Editorial: The reporting of statistics in research articles is key to the understanding and reproducibility of good research in animal science

Isabelle Ortigues Marty, H. Stryhn, E. Paquet, B. Ampe, C.A. Montoya, J. Fenlon

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Editorial: The reporting of statistics in research articles is key to the understanding and reproducibility of good research in animal science

I. Ortigues-Marty [a,*], H. Stryhn [b], E. Paquet [c], B. Ampe [d], C.A. Montoya [e], J. Fenlon [f]

[a] UMR1213 Herbivores, INRAE, Université Clermont Auvergne, VetAgro Sup, 63122 Saint-Genès-Champanelle, France
[b] Department of Health Management, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown, PE, Canada
[c] Département des sciences animales, Université Laval, Québec G1K 1E8, Canada
[d] Animal Sciences Unit, Institute for Agriculture and Fisheries Research (ILVO), 9090 Melle, Belgium
[e] Smart Foods and Bioproducts Group, AgResearch Ltd, Palmerston North, New Zealand
[f] Dept. of Statistics, University of Warwick, Coventry CV4 7AL, UK

The journal *animal* has just released its new Statistical Guidelines for Authors which are available online (Fenlon et al., 2024 and https://animal-journal.eu/animal-journal/instructions-and-policies/). By way of these Guidelines, *animal* recognises that there is usually no unique way to analyse data, but considers that for readers, editors and reviewers to understand and to reproduce the research, the statistical analysis and the conclusions, precise and thorough reporting together with a clear presentation are required.

There is no unique way to analyse data

'*It is easy to lie with statistics. It is hard to tell the truth without it.*'

(attributed to Andrejs Dunkels, a Swedish mathematician, quoted in Chapter 3 of Varsavsky et al. (2011)).

In their 2013 working paper, Gelman and Loken state " A dataset can be analysed in so many different ways (with the choices being not just what statistical test to perform but also decisions on what data to include or exclude, what measures to study, what interactions to consider, etc.), that very little information is provided by the statement that a study came up with a $P < 0.05$ result." Although they are making a point about the statistical analysis of a set of data, Gelman and Loken are actually referring to the decisions that surround the composition of that dataset.

Unless those decisions are stated clearly, then the assumptions necessary for a formal statistical analysis cannot be guaranteed, and reproducibility is compromised. Results and conclusions can differ widely depending on the way data are analysed, as a recent preprint by Gould et al. (2023) illustrates well. They shared two sets of data with over 200 biologists to analyse the same data in their own way to answer a similar question. The study showed a huge heterogeneity in results and interpretations by different scientists. This example is a perfect illustration of the fact that statistical analyses do not automatically follow from a given set of data. Whilst the analysis will depend on the origin and structure of the data, it is also dependent on the research hypothesis and/or objective, and on the assumptions and decisions made by the authors. This is the main thrust of the argument of Gelman and Loken (2013). It is therefore critical that when reading a research paper, the reviewers and editors, initially, but ultimately any reader, understand precisely how the study was conceived, designed, run and analysed, and they are able to reproduce it, at least intellectually. To effect this, a detailed description of what has been done at all stages of the study is essential.

The journal *animal* has a wide remit; studies submitted to the journal range from carefully controlled comparative experiments, through sample surveys and analyses of extensive database or observational studies to studies that are more exploratory, relying on statistical methods to elicit possible hypotheses and qualitative research. It is only in the first category of randomised controlled experiments that the standard analysis is (completely) defined by the experimental design, and even here, the choice of measurements, and the correlations between them can mean that the form of analysis is not unique. The review by Baker (2016) is an investigation of scientists' views on the problem of reproducibility, and one of the major conclusions was that some 90% of the respondents, in answer to the question "What can be done?", stated that more robust statistical design was necessary. Away from the very focused studies based on randomised control trials (particularly comparative studies) questions of inference rely very much on the assumptions of the researchers, and these assumptions determine the statistical methods that researchers adopt.

