Institution: University of Lincoln

Unit of Assessment: UoA6 Agriculture, Veterinary & Food Science

a. Overview

The School of Life Sciences (**SLS**) was created in 2012 and associated staff are being submitted to two UoAs (A6 and A3), reflecting the range of multidisciplinary research being undertaken within the School. Research in UoA6 takes place within two complementary groups: Animal Behaviour, Cognition and Welfare (**ABCW**), and Evolution and Ecology (**EE**). Some animal science staff from the former Department of Biological Sciences, and submitted to RAE2008, are included. Animal science staff are currently based on the Riseholme Park Campus (3 miles from the city), while microbiological staff are based on the city centre campus. From 2014, all staff and researchers from both campuses will move into the new Joseph Banks Laboratories (**JBL**), and Riseholme will remain solely as a field station facility. The general remits of the two groups are:

- **Animal Behaviour, Cognition and Welfare** (**ABCW**): Undertakes fundamental and translational research across clinical and environmental settings with an increasing interest in its relationship to human lifelong health and wellbeing.
- **Evolution and Ecology** (**EE**): Examines the dynamics of evolutionary and ecological processes in extant and extinct organisms, and its importance for living with environmental change.

Since RAE2008, research-active staff numbers in UoA6 have expanded to include 18 full-time academics, one emeritus Professor, two visiting Professors and a growing number of postdoctoral fellows and assistants. This reflects the success of an ambitious, innovative research strategy that is responsive to on-going change, and substantially revised in light of the opportunities generated through the creation of the **SLS**.

b. Research strategy

Since RAE2008, the University has identified major expansion in STEM subjects as a strategic priority and invested accordingly. From 2014, the **SLS** will be housed in the **JBL** alongside the new Schools of Pharmacy and Chemistry. The **JBL** is a new research-focused facility that forms part of a more than £20m investment in infrastructure to sustain our continued growth, including the creation of a research and enterprise hub at the Lincoln Science and Innovation Park (**LSIP**), a joint venture between the University and the Lincolnshire Co-operative Society.

Within our strong overarching vision for science at Lincoln, the **SLS** and its associated research groups have shaped their research strategy around the following key aims:

To enable, prioritise and promote research:

- Providing a vibrant, responsive and inclusive environment attracting world-leading scientists.
- Investing in research infrastructure (laboratories, equipment, services, etc.).
- Providing a supportive environment for generating external income to enable research, combined with explicit individualised expectations concerning external funding expectations.
- Increasing the number of research students and enhancing the quality of their experience.

To facilitate and promote interdisciplinarity:

- Financially supporting student projects (through PhD studentships) and associated activities (e.g. interdisciplinary forums).
- Encouraging staff involvement in international research networks.
- Fostering a culture of collaboration at all levels.

To ensure that our research achieves maximum possible impact:

- Providing expertise to enable engagement with potential stakeholders.
- Maintaining a culture in which the value of impact is inherent to our research.

The two Groups submitting to UOA6 share four chief research priorities:

- To position research on animal health and welfare in a comparative biological framework (Burman, Collins, Pilot, Mills).
- To unravel the complex interactions between organisms and their natural or domestic environments from an evolutionary perspective (Eady, Flint, John, Montealegre-Z, Osborn, Pilot, Pike, Pincheira-Donoso, Ruta, Soulsbury).

- To develop multidisciplinary/comparative approaches to research on animal cognition/perception (Burman, Collins, Mills, Montealegre-Z, Pike, Wilkinson).
- To quantify the evolutionary dynamics of life-history traits in rapidly changing environments (Eady, Deeming, John, Pincheira-Donoso, Ruta, Wilkinson).

