fitness costs, transmission, development and apoptosis of malaria sporogonic stages (**Hurd, Tripet, Eggleston**), mosquito genetic engineering, mosquito immunity and transgenic strategies for control of transmission (**Eggleston, Hurd, Tripet**), mosquito molecular ecology and genomics (**Tripet, Eggleston**), molecular mechanisms of mosquito olfaction (**Pelletier**), molecular biology, molecular genetics, virulence and antigenic variation of the malaria parasite (**Horrocks, Merrick**), molecular biology of *Leishmania* and *Trypanosoma* and validation of novel drug targets (**Price**), protein-carbohydrate interactions in novel malaria therapies (**Skidmore, Horrocks**), insect chemical communication and chemical ecology (**Hamilton, Drijfhout, Jones**) and fish diseases, structural biology, apoptosis/pathology and comparative immunology (**Hoole, Shrive, Skidmore**).

ii. Research students

Keele University has an active internal funding scheme to promote PGR recruitment (ACORN ~ 450k per annum), and facilitates PGR research through bursaries (KISS) and GTAs. In addition, staff have proved adept at funding PGR students through a range of shared-cost arrangements and made good use of CASE awards with industrial partners. Keele has made significant improvements to research training for PGRs, establishing a Learning and Professional Development Centre to provide both generic research training for research students and development courses for staff. PGR research training is monitored by the University Postgraduate Research Committee, which takes an institutional overview. On a social and pastoral level, PGR students are supported by supervisors, the RI, the Student Support and Development Service (SSDS) and by the Keele Postgraduate Association (KPA). As a contribution to consumables, travel and conference attendance, supervisors receive a specific return of part of the fees (37% - Home/EU; 24% - Overseas) to support their research students. PGRs also have access to Keele's established Researcher Training and Development Fund (post-Roberts funding), which provides £200 per annum. Within CAEP, PGR students benefit from a very active training programme involving seminars, journal clubs, techniques workshops and visiting speakers. PGR students have shared office accommodation, with excellent IT facilities, providing a welcome social experience and collegiate environment. Individual training programmes are co-ordinated by the Postgraduate Research Director, supported by a full-time administrator, within the framework of Keele's Code of Practice on PGR Degrees. All matters concerning progression, examination, approval of supervisors, examiners and independent chairs are co-ordinated by Keele's Research Degrees Committee. To give PGRs a voice and consider their needs, Keele established a Research Student Liaison Committee in 2011. Facilities for PGR students have been much improved since RAE2008, for example through strategic use of HEFCE Capital Funding, to provide better laboratory and office space, specialist equipment, 24-hour library opening, increased journal access and campus-wide WiFi. PGRs have a sabbatical officer and association (KPA), which

supports students through representation on all University Committees, including Senate and Council, and there is a new PGR mentoring scheme.

There have been significant improvements to research training and development since 2008 with the establishment of a Learning and Professional Development Centre. This interacts well with the PGR Directors and facilitates good engagement with VITAE. In addition to formal mentoring of new PGR supervisors, there is now a mandatory Research Supervisor Training Programme, which takes place over two days, led by the LPDC with support from the RIs and the PVC R&E. This programme has been very active, reflecting the growing number of ECR appointments, and has received excellent feedback. Keele has moved away from a credit-based training system towards a more bespoke provision, reflecting not only subject-specific training needs but also a wide range of optional personal development and employment skills modules. These are informed by the VITAE RDF and supported by an individual Personal Development and Learning Plan. Subject-specific requirements during the first 12 months include satisfactory completion of an extensive literature review and a 1st year report detailing the research plan, methodology and achievements (both essential requirements for progression). Every effort is made to provide a vibrant research environment for PGRs, through symposia, seminars, workshops and group meetings.

d. Income, infrastructure and facilities

CAEP has seen significant growth since 2008 in both research income and PGR numbers. Total income over the REF period was just over £5.3M (£428K per FTE). This represents an increase of 29% on income per FTE per year since RAE2008, which now stands at £86K per FTE per year. Doctoral awards over the REF period were well above the sector median, standing at almost 2 per FTE (up 16% since 2008) with an increase of 26% in the number of awards per year. On top of this, CAEP has seen a significant increase in PGR numbers (particularly overseas PGR) that will feed into completions in the next REF period. Currently, CAEP has 28 PGR enrolled, amounting to 2.26 PGR per FTE. At an institutional level, the period has seen the development of successful RI and Faculty Research Offices, augmented by central (RES) support, and there has been significant investment in specialized research support e.g. European Research Funding Manager; Enterprise Business Managers. This is supported by robust research governance arrangements for ethical review, animal experimentation, genetic modification, pathogens, radioactivity and human tissues.

