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NON-TECHNICAL SUMMARY

The mechanics and energetics of locomotion in birds

Project duration

5 years 0 months

Project purpose

- (a) Basic research

Key words

No answer provided

Animal types	Life stages
Galliformes (e.g. chicken, guineafowl)	adult

Retrospective assessment

The Secretary of State has determined that a retrospective assessment of this licence is not required.

Objectives and benefits

Description of the projects objectives, for example the scientific unknowns or clinical or scientific needs it's addressing.

What's the aim of this project?

The overall aim of the project is to determine how muscles are used during locomotion and how this determines the overall amount of energy used (or effort) during exercise. These measurements will underpin efforts to develop methodologies for estimating energy expenditure in freely living birds.

Potential benefits likely to derive from the project, for example how science might be advanced or how humans, animals or the environment might benefit - these could be short-term benefits within the duration of the project or long-term benefits that accrue after the project has finished.

Why is it important to undertake this work?

Improving understanding of the energy used during locomotor is of broad scientific relevance and will have impact on a range of disciplines, from ecology to engineering. Recent advances in engineering means that it is becoming possible to build legged-terrestrial robots and flapping air vehicles that operate on a similar scale to birds. However, their manoeuvrability, control and energy use are still far below that achieved in nature. Understanding bird locomotory systems will provide inspiration towards the development of bio-inspired robotics and more generally the design and control of micromechanical systems.

Such knowledge will also help in the development and refinement of computer models of animal movement. Ultimately, the research will contribute to the replacement, reduction and refinement of animals in testing since the development accurate computational models will allow some animal experiments to be replaced and in other cases reduce the numbers of animals required, as model simulations may allow research involving animals to be better designed.

There increasing interest in the changes in the distribution of organisms in response to climate change. Energy expenditure during movement is an important factor that could influence their migratory paths, distribution and ultimately their survival of birds. An improved ability to study energetics in the field will provide a useful tool to help explain current changes in population and species distribution and in predicting which species are likely to be adversely or favourably affected by future changes in climate.

What outputs do you think you will see at the end of this project?

Research publications targetted at the leading journals in the field.

Conference presentations at leading national and international conferences in a variety of fields to maximize impact.

Practical tools that will allow researchers to better estimate organismal energetics in the field.

Who or what will benefit from these outputs, and how?

Academic beneficiaries (Years 1-5): the research will be of interest to a range of biological fields, including physiology, biomechanics, ecology, robotics, computational biology. For example, ecologists studying the links between animal morphology and ecology and those interested in using practical tools for making informed assessments of bird energy use in the field.

General public (Years 1-5): animal locomotion is a topic that consistently arouses public interest. The research will inspire young audiences to take an interest in science and will have a positive impact by informing the general public about technological advances in animal science and the applications of biological research.

3Rs (Year 5): Developing accurate computational models of locomotion may allow some animal experiments to be replaced and in other cases refined or reduced as model simulations may allow research efforts involving animal research to be better designed.

Conservation NGOs (Year 5): An improved ability to study energetics of locomotion in the field will provide a useful tool, alongside ecological and developmental factors, to help explain current changes in population and species distribution and in predicting which species are likely to be adversely or favourably affected by future changes in climate. The rapid increase in the number of migratory species being studied has revealed the importance of higher resolution data at the individual and population level and the need to understand the ecological and energetic drivers that underpin lifetime reproductive success.

How will you look to maximise the outputs of this work?

Communication and Engagement: presentation of the research at leading national and international conferences in a variety of fields to maximize impact.

Public Engagement: Present our findings to audiences primarily made up of school children/young people [e.g. presentations/ activities associated with animal locomotion at National Science and Engineering Week events).

Internet Resources: A website detailing the objectives of the research will be set up for access by anyone with interest, including school children and teachers. The website will contain details about the project, links to our publications, public engagement activities, conference talks, and associated media exposure. Examples of high-speed video recordings illustrating the science will be included to engage public interest and inform them of the research and its applications.

Symposium/Workshop: organized to disseminate the information acquired during the project. Leading academics will be invited from biomechanical, physiological, and ecological fields, together with representatives from research departments at NGOs such as Royal Society for the Protection of Birds and British Trust for Ornithology.

Species and numbers of animals expected to be used

- Other birds: No answer provided

Predicted harms

Typical procedures done to animals, for example injections or surgical procedures, including duration of the experiment and number of procedures.

Explain why you are using these types of animals and your choice of life stages.

Birds have been selected that will sustain either exercise in the laboratory. Species choice is based on experience in previous work. The size of animals that will be used will be determined by that which is suitable for the techniques that we will use. Relatively large species are most suitable because any added recording equipment will have negligible effect on their locomotion.

Typically, what will be done to an animal used in your project?

Most birds will be trained to exercise until they can sustain locomotion for several minutes, including with the addition of external recording equipment. This may take several months.

