

COMMENTARY

Open Access



A plea for standards in reporting data collected by animal-borne electronic devices

Hamish A. Campbell^{1*} , Ferdi Urbano², Sarah Davidson³, Holger Dettki⁴ and Francesca Cagnacci^{5,6}

Abstract

In recent years, there has been significant investment in collaborative e-infrastructures to support biotelemetry research. Whilst these e-infrastructures are rapidly growing in size and sophistication, the current lack of standards for reporting and documenting the data collected by animal-borne telemetry devices is hampering their effectiveness. Here, we demonstrate why the current lack of standards is severely complicating the process for those developing and maintaining biotelemetry-related e-infrastructures, and provide suggestions as to how the current issue may be resolved. We hope this article will stimulate discussion across the community and facilitate the first steps towards the creation and adoption of industry standards for data collected by animal-borne telemetry devices.

Keywords: Telemetry, Tagging, Animal, Bio-logging, Database, eResearch, Electronic tagging

Background

The technological innovation of animal-borne telemetry devices is enabling an ever-increasing quantity of variables to be recorded about an animal's location, internal state, and external environment [1]. As such, the scope of the research and application has broadened, substantially increasing the volume of device deployments around the globe [2]. At the same time, researchers seek to compile the resulting datasets to address questions requiring larger timescales and sample sizes than most individual studies can provide, and journals and funding agencies are increasingly encouraging or requiring these data to be archived as part of the research process.

To support this general trend across natural resource management and scientific communities, a number of e-infrastructures have appeared in recent years to help researchers manage, analyse, archive, and share the data collected by animal-borne telemetry devices (Table 1). These e-infrastructures assure the permanence and integrity of these data for future use and enable scientists to share data within and between disciplines [3–7].

Main text

The development and maintenance of these e-infrastructures require significant economic investment and a coordinated effort to address the many political, technical, and funding challenges. A key step in the growth and sustainability of these information systems, and their capacity to support the research community, is the ease by which data can be transferred from device to repository. The assortment of sensors now available, combined with the range of methods for the automated download of these data (ARGOS, Bluetooth, email, Iridium, Globalstar, GSM, SMS) and the sheer number of companies producing the devices, is resulting in many different attribute names, definitions, units, and file formats for reporting the same types of data. For example, different manufacturers currently report the time and date in numerous disparate formats (e.g. dd/MM/yyyy h:mm; h:mm:ss MM.dd.yyyy; yyyy.MM.dd hh:mm:ss; yyyy-MM-dd hh:mm:ss.s, etc.). In some cases, data files and documentation provide no reference to the time zone, even when allowing researchers to choose (and sometimes change on the fly) the time zone in which their data are provided. In addition, data generated by individual manufacturers can change over time, leading to outputs that misleadingly appear to be in the same format; for example, the development of a new device model or software version that changes the units for reporting

*Correspondence: Dr.hamish.campbell@gmail.com

¹ Research Institute for the Environment and Livelihoods, Charles Darwin University, Darwin, NT 0909, Australia

Full list of author information is available at the end of the article

Table 1 The current catalogue of web-based e-infrastructures for the collation, sharing, and reuse of animal biotelemetry data

Repository name	Host	Species	Regional focus	Data type	Web address
Australian animal tracking and monitoring system	Australian government	Marine species	Australia to Antarctica	Any location and biosensor data	aatams.emii.org.au
Animal telemetry network	US Integrated ocean observing system	Marine species	North America	Any location and biosensor data	http://www.ioos.noaa.gov/observing/animal_telemetry
Eurodeer	Fondazione Edmund Mach	Ungulates	Europe	Any location and acceleration data	eurodeer.org
Great Lakes acoustic telemetry observation system (GLATOS)	Great Lakes fishery commission	Freshwater species	Great lakes (North America)	Any location and biosensor data (passive acoustic)	data.glos.us/glatos
Global tagging of pelagic predators (GTOPP)	International collaboration	Marine species	Pacific	Any location and biosensor data	gtopp.org
Movebank	Max Planck Institute for Ornithology and University of Konstanz	All species	Global	Any location and biosensor data	movebank.org
OBIS-SEAMAP	Duke University	Marine mammals, seabirds, sea turtles	Global	Any location and biosensor data	seamapenv.duke.edu/
Ocean tracking network	Dalhousie University	Aquatic species	North America	Any location and biosensor data (passive acoustic)	oceantrackingnetwork.org/
Seaturtle.org	private organization	Sea turtles	Global	Location data (Argos)	seaturtle.org
Global procellariiform tracking database	BirdLife international	Seabirds	Global	Location data	seabirdtracking.org
Wildlife tracking	private organization	All species	Global	Location data (Argos)	wildlifetracking.org
Wireless remote animal monitoring (WRAM)	Swedish University of Agricultural Sciences	All species	Global	Any location and biosensor data	http://www.slu.se/wram/
ZoaTrack	Atlas of living Australia	All species	Australasia	Any location data	zoatrack.org