CAEP has received significant financial investment from Keele University during the census period, including major refurbishment of facilities, the appointment of two ECRs and two further posts from a specific collaboration between Keele University and FAPESP (Brazil), designed to focus on the strengths of each partner, to strengthen links from basic to translational studies in tropical disease research, and to foster additional collaborative activity between the two institutions in the future.

CAEP members share access to excellent facilities that include a recently refurbished suite of laboratories, aquarium facilities, insectaries, animal house, behavioural chambers, Y tube olfactometers for chemical communication studies, GC-MS and LC-MS platforms, tissue culture suites and CAT3 biosafety facilities for the culture of human malaria parasites, mosquito infections and culture of *Leishmania* and trypanosomes. This facility makes Keele one of a handful of UK Institutions capable of undertaking research that bridges both the sexual and asexual stages of the malaria parasite. The ISTM proteomics suite includes fully equipped biochemistry labs, in-house x-ray crystallographic data collection facilities, programme access to synchrotron beam time (via the structural biology PIs) and mass spectrometry facilities including MALDI-ToF/ToF and ESI-MS/MS. In 2012-13, Keele funded major upgrades to the animal facility and aquarium, in line with current Home Office expectations.

Research activity is funded by The Wellcome Trust, EU, MRC, BBSRC, NERC, STFC, DEFRA, Leverhulme Trust, Royal Society, British Council, UNESCO, WHO and industrial partners such as Syngenta Bioline, PepTcell, Astra-Zeneca Pharmaceuticals, Pfizer, Santander, Biorigin, Biomar and Tetra. The following key grants were awarded during the census period: **Eggleston**, Wellcome Trust Programme Grant, £827,750, EU FP7 Infrastructures Award, £221,494; **Drijfhout**, NERC Project Grant, £328,161, BBSRC CASE Studentship, £75,281; **Hamilton**, Wellcome Trust Strategic Translation Award, £2,562,995, Wellcome Trust Equipment Grant, £290,531, EU FP7 Marie Curie Fellowship, €167,689, University Translation Award, £60,000, NMRCD Research Consultancy, £12,605, BBSRC CASE Studentship, £64,020; EU FP7 Marie Curie Fellowship, €167,689, DEFRA Project Grant, £20,000, EU FP7 IRSES project, £51,130; DEFRA Hort-Link, £847,420, EU FP7 Marie Curie Fellowship, €196,000; **Hoole**, EU FP7 Marie Curie Training

Network, €3,100,000; **Horrocks**, BBSRC New Investigator Award, £342,745; **Merrick**, BBSRC Project Grant, £360,000, MRC New Investigator Award, £141,899, ILL/ESRF PhD Studentship, €88,800; **Pelletier**, Carl Trygger Foundation, €18,000; Nilsson Ehle Foundation, €10,000; Lars Hiertas Foundation, €2500; **Shrive**, STFC/Diamond Structural Biology Programme Grant, £83,269, STFC/LSF Award, £145,000, ESRF Award, £30,742; **Skidmore and Horrocks**, MRC Industrial CASE Studentship, £125,888; **Tripet**, MRC African Research Leader Scheme, £1,000,000.

e. Collaboration or contribution to the discipline or research base

Esteem Indicators (Professional and Scientific Societies)

Eggleston: Member of Council and Trustee: Royal Entomological Society (2008-12); Member of the Lister Institute of Preventive Medicine (1996-date). ***Hamilton***: Life Member of the International Society of Chemical Ecology. ***Horrocks***: Council Member and Director of the British Society for Parasitology (2010-13). ***Hurd:*** Honorary Member and former President of the British Society for Parasitology; Member of the Royal Society for Tropical Medicine and Hygiene (former Council Member), Member of the American Society of Parasitology (former Council Member). ***Merrick*****:** Council Member of the British Society for Parasitology (2013). ***Pelletier:*** Member of the Entomological Society of America (2009-date) ***Price:*** Member of the British Society for Parasitology (2001-date). ***Shrive***: Member of the BSG Committee of the British Crystallographic Association (2011-14). ***Tripet***: Member of the Research Committee of (IRSS), Burkina Faso.

