Moving toward a sustainable ecological science: don't let data go to waste!

Timothée Poisot, Ross Mounce, Dominique Gravel

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Introduction

Claude Bernard (Bernard 1864) wrote that "art is *me*; science is *us*". This sentence has two meaning. First, the altruism of scientists is worth more than the self-indulgence of mid-nineteenth century Parisian art scene. Second, and we will keep this one in mind, creativity and insights come from individuals, but validation and rigor are reached through collective efforts, cross- validation, and peerage. Given enough time, the conclusions reached and validated by the efforts of many will take prominence over individualities, and this (as far as Bernard is concerned), is what science is about. With the technology available to a modern scientist, one should expect that the dissolution of *me* would be accelerated, and that several scientists should be able to cast a critical eye on data, and use this collective effort to draw robust conclusions.

In molecular evolution, there exists a large number of databases (GenBank, EMBL, SwissProt, and many more) in which information can be retrieved. This values (and allows) a new type of scientific research: building over the raw material of others, it is now possible to identify new phenomenon or evaluate the generality of previously studied ones. The job of these scientists is not to *make* data, neither to *stole* them, it's rather to gather them and, most of all, look at them in a different way. This would not be possible, if not for the existence of public, free, online repositories. It's impossible to be as enthusiastic when looking at current practices in ecology. Apart from a few, non-specific initiatives (*DataDryad*), or small-scale initiatives which are not always properly maintained (*Interaction Web Networks Database*), there is no data sharing culture among ecologists.

Yet in the recent years, there has been a strong signal that some organizations are ready to invest time and money in data sharing. For example, *DataONE* (Reichman, Jones, and Schildhauer 2011) is a large scale initiative, seeking to curate and make available observational data. We foresee that improving our data sharing practices will be an important thing in the coming years, and

it is important to increase the awareness of the scientific community to these practices.

In this paper, using example primarily taken from ecology and evolutionary biology, we will argue that improving our data sharing practices will improve both the science, and the reputation of the scientists. We will illustrate how simple steps can be taken to greatly improve the situation, and how we can encourage the practice of data-sharing at different levels (Whitlock et al. 2010), and data citation, to encourage and reward sharing. Our most important point is that through sharing more data, we will increase both the quality and visibility of the science we produce. We conclude this paper by showing that most of the technical aspects of data sharing can easily be mastered, meaning that data are ready to be liberated!

Why we morally must

An important point to make is that data sharing is a moral obligation of sorts. In this part, we point out the ethical aspects of data sharing, both with regards to other scientists, funding agencies, and your own collaborators.

Data acquisition is (mostly) publicly funded

In contrasts with other fields such as energy, medicine, and pharmaceutical research, most ecology research is funded through public grants or charitably-funded programs. Or in other words, ecological research is enabled by the taxpayers. In some fields, most notably conservation biology, it is not uncommon that eco-volunteers participate in data gathering. For example, the French temporal survey of common birds (Jiguet and Julliard 2006), which resulted in 29 publications in peer-reviewed journals, is fed entirely through the work of amateur ornithologists. Given the direct (participatory) or indirect (financial) involvement of the public in ecological data collection, it is not surprizing that some funding agencies have implemented data availability policies. For example, the british *BBSRC* requires that "[p]ublicly-funded research data are a public good, produced in the public interest", which "should be openly available to the maximum extent possible". It then further adds that "[t]he value of data often depends on timeliness[;] it is expected that timely release would generally be no later than the release through publication of the main findings". Similarly, *NERC* states that "[a]ll the environmental data held by the NERC Environmental Data Centres will normally be made openly available to any person or any organisation who requests them.". Sanctions are also put in place, as "[t]hose funded by NERC who do not meet these requirements risk having award payments withheld or becoming ineligible for future funding from NERC". This perfectly mirrors one of the earliest debate about open-access: science which is made possible through public involvment must be made public. Publicly funded scientists, in most

countries, are civil servants. Generating data is part of their job description, and there is no rational argument for whic they should claim *property* of it. Claiming *paternity* of the data, as we discuss below, is a perfectly legitimate claim, but does not prevent sharing them.

It improves reproducibility

Using journals to publish scientific information should not only serve the purpose of disseminating an interesting discussion of data; it should maximize the ability of other researchers to replicate, and thus both validate and expand, results. It is arguably a perversion of the *publish-or-perish* mentality, that we think only in terms of papers. Interestingly, although editors and referees are very careful about the way the *Materials & Methods* sections of a paper are worded, it is extremely rare to receive any comment about the data availability. This can cause problems at all steps of the life of a paper. How can a paper describing a new method be adequately reviewed if data are not available? How can you be sure that you are correctly applying a method if you can't reproduce the results? The movement of *reproducible research* (Mesirov 2010) advocates that a paper should be self-contained, *i.e.* be not only the text, but also the data, and the computer code to reproduce the figures. Even without going to such lengths, releasing data and computer code alongside a paper should be viewed as an ethical decision. Barnes (Barnes 2010) made the point that even though researchers are not professional programmers, computer code is good enough to be shared.

It will clarify authorship

Also, add a point about the quantification of authorship, some refs to cite here: http://aidanmkeith.wordpress.com/2012/11/06/tiered-authorship-as-a-simple-quantifiable-and-greyscale-measure-of-contribution/

(McGee 2011) takes a village

(Weltzin et al. 2006) important for responsibility accountability

(Tscharntke et al. 2007) authorship should be about reflecting who did what, and quantifying it

Data cost money

(Heidorn 2008) dark data, there is already enough material to answer some pending questions

(Wicherts et al. 2006) surveyed the field of psychology, and showed that asking for the raw data often doesn't result in a successful data sharing outcome, even

after 6 months of repeated inquiries. Authors can claim to have 'lost' the data, can be extremely slow to reply, can ignore emails, the given contact email address may be invalid and difficult to find the 'current' contact address. Authors also die, and sadly this can result in the loss of valuable scientific data unless it has been accessibly and discoverably archived elsewhere. Ultimately, authors can also flat out refuse to give the data.

