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The Movebank data model for animal tracking

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ABSTRACT

Studies of animal movement are rapidly increasing as tracking technologies make it possible to collect more data of a larger variety of species. Comparisons of animal movement across sites, times, or species are key to asking questions about animal adaptation, responses to climate and land-use change. Thus, great gains can be made by sharing and exchanging animal tracking data. Here we present an animal movement data model that we use within the Movebank web application to describe tracked animals. The model facilitates data comparisons across a broad range of taxa, study designs, and technologies, and is based on the scientific questions that could be addressed with the data.

1. Introduction

Movement is a defining character of most animals, and documenting movement is key to understanding the ecology of a species, as well for the impact on its environment. Movement data is generally collected by attaching an electronic tag, such as a VHF-transmitter, GPS logger or other satellite tag, to an animal. This type of animal tracking has been conducted for almost 50 years (Cochran and Lord, 1963; Cochran, 1972; Burger and Shaffer, 2008), providing important data on many species.

Tracking technology is constantly improving, enabling tracking of lighter animals, over larger areas (Wikelski et al., 2007), for longer periods of time, with more accurate locations and with a higher temporal resolution (Rutz and Hays, 2009). If shared, these data could be used not only for the initial study objectives, but also for broader comparisons across studies, species, geographical range and years (Nathan et al., 2008). Because of the great potential for additional scientific discoveries through the comparison of these data Movebank is developed, a database and web application for their archiving and sharing. Sharing efforts like these require standardized data models, which have facilitated impressive results of large collaboration (Birdlife International, 2004; Durner et al., 2009).

Here we present the Movebank data model, which enables the description of movement data across tracking methods and taxa. It is not meant to be a direct template for a relational database but more a common standard vocabulary to discuss and share movement data.

2. Conceptual model

The conceptual model describes the key "concepts" and their "relationships". For movement data we have identified the following six concepts (Fig. 1) each are defined by a number of separate terms that can be found online (http://www.movebank.org/standards/model.rdf).

- *Animal*: An animal contains specific information about the individual of interest that was tracked, most important is the taxonomic identification and a unique identifier. An animal can also include basic descriptive data that does not change over time like sex, and date of birth.
- *Tag*: This represents the specific tag used to track an animal, including the tag model, type, weight and manufacturer. A tag can be anything, but typically are conventional radio-transmitters, bird rings, GPS, solar geolocators or Argos satellite tags.
- *Tag Deployment*: Tag deployment contains the information about the attachment of a specific tag to a specific animal. It specifies if the animal was manipulated and how the tag deployment ended, for example by death of the animal or failure of the tag.
- *Observations*: The consecutive locations are stored in observations and contain the date, time, longitude, latitude and

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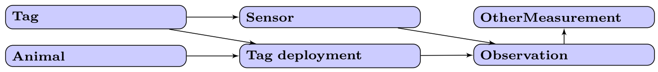

Fig. 1. Relationships between the concepts in our data model.

altitude. Also relevant here are indications of error in position estimation, and data used for position estimation.

- *Other Measurement*: Besides the common measures described in Observations, many other measures could be recorded that are either rarely taken or specific to a study, these are grouped in Other Measurements. This could for example be the forearm length of a bat measured once during a capture, or heart rate measured every minute by a sensor on the tag.
- *Sensor*: Tags vary in capabilities but in general there is a trend towards more complex tags, offering multiple functions, e.g. GPS-Argos tags that provide Argos as well as GPS locations. In order to capture the origin of each observation it is linked to a specific sensor on the tag.

3. Conclusion

This data model provides tools to describe movement data in a standardized way, whilst maintaining sufficient flexibility to describe a variety of data. It is already being applied in the Movebank project (http://www.movebank.org). Due to the dynamic nature of the field it is not possible to define one static standard. We present this model as a basic standard that can be easily adjusted and developed as new tracking technologies emerge.

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References

Birdlife International, 2004. Tracking ocean wanderers: the global distribution of albatrosses and petrels. Results from the global procellariiform tracking workshop.

Burger, A.E., Shaffer, S.A., 2008. Application of tracking and data-logging technology in research and conservation of seabirds. The Auk 125 (2), 253–264.

Cochran, W.W., 1972. Long-distance tracking of birds. In: Animal Orientation and Navigation. U.S. Gov. Printing Off., Washington D.C., pp. 39–59.

Cochran, W.W., Lord, R.D., 1963. A radio-tracking system for wild animals. The Journal of Wildlife Management 27 (1), 9–24.

Durner, G.M., Douglas, D.C., Nielson, R.M., Amstrup, S.C., McDonald, T.L., Stirling, I., Mauritzen, M., Born, E.W., Wiig, Ø, DeWeaver, E., Serreze, M.C., Belikov, S.E., Holland, M.M., Maslanik, J., Aars, J., Bailey, D.A., Derocher, A.E., 2009. Predicting 21st-century polar bear habitat distribution from global climate models. Ecological Monographs 79 (1), 25–58.

Nathan, R., Getz, W.M., Revilla, E., Holyoak, M., Kadmon, R., Saltz, D., Smouse, P.E., 2008. A movement ecology paradigm for unifying organismal movement research. Proceedings of the National Academy of Sciences 105 (49), 19052–19059.

Rutz, C., Hays, G.C., 2009. New frontiers in biologging science. Biology Letters 5 (3), 289–292.

Wikelski, M., Kays, R.W., Kasdin, N.J., Thorup, K., Smith, J.A., Swenson, G.W., 2007. Going wild: what a global small-animal tracking system could do for experimental biologists. Journal of Experimental Biolology 210 (2), 181–186.