Esteem Indicators (Editorial Roles)

Drijfhout: Subject Editor, *Myrmecological News*; Subject Editor, *Psyche*. ***Eggleston***: Editor-in-Chief, Insect Molecular Biology. ***Hoole***: Editorial Board, *Diseases of Aquatic Organisms*. ***Horrocks***: Editor, *Malaria Research and Treatment*; Editor, *Case Reports in Infectious Diseases*; Editor, *ISRN Tropical Diseases.* ***Hurd:*** Editor, *Microbes and Infection*; Editorial Board, *Malaria Journal*; Editorial Board, *Parasites and Vectors*; Thematic Series Editor *Protozoan Parasites and Cell Death* in *Parasites and Vectors*. ***Skidmore***: Editor, *International Journal of Biology* (2006-12).

Esteem Indicators (Invited Presentations and International Conference Organization)

Drijfhout: Convener and Session Chair: Semiochemicals in Insect Societies - The Effects of Genes and Environment and their Interaction, XVI International Union for the Study of Social Insects (IUSSI) International Congress, Copenhagen, Denmark (2010); Invited Speaker: Use of Hydrocarbons in Forensic Entomology, EAFE Meeting, Kolymbari, Greece (2008). ***Eggleston***: Convenor and Session Chair: Practical Applications of Transgenic Insect Technology, Fifth International Workshop on Transgenesis and Genomics of Invertebrate Organisms, USA (2008); Expert Consultant and Invited Speaker: Transgenic Mosquitoes: UK Parliamentary Briefing. Parliamentary Office for Science and Technology, Houses of Parliament, (2010); Expert Consultant and Invited Speaker, Genetically Modified Mosquitoes: DEFRA / ACRE Evidence Gathering Workshop, London (2010); Invited Speaker or Chair at eight other national and international meetings or institutions. ***Hamilton***: Co-chairman and Keynote Speaker: Vectors and Control Strategies, X European Multi-Colloquium of Parasitology “From Satellites to Microsatellites” Cité Internationale Universitaire de Paris (2008); Invited Speaker at 14 other national and international meetings or institutions. ***Hoole***: Co-ordinator for Immuno-Stimulant Sessions and Workshop: European Association of Fish Pathologists Meeting, Split, Croatia (2011); Co-ordinator for EU Conference on Prebiotics and Probiotics in Medical, Veterinary and Aquatic Sciences, Keele, UK (2012); Co-ordinator for Joint CEFAS/NEMO ITN Meeting, Weymouth, UK (2012); Session Chair European Association of Fish Pathologists Meeting, Finland (2013); Invited Presentations at eleven other national and international meetings or institutions. ***Horrocks***: Convenor and Session Chair, Malaria Symposium of the British Society of Parasitology Spring Meeting (2010-12); Invited Speaker at 5 other national and international meetings or institutions. ***Hurd:*** Keynote Speaker and Session Organiser: Cell Biology of Malaria, XVII International Congress for Tropical Medicine and Malaria, Jeju, South Korea (2008); Invited Speaker and Session Chair: X European Multi-Colloquium on Parasitology, Paris, (2008); Invited Speaker: Leopoldina Symposium on Evolution of Programmed Cell Death in Infection and Immunity, Würzburg, Germany (2009); Invited Speaker and Session Chair: European Science Foundation-FWF-LFUI Conference on The Impact of the Environment on Innate Immunity, Obergurgle, Austria (2009); Session Chair: BioMedCentral Conference, Parasites to Prevention, Edinburgh (2010); Keynote Speaker: The American Phytopathological Society, Rhode Island, USA (2012); Invited Speaker or Chair at seven other national and international meetings or institutions. ***Merrick*****:** Convenor and Session Chair, Malaria

Symposium of the British Society of Parasitology Spring Meeting (2013); Invited Speaker at the Pasteur Institute, Paris (2013). ***Price:*** Invited Seminar Speaker at the University of Hull (2011) and the Pasteur Institute, Paris (2013); Invited Speaker and Session Chair at the Northern UK Kinetoplastid Forum at the University of Hull (2010); Invited Speaker at four other national and international meetings. ***Shrive***: Joint organiser for Biological Structures Group for the British Crystallographic Association Annual Meeting, (2011); Co-ordinator for EU Workshop on 'An Essential Guide to 3-Dimensional Protein Structure and its Determination, (2010); Invited Speaker at 23rd International Lectin Meeting (INTERLEC-23), Edinburgh, UK (2008). ***Skidmore***: Invited Speaker at four national or international meetings or institutions. ***Tripet***: Invited Speaker at four national and international meetings or institutions. ***Pelletier:*** Invited Speaker, Diversity in Olfaction and Taste Symposium, 58th annual meeting of the Entomological Society of America (2010).