Examples of our contributions to our research fields are:

- Our research on animal health and welfare transcends many traditional boundaries by developing objective and innovative ways to assess animal cognition, and placing it within an evolutionary framework. We are experiencing a steady stream of young and experienced researchers exchanging visits with us, funded by networking grants (e.g. CompCog) and exchange schemes (e.g. Erasmus). In recognition of her work in this area, Collins was awarded Young Animal Welfare Scientist of the Year (UFAW 2011).
- Unpicking the complex links between organisms and their environments encompasses the capacity to examine change seen at the level of molecular biology (Flint, Pilot), individuals (Eady, Deeming), populations (Pincheira-Donoso, Pilot, Ruta, Soulsbury) and ecosystems (John, Osborn, Ruta, Soulsbury). The vibrancy of our approach is evidenced by Pincheira-Donoso, an ECR, recently being listed among the fifty-five most influential reptile biologists in the world.
- Our innovative approaches to studying animal cognition and sensory perception are focused on truly comparative work for example between humans and distant phylogenetic groups (see publications by Mills with Guo and Meints); while the cold-blooded cognition laboratory of Wilkinson has facilitated important collaborations with the Universities of Vienna (Huber) and York (Hall), and avian research unit at the Parrot Zoo (Wilkinson and Pike) led similar collaborations at York, St Andrews and Vienna. We also explore invertebrates to gain knowledge of sensory systems that feed into biomedical and bioengineering research (Montealegre-Z's work on insect hearing structures).
- Finally, our expertise in understanding patterns and processes of biological change in fossil and living organisms enables us to generate unique perspectives on diversification in a rapidly changing environment. Using data from the vertebrate fossil record, Ruta has pioneered new techniques for analyses of biological shape variation and recovery in response to catastrophic events.

The success of our strategy is further evidenced by key developments in the census period:

- Recruitment of 13 new research-active faculty members and two independent NERC-funded research Fellows (Pike and Ruta).
- New equipment purchases (over £500k in the financial year 2012/13), and over £20m investment in the new **JBL.**
- Growth in research income of nearly 60% (from £450k in 2008/9 to over £705k in 2012/13), including the first RC-UK awards to Lincoln PIs within UoA6 (Burman; Osborn; Pike), and our first support from the Royal Society (Montealegre-Z).
- Increasing number of completed PhDs (none before 2008; 14 in the census period)

Evolution and Ecology (**EE**): Explores the tempo and mode of ecological and evolutionary change, from genes to ecosystems. The Group's activities also offer the fundamental comparative basis for contextualizing key elements of the **ABCW** Group's work. Significant achievements include:

- Discovery of an insect hearing organ analogous to mammalian cochlea (Montealegre-Z: *Science*, 338 (2012), pp. 968-971).
- Quantifying environmental, phylogenetic and body-size effects on bird nest characteristics (Deeming: *Journal of Biogeography*, 39 (2012), pp. 1669-1677; *Avian Biology Research*, **6** (2013), pp. 1-11).
- Reconstruction of evolutionary diversification in terrestrial vertebrates in the aftermath of mass extinctions (Ruta: *Proceedings of the Royal Society B*, **280** (2013; e20131071), pp. 1-9; *Proceedings of the Royal Society B*, **280** (2013; e20131865), pp. 1-10).
- The finding that social network structure can explain multi-level fitness in animal groups (Pike: *Proceedings of the Royal Society B*, **279** (2012), pp. 4914-4922).
- Formulation of a novel theory predicting how natural selection on life histories promotes

evolutionary radiations (Pincheira-Donoso: *Global Ecology and Biogeography*, **22** (2013), pp. 857-867)

Animal Behaviour, Cognition and Welfare (**ABCW**): Uses multidisciplinary approaches to determine, within an evolutionary framework, the mechanisms, capacities and function of the perceptual, cognitive and affective processes of animals, and how these impact on their behaviour and welfare. Significant achievements include:

- Development of a new approach – the cognitive bias paradigm – for assessing emotions and moods in animals (Burman: *Current Biology*, 20 (2010), pp. R839-R840; *Proceedings of the Royal Society B* **277**(2010), pp. 2895-2904).
- First evidence of social cognition in reptiles (Wilkinson: *Biology Letters*, **6** (2010), pp. 614-616; *Animal Cognition*, **13** (2010), pp. 765-769).
- Novel insights into the perceptual and cognitive ability of dogs (Mills: Animal Cognition, 12 (2009), pp. 409-418; PLOS ONE, **7** (2012), pp. E36076; Zulch and Mills: *PLOS ONE*, **7** (2012), pp. E49382).
- First meta-analytical evaluation to determine the evidence base for clinical animal behaviour interventions (Mills: *PLOS ONE*, (2011) **6**(4): e18448).