instantaneous ground speed without any related change in data output files. Such changes may or may not be discovered during import to an e-infrastructure and data analysis. The quality of metadata describing data output varies widely—whilst some manufacturers provide thorough and up-to-date manuals, data for many devices lack complete written documentation defining variables, units, accuracy/precision, etc., and including a history of changes.

The resulting ambiguities in how data, and even the same variables, are reported make it almost impossible for data upload into the repositories to be a fully automated process and are creating serious challenges for those wishing to store and integrate data from multiple telemetry devices within a single database. All existing e-infrastructures are severely affected by this problem because the creation of dedicated import procedures, each tailored to the device, manufacturer, and model, is a time-consuming and error-prone task that also requires continual monitoring and updating as new models and manufacturers enter the research arena. The current approach is expensive and will become increasingly infeasible if manufacture proliferation and device diversification continue at the current rate without globally adopted data standards.

Here, we request that the device manufacturers and scientific community take steps to develop and instigate standards for the reporting and documentation of data collected by an increasing plethora of animal-borne telemetry devices. We understand that sensors differ in design and purpose; however, we believe that most of the scientifically relevant data collected can be described by a finite set of variables. When stored along with information about the sensor (manufacturer, model, etc.), shared data standards can allow data from a wide range of sensors to be properly archived and analysed together. In particular, we ask that manufacturers and the research community design and implement.

- Standard variable names, definitions, data types, and units for commonly used data attributes.
- A standard and documented file format, such as an Extensible Markup Language (XML) schema, as an option for receiving data. There are already widely accepted standards for reporting many of the variables most commonly used by biotelemetry devices (for example, providing timestamps in Coordinated Universal Time (UTC) and geographic coordinates in the WGS84 reference system). Several standards already exist to describe ecological and geospatial data that can be used as a preliminary reference, for example: Darwin Core and ABCD from TDWG for biological collections; Ecological Metadata Language

(EML) from the Knowledge Network for Biocomplexity; the US Federal Geographic Data Committee's (FGDC) standards for geographic information (with an extension for biological information); ISO 19115 from the International Organization for Standardization for geographic information; and GPX (GPS Exchange Format).

- As a first step, we also request that individual device manufacturers, if they have not done so already, provide complete written documentation (metadata) for all variables and formats currently used by their devices, if needed including a history of past changes and description of how data differ between devices, user-specific preferences, data access methods, or file formats. Such documentation does not allow for interoperability or automated integration of data into repository, but would minimize archiving errors and enable future implementation of the standards above with historical data.

The definition and adoption of such standards by all manufacturers would dramatically simplify the data acquisition process, augmenting the willingness of biotelemetry researchers to archive their hard-won data-collections; reduce data management costs, allowing e-infrastructures to focus on developing shared analysis tools; and minimize the risk of errors derived from data handling, enhancing data reusability. These improvements in how the community share and reuse data would in turn benefit the device manufacturers by placing greater value on the data their devices collect to the wider scientific and natural resource management communities.

The definition and adoption of standards in the reporting of data collected by animal-borne electronic devices are the first necessary step towards a more general and comprehensive set of data standards that would enhance interoperability amongst the different e-infrastructures. The recently formed International Bio-Logging Society has made one of its goals to “standardize data protocols to make the various marine and terrestrial databases interoperable”. For reasons outlined in this article, we urge for this to be instigated at the level of device manufacture and propose a dedicated workshop at the next International Bio-Logging Science Symposium, inviting developers from all the Animal Biotelemetry e-infrastructures, as well as the leading device manufacturers and research scientists.

