

Master thesis proposal

Predicting birds' flight range

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November 6, 2018

Background—Flight

Birds' migrations have been studied since the ancient times. Today, all along their flight route birds are captured, tagged, have some measurements taken and released. However, not many are recaptured, making estimation of their target destinations very difficult. Therefore, detailed mechanistic models have been proposed to calculate a bird's flight range. They are based on the bird's physical characteristics, energetic resources available and properties of the travel medium—air. The models are step-wise models. For each time step they calculate the distance flown and energetic resources used. The range is the flown distance after all resources have been depleted.

Thesis project

Currently, flight range is estimated using C. J. Pennycuick's Flight program [2]. There are two problems with the program. Firstly, it is available only for Windows and secondly, more importantly, it allows for estimation of a single bird's range with manual imputation of its characteristics. This makes for extremely tedious work when one has measured hundreds or thousands of birds. Therefore, the first aim of the project is to build an R-package, publicly available on CRAN, that implements provided algorithms that estimate the flight range. The package should have the possibility to read-in a file (e.g. `.csv`) with measurements from multiple birds and automatically calculate the range for all of them. Following this step, exploration of statistical questions related to the range models should be done. It can happen, that biological parameters are missing or measured with great uncertainty. Therefore, various missing data imputation methods should be tested and also the sensitivity of the prediction to variation in variables. The latter could allow for quantifying error for the predicted ranges. For comparison, estimation of flight costs has been implemented in the **afpt** R package [1].

The thesis will be done in collaboration with the Department of Vertebrate Ecology and Zoology, University of Gdańsk, who will provide support from the “biological” side and a file with measurements on various birds.

Goals

1. An R package on CRAN that estimates the flight range for multiple birds at once.
2. Estimation of flight ranges for the provided data set.
3. Exploration of various missing data imputation methods. Rules of thumb: which methods should be used for which variables.
4. Exploration of the sensitivity of the range calculations to measurement error in various variables. Rules of thumb on how much care should be taken when measuring each variable.
5. Estimation, via simulations, of confidence intervals for the predicted flight ranges.
6. Study the effects of (random) variation in wind speeds and air density.

Data

The topic can be illustrated with both real and simulated data. The Department of Vertebrate Ecology and Zoology, University of Gdańsk will provide a data set with measurements on various birds.

References

- [1] K. Heerenbrink, L. Johansson, and A. Hedenström. Power of the wingbeat: modelling the effects of flapping wings in vertebrate flight. *P. Roy. Soc. A-Math. Phy.*, 471(2177), 2015.
- [2] C.J. Pennycuick. *Modelling the Flying Bird*. Elsevier (Academic Press), 2008.