The shared skills, knowledge and techniques of the **EE** and **ABCW** groups have resulted in successful novel cross-disciplinary research collaborations, both within the UoA and with researchers from other disciplines at all levels of maturity, supported by University-sponsored PhD studentships, such as:

- The role of animal cognition in seed dispersal (2011 - Wilkinson ABCW with John EE),
- The influence of individual cognition on their position in social networks (2011 - Pike EE, Burman ABCW).
- The genetic and neurological basis of impulse aggression in dogs (2013 - Pilot EE, Mills ABCW and Gutierrez UoA 3).
- Models of animal cognition in the design of robots (2013 - Wilkinson and Pike UoA 6 with Murray UoA 11).
- Face processing by dogs (2008 - Mills UoA 6 with Gou and Meints UoA 4).
- Biochemical composition and biophysical properties of katydid ears (2013 – Montealegre-Z UoA 6 with Gonzalez-Rodriguez – School of Chemistry).

There are also several subsequent collaborative funded research projects, including:

- Mills and Zulch ABCW with Pike EE – determination of olfactory threshold in the dog (2011 €200k Royal Canin with Medical Detection Dogs).
- Wilkinson and Zulch UoA6 with Croxton UoA3 - olfactory categorisation in dogs (2013 $275k US Office of Naval research).

Income generation plans build on our diverse types of sponsor, with particular attention paid to increasing income from National and European funding agencies and the opportunities that will be created through **LSIP**. Accordingly, we have set the following ambitious but achievable targets for the next five years:

- Further increase in postgraduate research student numbers, to establish a ratio of 3 FTE students per FTE staff member. Currently we have 38 students in the research groups within this UoA, compared to 27 at the same point in 2012.
- Continued growth in post-doctoral researchers, to establish a ratio of one per FTE staff member.
- Annual research increasing income of >£60k per FTE staff member.

The **SLS** Research Committee (including Professors and Readers from across **SLS**, representatives of each Research Group, Early Career Researchers (ECRs) and our Research Manager) provides a steering body to implement and review our strategic plan, responding to changing national and international priorities. The Committee organizes a weekly research seminar series and biannual research away-days, and manages the support for interdisciplinary forums and their agreed deliverables. Interdisciplinary forums are driven by individual Research Groups and

provide an internal framework for collaboration between Schools and external stakeholders, e.g. "The Vision Forum – from pixels to primates". In addition, the Committee advises the Head of School on the allocation of the **SLS** research support budget for internal pump-priming initiatives and research-related travel, and the prioritisation of the University's Research Infrastructure Fund (over £500k annually). The Committee is also responsible for identifying emerging funding streams of strategic relevance to the **SLS** and planning our response to them.

Our strategy seeks to develop our existing expertise and widen our research scope through collaborations with other groups (e.g. Lincoln Centre for Autonomous Systems in the School of Computer Science and Evolution and Development Research Group in the School of Psychology) and, of course, externally.

c. People, including:

i. Staffing strategy and staff development

Since RAE2008, **SLS** has recruited 13 permanent staff associated with this UoA, including 3 ECRs, each with strong track records of internationally recognised research. We have identified researchers that enhance our research priority areas. New staff have reduced teaching and administrative activities for their first three years, together with an experienced mentor to assist them in establishing a well-founded research career.

All **SLS** staff share a common consumables budget to support pump-priming research while they seek their own funding. New equipment purchases are agreed by all staff in accordance with recognised priorities (over £500k in financial year 2012 - 13). Since 2008, six internally funded PhD bursaries have been awarded to new staff within UoA6. Staff that are new to PhD supervision are supported by academics that have a successful track record of postgraduate supervision; in addition to attending appropriate training courses.