Which benefits it will bring us

- A proxy to your science: data are a mean for people to get familiar with what you do

(Ince, Hatton, and Graham-Cumming 2012) improves reproducibility and adequate communication of your results

(Vandewalle 2012) showed that sharing computer code improved the scientific impact

(Piwowar, Day, and Fridsma 2007) Sharing detailed research data is associated with increased citation rate for your papers

- It stimulates collaboration and creativity
- A measure of your productivity that is increasingly being appreciated and encouraged by research funder agencies, as an example: the NSF (US) Grant Proposal Guidelines for 2013 have renamed the 'Publications' section to 'Products' specifically to make it clear that they apppreciate research products that "include, but are not limited to, publications, data sets, software, patents, and copyrights" (http://nsf.gov/pubs/policydocs/pappguide/nsf13001/gpg_sigchanges.jsp). Published datasets are now truly creditworthy, first class research objects (http://www.force11.org/white_paper) in the eyes of many funders.

How we technically can

Data representation

Except when they are deposited into large-scale databases, such as the ones we previously mentioned, data usually live (in various states of dormancy) on the hard drives of researchers. These data are usually formatted in the way where they were used to produce the few figures used in the published account, which is to say mostly as a spreadsheet, or a raw text file (Akmon et al. 2011). JSON / XML

Data sharing

- Local databases but linked globally: APIs and programmatic access

An important obstacle is that maintaining a global database requires funding on a scale which is orders of magnitude higher than what most grants will cover. The other solution, building on an increased use of strict data specification, is to link several local databases through APIs. A potential research output for working groups should thus be to design a strong data specification, and to publish it for other researchers to adopt. In the ecological sciences, there are now publications outlets focused only on methodological papers (*Methods in Ecology and Evolution*, and to some extent *BMC Bioinformatics*), and several other journals have sections for methodological papers. The conception of a data specification can thus be valorised as a research output in the form of a publication, which is accounted for by funding and tenure committees.

- FigShare and other projects: data can have a DOI and be cited/shared

Data freedom!

- Apply appropriate Creative Commons licenses or waivers to digitally available research data to remove legal barriers to re-use and prevent legal ambiguity over what type of re-use is allowed by the authors. We echo (Hrynaszkiewicz and Cockerill 2012) that the CCO waiver is best for factual non-copyrightable data (e.g. measurements) and that the Creative Commons Attribution license (CC BY) is best for copyrightable data such as photographs. Both these licenses are in accordance with the Panton Principles (http://pantonprinciples.org/) for open data in science. See (Hagedorn et al. 2011) for further details, including an explanation of the pitfalls of more restrictive Creative Commons licenses.

How it should be encouraged

The role of journals

Journals are in the best position to make things move (Vision 2010), because a scientist career depend on getting its papers accepted. Although when possible, a bottom-up approach should always be preferred, editors have in their hand a formidable lever to modify our collective behavior. Some journals are now asking the authors to deposit their ecological data in a public repository (Fairbairn 2011 ; Whitlock et al. 2010). This is mandatory for sequences in all journals (*GenBank*), and archiving of all data in TreeBase, DataDryad, or FigShare is becoming a common practice. The referees are, however, rarely asked to evaluate

if the adequate data are released (*e.g.* network metrics and summary statistics instead of full networks), and even more rarely given access to the data during the evaluation process. In practice, authors are still free to release summary statistics instead of raw data, which allows to reproduce the paper, but not to confirm the validity of the approach.

Journal-led mandates cannot be the only solution used. When compliance with journal stipulations are retrospectively checked, even clinical trials data compliance (Prayle, Hurley, and Smyth 2012) and *GenBank* archiving of data are not universally adhered to, even in the 'best' journals of highest reputation (Noor, Zimmerman, and Teeter 2006). Journals must take care that data archiving mandates are enforced and not just 'rhetoric', be it through increased editorial control, or by asking the referees to evaluate the data sharing plans.

Ecological journals have policies in place

The role of funding agencies

Conclusion

In the last two years, there were an important number of media outbursts, and public indignation, about the role of science and scientific conduct, which may all have been avoided if the practice of putting data publicly online was widespread. The so-called *climategate* (Jasanoff 2010) could have been largely averted if all data were made public in the earlier days of the affair, as it was later clearly demonstrated that the apparent lack of transparency eroded public trust in scientists (Leiserowitz et al. 2010 ; Ravetz 2011). Even more recently, the controversy over a study on the carcinogenicity of GM maize (Séralini et al. 2012) was thickened by the refusal of both sides (Monsanto and the French research group) to release the full data, in addition to many undisclosed conflicts of interests (Meldolesi 2012).

When journal editors started publicly discussing the matter, they called this *data archiving* (Fairbairn 2011 ; Whitlock et al. 2010). We would exhort other scientists not to use this expression. Data *archiving* evocates cardboard boxes, in which data are put to collect some dust. Wether this happens in the hard-drive of a scientist or in a well-maintained repository only differs in the fact that the later solution comes with a DOI. We think that the process or making data available should be called in a way which reflects its objectives: *data sharing*. We have the technology in place to give data a second life, in which the scientific community can appropriate them, recognize the paternity of those who generated them, and acknowledge this through citations. Data are all we care about. They make our papers possible. They bring answers to our questions, and much better, questions to our answers. After serving us so well, they deserve better than to be *archived*.

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