Awards and Other Indicators of Esteem

Eggleston: Expert Consultant on Transgenic Mosquitoes for WHO (TDR), Bulletin WHO (2009) 87: 167-168; Invited Participant and Expert Advisor for the WHO (TDR) Technical Consultation on Genetically Modified Mosquitoes. Geneva, Switzerland (2009); Expert Consultant for SciDevNet - The Right Way to Tackle Malaria with GM Mosquitoes (2010); Expert Consultant on Transgenic Mosquitoes for BBC World Service, Discovery – Dengue Fever (2011). ***Hamilton***: Member of the British Foreign and Commonwealth Office Innovation in Life Sciences Inward Mission to Brazil (2009); Invited Expert on the *Lutzomyia longipalpis* Species Complex: Workshop on Genetics and Molecular Biology of Vectors of Tropical Diseases - Entomol-3, Brazil (2008). ***Hoole***: Member of the Board of Research Examiners at University of Sains, Malaysia; Co-ordinator for EU 7th Framework Marie Curie ITN – NEMO; Laboratory and expertise recognised by the Environment Agency as 'Centre of Excellence' for fish disease diagnosis under the Freshwater Fish Diseases Act and 'Buyer Beware' policy. ***Hurd***: Member of the Management Committee and Chair of Work Programme 2, COST Action BM0802, Life or Death of Protozoan Parasites (2008-2012); Member of the Advisory Board of International Congress for Tropical Medicine and Malaria (2008); Expert Consultant to Sanaria Inc, USA (2011- to date). ***Pelletier:*** Silver Medal of the French National Academy of Agriculture for contributing to the identification and characterization of genes involved in pheromonal communication in the silkmoth (2008); Winner of the French-Swedish Prize for Young Researchers in the category “Green Chemistry Serving Human Health" (2011). ***Tripet:*** Expert Consultant on Mosquito and Malaria Control for the Sunday Times (2012); Session Chair, BSP Spring Meeting (2010-12); Invited Speaker at six national and international meetings or institutions and Keynote speaker at the Evolution/Speciation symposium, Texas A&M, USA (2013).

CAEP is internationally recognised with many productive collaborations during the census period: MRTC-Bamako (**Eggleston, Hurd, Tripet**); Imperial College (**Eggleston, Hurd, Price, Tripet**); LSTM (**Eggleston, Horrocks**); Pasteur Institute, Paris (**Eggleston**); LSTMH (**Hamilton, Hurd**); University of Notre Dame (**Merrick, Pelletier**); Sanger Centre (**Merrick**); University of Nijmegan (**Merrick**); University Sains Malaysia (**Tripet, Hoole**); IRSS-Burkina Faso (**Tripet**); University of Ghana, Legon (**Tripet**); University of Massachusetts (**Horrocks**); Charnwood Molecular (**Horrocks**); Georgetown University (**Horrocks**); Danish Technical University (**Hoole**); Wageningen University (**Hoole, Shrive**); Hannover Veterinary School (**Hoole, Shrive**); Polish Academy of Sciences (**Hoole**); Plymouth University (**Hoole**); FIOCRUZ and FAPESP, Brazil (**Hamilton**, **Price**); Institute Pasteur de Tunis (**Hamilton**); UC San Diego (**Hamilton**); Indian Institute of Chemical Technology (**Hamilton**); Warwick University (**Hamilton**); University of Southern Denmark (**Shrive**); UC Davis (**Shrive, Pelletier**); University of Dundee (**Price**); University of Durham (**Price**); University of York (**Price**), University of Cambridge (**Price**), Charles University, Prague (**Price**). Université de Strasbourg (**Pelletier**), INRA (**Pelletier**), Swedish University of Agricultural Sciences (**Pelletier**).

Patents and Licences.

CAEP has significant translational activity. During the census period the following patents were granted: **Hamilton, J.G.C**. (2008) Insect attractants and their use in methods of insect control, UK PCT/GB2009000474, 20th Feb 2009, US 8,277,825 B2, 2nd Oct 2012; **Hamilton, JGC** and **Kirk, WDJ** (2012) Method of monitoring and/or controlling Thysanoptera, filed in UK PO (No:006768) 30th October 2012. In addition a technology licence with Syngenta Bioline Ltd., issued in 2004, for **Hamilton, J,G.C**. was updated in 2008.