Once the birds are trained, the birds will undergo exercise tests under a range of conditions while physiological recordings are made. Some of these recordings will be made while the bird exercises with external recording equipment attached. Other recordings will require the prior surgical implantation of devices internally, which will last approximately 2-4 hours, followed by recordings from the implanted devices once the birds has recovered from surgery, several days later. Once the recordings have been made during locomotion, some birds will be used to measure muscle contractile properties under non-recovery anaesthesia. Birds will be killed at the end of the protocol (7-10 days after surgery).

What are the expected impacts and/or adverse effects for the animals during your project?

Some discomfort may be experienced from the presence of the internal devices and from the surgery for up to 24 hours. It is possible that some birds could lose blood during surgery.

Expected severity categories and the proportion of animals in each category, per species.

What are the expected severities and the proportion of animals in each category (per animal type)?

Unclassified - 29%

Mild - 21%

Moderate - 50%

What will happen to animals at the end of this project?

- Killed

Replacement

State what non-animal alternatives are available in this field, which alternatives you have considered and why they cannot be used for this purpose.

Why do you need to use animals to achieve the aim of your project?

The overall aims of our research are to improve our understanding of how muscles function during locomotion. This work can only be done on live, freely moving animals and could not be replaced by a non-animal method. Furthermore to develop and validate computer models of locomotion requires data on the mechanics and energetics of movement. These data do not currently exist for birds, or indeed any other experimental animal. Therefore a systematic physiological and biomechanical investigation of bird locomotion is required in which all the primary determinants and measures of movement and energy expenditure are measured.

Which non-animal alternatives did you consider for use in this project?

Computational models could potentially be used to investigate the control of locomotion and the influence of the energetics of locomotion on animal behaviour.

Why were they not suitable?

A comprehensive validation of a computer model requires that a high proportion of the model inputs are measured directly so that the model represents the behaviour of a real animal to the highest possible degree, and that a high proportion of biomechanical outputs are measured directly so that the accuracy of the model outputs can be measured directly against real data. These data do not exist for the locomotory system of birds, or indeed any other experimental animal. Although locomotion in animals has been extensively studied, no single study has measured both mechanical and energetics variables in the same species.

Reduction

Explain how the numbers of animals for this project were determined. Describe steps that have been taken to reduce animal numbers, and principles used to design studies. Describe practices that are used throughout the project to minimise numbers consistent with scientific objectives, if any. These may include e.g. pilot studies, computer modelling, sharing of tissue and reuse.

How have you estimated the numbers of animals you will use?

Power calculations were performed for each principal outcome measure to determine the minimum number of animals required. Past experience in performing each technique was used to assess the likelihood of success for each measurement, and incorporated into the calculation of animal numbers.

What steps did you take during the experimental design phase to reduce the number of animals being used in this project?

Online sample size calculators were used to calculate the appropriate number of animals for each part of the study together with means and standard deviations from the literature for each of the variables to

be measured.

http://www.3rs-reduction.co.uk/html/6__power_and_sample_size.html

http://www.biomath.info

What measures, apart from good experimental design, will you use to optimise the number of animals you plan to use in your project?

To minimise animal numbers, where feasible, multiple measurements will be made on each animal.

Refinement

Give examples of the specific measures (e.g., increased monitoring, post-operative care, pain management, training of animals) to be taken, in relation to the procedures, to minimise welfare costs (harms) to the animals. Describe the mechanisms in place to take up emerging refinement techniques during the lifetime of the project.

Which animal models and methods will you use during this project? Explain why these models and methods cause the least pain, suffering, distress, or lasting harm to the animals.

Muscle performance during locomotion will be investigated using a variety of physiological techniques that have been selected as the most suitable approaches currently available for acquiring the data required. Since the purpose of the research is to investigate normal locomotion, it is important to select techniques that will not adversely affect locomotion.

Why can’t you use animals that are less sentient?

The research must be carried out on animals capable of performing normal locomotion, and can only be done on live, freely moving animals, fully developed, adult animals.

How will you refine the procedures you're using to minimise the welfare costs (harms) for the animals?

Surgeries will be carried out by experienced (or closely supervised) individuals. Analgesics will be used post-surgery for pain relief. Post-surgery we will observe the animals for appearance and potential behaviour indicators of pain. In event of observing indicators of pain, analgesia will be used. Any animal exhibiting excessive swelling at the surgical sites will be killed humanely using a schedule 1 method.

What published best practice guidance will you follow to ensure experiments are conducted in the most refined way?

Including, but not limited to,

On anaesthesia and surgery: Degernes, L. (2008). Anesthesia for companion birds. Compend Contin Educ Vet. 30:E2

On husbandry: Hawkins, P. et al. (2001). Laboratory birds: re finements in husbandry and procedures. Laboratory Animals 35 (Suppl. 1).

Guiding pricicples for preparing for and undertaking aseptic surgery. Laboratory Animal Science Laboratory (2017). http://www.lasa.co.uk/wp-content/uploads/2017/04/Aseptic-surgery-final.pdf

How will you stay informed about advances in the 3Rs, and implement these advances effectively, during the project?

All project partners are already involved with 3Rs and will participate in reginal NC3R events and liaise with the NC3Rs regional programme manager. In pursuing the programme of research we will implement any advances into our research programme.