Independent fellows are treated as full academic staff with equal involvement in **SLS** affairs, full access to facilities, and with teaching loads commensurate with their professional development goals. Upon fellowship completion, they are normally offered permanent academic contracts.

Our staffing policy is supported by the University's People Strategy, which provides a comprehensive range of policies around employment and progression, equal opportunities, research management, governance and ethics, each with an element designed to facilitate, support and sustain research activity among staff. The 7 Principles of the Concordat to Support the Career Development of Researchers are embedded within our staffing and research strategies.

Equality and diversity are highly valued within the School. The Head of School and approximately one-third of research group members are women. We are working towards Athena Swan recognition, with our most recent appointee, Collins, being instrumental to her previous Department's Gold award. Nearly 40% of the academics within the **ABCW** and **EE** groups are non-UK nationals.

For non-probationary staff, individual research plans are developed alongside research leaders within the framework of the University's Achievement, Development and Appraisal (ADA) scheme, with the Head of School ultimately providing authorisation for resource allocation necessary to support agreed research plans. ADA plans are reviewed throughout the year and evaluated formally at least once a year. On-line tools provided as part of the University's Continuing Personal and Professional Development programme help researchers review and critically reflect on their skills, knowledge and expertise.

Staff are further empowered to manage their own professional development through a proportion of contribution income from research grants returned to the PI. The SLS supports staff without external grant income to attend meetings to present high-quality scientific papers and to allow them to build their research profile and academic credibility.

The SLS operates a research leave scheme (with Eady on leave in the 2013/14 academic year). Leave is granted based on transparent criteria including strategic importance of potential outputs (e.g. pump-priming leading to large grant applications).

ii. Research students

The census period has seen a transformation in the postgraduate research student population and their success, with 24.5 FTE MPhil/PhD students and 4.5 FTE Masters by Research students in 2013, and 11 PhD completions in the census period for UoA6. The sustained development of a vibrant postgraduate research student culture that recognises their contribution to the research environment is a core element of our strategy, and is supported by the University Graduate School. Students are team-supervised (with supervisors required to update their training every 3 years), and are also allocated a separate postgraduate mentor responsible for general guidance and pastoral care. We provide students with core transferable skills (including bioethics, IP protection, and impact generation), generic research training opportunities (e.g. journal club), a research seminar programme, an annual Life Sciences postgraduate conference and "walks and talks" - away-days with academic staff and graduate students engaged in similar research from other HE institutions. These activities provide students with frequent opportunities to present their ideas and findings to an informal and supportive cross-disciplinary audience of peers and academics.

We aim to produce confident researchers who can act as international ambassadors for the University, presenting their innovations and insights to a global audience. For example, Williams (**ABCW**) has accepted invitations from the University of Sao Paulo, Brazil and Astra Zeneca to explore future collaborations using the mobile eye-tracker system designed for dogs and developed as part of her PhD studies. Our commitment to supporting students present their research, is illustrated by Chivers (**EE**), now a graduate student in Montealegre-Z's laboratory, who produced two papers from his Lincoln dissertation, and was given financial assistance by **SLS** to present his work at national and international conferences. In the absence of external funding opportunities, we offer support to research students to attend conferences each year of their study and undertake placements at other HEIs (e.g. Racca's visit to Miklosi's lab at Eotvos, University, Hungary).

c. Income, infrastructure and facilities

A step-change in investment during the census period, culminating in the creation of **JBL** and **LSIP** reflect the confidence we have in our vitality and sustainability, based on our growing achievements. For example, the £300k invested in 2012 to build the new dedicated animal behaviour and training facility to support Burman's BBSRC project and will further support Zulch and Wilkinson's ONR award. In the last year, we have invested more than £500k in a new high-specification imaging suite. This benefits all researchers through our policy of shared access to all laboratories and facilities, which in turn promotes interdisciplinarity. The last five years has seen our research income rise from less than £400k in the assessment period leading up to RAE2008 to awards totalling around £3.2m in the current census period.