Conclusions

We have a unique community in which researchers, software developers, and manufacturers work collaboratively to develop new tools to address novel research questions. We believe we can now work together to develop the

data standards needed to meet growing data archiving requirements and enable the multi-species, long-term, and continental-scale ecological studies that the research community is striving towards [1, 8].

Authors' contributions

All authors contributed equally in the writing and proofing of this manuscript. All authors read and approved the final manuscript.

Author details

¹ Research Institute for the Environment and Livelihoods, Charles Darwin University, Darwin, NT 0909, Australia. ² Freelance consultant, Milan, Italy. ³ Max Planck Institute for Ornithology, Am Obstberg 1, 78315 Radolfzell, Germany.

⁴ Department of Wildlife, Fish, and Environmental Studies, Swedish University of Agricultural Sciences, Skogsmarksgränd, 90183 Umeå, Sweden. ⁵ Department of Biodiversity and Molecular Ecology, Fondazione Edmund Mach, Via Edmund Mach 1, 38010 S. Michele All'adige, Trentino, Italy. ⁶ Organismic and Evolutionary Biology Department, Harvard University, 26 Oxford St, Cambridge, MA 02138, USA.

Competing interests

The authors declare that they have no competing interests.

Received: 3 September 2015 Accepted: 23 December 2015

Published online: 06 January 2016

References

1. Kays R, Crofoot MC, Jetz W, Wikelski M. Terrestrial animal tracking as an eye on life and planet. *Science*. 2015;348(6240):aaa2478. doi:[10.1126/science.aaa2478](https://doi.org/10.1126/science.aaa2478).
2. Campbell HA, Beyer HL, Dennis TE, Dwyer RG, Forester JD, Fukuda Y, Lynch C, Hindell MA, Menke N, Morales JM, Richardson C, Rodgers E, Taylor G, Watts ME, Westcott DA. Finding our way: on the sharing and reuse of animal telemetry data in Australasia. *Sci Total Environ*. 2015; doi:[10.1016/j.scitotenv.2015.01.089](https://doi.org/10.1016/j.scitotenv.2015.01.089).
3. Coyne MS, Godley BJ. Satellite tracking and analysis tool (STAT): an integrated system for archiving, analyzing and mapping animal tracking data. *Mar Ecol Prog Ser*. 2005;301:1–7.
4. Kranstauber B, Cameron A, Weinzierl R, Fountain T, Tilak S, Wikelski M, Kays R. The Movebank data model for animal tracking. *Environ Model Softw*. 2011;26(6):834–5.
5. Cagnacci F, Focardi S, Hewison AJM, Morellet N, Heurich M, Stache A, Kjellander P, Linnell JDC, Mysterud A, Neteler M, Delucchi L, Ossi F, Urbano F. Partial migration in roe deer: migratory and resident tactics are end points of a behavioural gradient determined by ecological factors. *Oikos*. 2011;120:1790–802.
6. Dwyer RG, Campbell HA, Brooking C, Brimblecombe W, Hunter J, Watts ME, Franklin CE. An open web-based system for the analysis and sharing and analysis of animal tracking data. *Anim Biotelemetry*. 2015;3(1):1–11.
7. Dettki H, Brode M, Clegg I, Giles T, Hallgren J. Wireless remote animal monitoring (WRAM)—a new international database e-infrastructure for management and sharing of telemetry sensor data from fish and wildlife. In: Ames DP, Quinn NWT, Rizzoli AE, editors. *Proceedings of the 7th International Congress on Environmental Modelling and Software*, June 15–19, San Diego; 2014. p. 122–8. ISBN: 978-88-9035-744-2.
8. Hussey NE, Kessel ST, Aarestrup K, Cooke SJ, Cowley PD, Fisk AT, Harcourt RG, Holland KN, Iverson SJ, Kocik JF, Mills Flemming JE, Whosiskey FG. Aquatic animal telemetry: a panoramic window into the underwater world. *Science*. 2015;348(6240):1255642. doi:[10.1126/science.1255642](https://doi.org/10.1126/science.1255642).

Submit your next manuscript to BioMed Central and we will help you at every step:

- We accept pre-submission inquiries
- Our selector tool helps you to find the most relevant journal
- We provide round the clock customer support
- Convenient online submission
- Thorough peer review
- Inclusion in PubMed and all major indexing services
- Maximum visibility for your research

Submit your manuscript at
www.biomedcentral.com/submit