In the last 12 months research income secured has more than doubled compared to the preceding 12-month period. In RAE2008, 34% of our research-related expenditure came from funding from UK government bodies, 55% from industry and 11% from charities, during the current census period 23% of awards have come from RC-UK/Royal Society, 22% from other government bodies (e.g. Defra), 26% from industry and 29% from charities, demonstrating how successful diversification of income streams is enabling our growth. In the current census period this more diverse landscape includes BBSRC (Burman 2012; Collins 2013), NERC (Eady 2008; Osborn 2012, 2013; Pike 2011, 2012; Ruta 2012), Royal Society (Montealegre-Z 2013), Defra (Cooper, 2010), DSTL (Mills 2013), US Office of Naval Research (Zulch, Wilkinson and Croxton 2013).

A Research Support team facilitates our income generating activity, with separate staff supporting pre- and post-award processes. The University's Enterprise team manage legal, commercial and industrial relationships and interests, alongside the provision of independent specialist consultant support for research bids. A centralised on-line database ensures effective costing and management of financial resources.

We operate a pre-review scheme that has produced a more effective grant writing culture and markedly improved the quality of submissions. Staff intending to submit applications are required to engage with internal and external pre-submission reviewers, to discuss resourcing and infrastructure requirements, and where appropriate an ethical review that ensures best practice with regard to ethical legislative and regulatory requirements, with expertise available from our visiting Professor of Bioethics (Mepham) as required.

Facilities available to staff and researchers in UoA6 include:

- Four hundred hectare agricultural and parkland site, at Riseholme with pasture and wetland habitats.
- Five dedicated Animal Behaviour and Cognition Laboratories plus an additional 253 m^2 animal training facility erected in 2012, where laboratories are equipped with touch screen facilities, visible and thermographic imagery, and olfactory operant chambers for dogs, partly supported by $274k funding from US Office of Naval Research. The visual perception laboratory is shared with Colleagues in Psychology to allow unique comparative work using an EyeLink eye tracker system.
- Cattery, with aerial isolation facilities and integrated behavioural monitoring system – partly funded by Ceva Animal Health grant started in 2007.
- Bioacoustics laboratory (partly supported by an equipment grant from the Royal Society £15,000 for Montealegre-Z), with acoustic booths worth £45k instated in partnership with the University of Sussex.
- Two fully equipped molecular biology suites (at Main Campus and Riseholme).
- Wide range of analytical chemistry equipment, including EI GC-MS, HPLC, Spectrofluorophotometers, and Flame Atomic Absorption Spectrometers.
- Image analysis suite including SEM, confocal and atomic force microscopes.
- Two Category 2 microbiology suites (one each at Main Campus and Riseholme).
- Research partnership with the Parrot Zoo, Friskney Fen, the largest parrot sanctuary in the world. This has resulted in every new aviary being purpose built to accommodate research; e.g. an annex for visual perception work, and sharing the facility with the Universities of York, St Andrews and Vienna.

When the **SLS** is co-located in the newly refurbished Joseph Banks Laboratories in June 2014, staff and research students will additionally have access to:

- Dedicated ancient DNA and fossil preparation laboratory suites.
- New multi-group molecular biology laboratory (approximately 600 m^2)
- Dedicated 1,000 m^2 animal behaviour and cognition facility adjacent to the **JBL** that includes an aquarium, insectary, reptile house and accommodation for up to 20 cats and 20 dogs.
- Newly designed substantial Category 2 microbiology laboratories.
- Collaborative facilities and opportunities associated with stakeholders at **LSIP**.

These provide us with the infrastructure and facilities to support continuous growth of our research income in line with our strategic plan.

d. Collaboration or contribution to the discipline or research base

Awards and recognitions

Several staff have received recognition through academic awards and significant high-profile events. For example, John's award from the British Ecological Society (2013) recognizes her work for the Society, and Mills (2009) and Osborn (2010) were elected as Fellows of the Society of Biology. Our staff also hold visiting positions at other universities both in the UK (Mills, Zulch, Nottingham) and overseas (Ruta, Vienna; Montealegre-Z, Beijing), and are regularly called upon to work with universities internationally such as Aarhus, Bern, Monash, New England, Sao Paulo, Tel Aviv, Vienna, Jyvaskyla (Finland), Leuven (Belgium), Manhattan (Kansas, US). Montealegre-Z has recently been appointed to a Visiting Professorship at Normal Capital University in Beijing.

Membership of learned societies and advisory groups

Our staff make wide-ranging contributions to their disciplines through recognised positions on the executives of learned societies (e.g. Collins, Association for the Study of Animal Behaviour; Montealegre-Z, Orthopterist Society; John, Honorary Committee Chair and Council Member, British Ecological Society). We have increased key appointments to influential advisory groups (e.g. Burman on the BVAAWF/FRAME/RSPCA/UFAW; Collins on the Dog Advisory Council) and to funding bodies (John, Osborn, Eady and Pike – NERC Peer Review College; Collins – BBSRC

Pool of Experts).

Editorial roles for academic journals and grant reviewing

Several staff take a lead on journal editorial teams, for example Deeming is the editor-in-chief for Avian Biology Research, and key positions for other staff on international journals include: Animal Welfare (Cooper), Applied Animal Behaviour Science (Burman, Cooper), Applied Environmental Microbiology (Osborn), Behavioural Ecology and Sociobiology (Soulsbury), BMC Ecology (Pike), BMC Microbiology (Osborn), British Poultry Science (Deeming), Comparative Cognition & Behavior Reviews (Wilkinson), Comptes Rendus Palevol (Ruta), Frontiers in Comparative Psychology (Wilkinson), ISME Journal (Osborn), Journal of Herpetology (Pincheira-Donoso), Journal of Veterinary Behavior (Mills), Microbiology (Osborn), Palaeontology (Ruta), Wildlife Research (Soulsbury). Our researchers have assisted in the review process for more than 50 international journals including Science and Nature.

Staff are also making significant contributions to national and international review panels and/or act as external reviewers for such panels. Examples include ESF (Mills, Collins), EFSA (Collins), BBSRC (Burman, Osborn, Ruta), EPSRC (Osborn), NC3Rs (Burman), NERC (Eady, John, Osborn, Pike, Ruta), National Science Foundation, USA (Osborn, Ruta), Swiss National Science Foundation (Burman), National Research Foundation, South Africa (Ruta), German Research Foundation (Ruta), Humboldt Foundation, Germany (Ruta), National Geographic (Ruta), The Royal Society of New Zealand (Eady), Slovak Academy of Sciences (Ruta), ARC, Australia (Osborn), Foundation for Polish Science (Pilot), FONDECYT, Chile (Pincheira-Donoso).

Invited talks, presentations and public lectures

Members of ABCW and EE Groups have been invited to give international plenaries at leading research conferences: Burman (ECLAM/ESLAV, Israel 2011), Deeming (4th International Conference on Dinosaur Eggs and Babies, USA, 2009), Mills (Canine Science Forum Austria 2010, RSM 2011, ESCVE/ECAWBM Switzerland 2012), Montealegre-Z (International Bioacoustics Council, France 2011, Cold Spring Harbor Asia Conference on Invertebrate Neurobiology, Shanghai, 2012, International Conference of Orthopterology, Kunming, China, 2013), Osborn (International Symposium on Microbial Ecology, USA 2010), Wilkinson (Primate Society of Great Britain, 2013), Zulch (SEEVAD, 2013).

Other contributions

We continue to extend our international scientific collaborations with researchers and graduate students from all continents, through membership of the steering committee of significant nationally funded research networks (e.g. CompCog: Mills) and the organisation of international research conferences (e.g. International Veterinary Behaviour 2009 Glasgow, 2013 Portugal – Mills; Association for the Study of Animal Behaviour 2013 Lincoln – Pike, Wilkinson; Society for General Microbiology 2009, 2010 - Osborn), with Lincoln due to host the 2014 Canine Science Forum.