Philosophy of the new Statistical Guidelines for Authors: thorough reporting for an improved understandability and reproducibility

The Guidelines do not define 'good' or 'bad' practices. Rather, they stress the importance of a good quality of reporting and define reporting requirements for each section of an article. Associated with each requirement, advice on good practice is provided. The entry point for authors is the Instructions for Authors, which list the reporting requirements and direct authors to appropriate parts

* Corresponding author.
E-mail address: isabelle.ortigues@inrae.fr (I. Ortigues-Marty).

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of the Statistical Guidelines for Authors should they want more guidance. The Guidelines also include some general principles that may be of interest, such as good ethical practice in statistics, and highlight frequent flaws. The objective is not to drown authors under heavy and unrealistic procedural requirements. Instead, it is intended to offer authors an operational tool, a list of reporting requirements adapted to animal science, to help them present their work and make it better understandable to readers. Incidentally, the tool can also be helpful when planning an experiment. The help offered by the guidelines is not strictly directed at authors submitting manuscripts to *animal*, but at any author submitting a manuscript to any animal science journal and at readers wishing to make their own mind up on the quality and the inference of results they are reading in an article. The Statistical Guidelines also provide help for editors in deciding on the quality of a submission.

Why has the journal developed new Statistical Guidelines for Authors?

The previous Guidelines had become out of date, in view of the rapid and recent progress in statistical methodology (and software), new research directions throughout the world, and the variety of study approaches. When statistical editors of the journal carefully analysed almost 2 years of publications in *animal*, they observed that the quality of statistical analyses and results published in *animal* was variable; for designed experiments, for example, the gold standards of Replication, Randomisation, Representativeness and Blocking were not always met; more worryingly, articles did not always provide the information necessary to evaluate the quality of the statistical analyses and results. Some published studies were underpowered, and authors sometimes formulated inferences that were not supported by the data. Three obvious factors can be cited here that impinge on the nature and use of statistics, and are worth commenting on. One is the availability of large data sets and the emergence of data science as a discipline to analyse them. Data science and statistics do not fully align, and the strong focus on inference in the historical discipline of statistics and its provision of a scientific framework for distinguishing between correlation and causation are sometimes lost in the drive to analyse large data sets; without randomisation inference becomes less straightforward. Indeed '*The central dogma of statistical inference, that there is a component of randomness in data, enables researchers to formulate questions in terms of underlying processes, quantify uncertainty in their answers, and separate signal from noise*.' (American Statistical Association, 2023). The second point relates to the tendency to focus on large production units and systems. This often undermines some of the basic principles of historical experimental design and poses a huge challenge for the use of classical statistical inference. A third point, which relates somewhat to the first, is the proliferation of statistical software that enables researchers to use methods and models that could only be dreamt of in the past – such software often makes assumptions and relies on default settings that can have a marked impact on the results of an analysis, the implications of which are not always understood by researchers.

These observations were of serious concern at a time when science is generally facing a reproducibility crisis (Baker, 2016; Raphael et al., 2020) and a loss of trust from society. The journal decided to act and contribute to the general challenge, faced by all science-driven journals, of improving the quality of published research. *animal* belongs to a consortium of international scientific institutions, that is managed by scientists who are both conscious of their responsibility and aim to apply the best ethical and scientific practices in animal science publishing. It is the duty of the journal to our peer researchers and more generally to society.

The updated Statistical Guidelines are based on four principles

1. *animal* is a science journal where statistics is 'the servant not the master';
2. it is not the place of the journal to dictate statistical methods but to encourage good statistical practice and presentation;
3. the guidelines focus on transparent reporting for reproducible research rather than prescribing methods; and
4. the guidelines include a reasonable level of requirements but imbed flexibility.

The group of statistical editors of the journal worked for almost 3 years, in close collaboration with the Section Editors and the (Deputy) Editors-in-Chief to produce the updated Guidelines. The present outcome covers close to 70% of published research in *animal* (i.e., on average 50% relying on designed experiments and 20% on database analyses). It will remain a living document that will be updated in the future to cover the newly arising practices. Also, to ensure that the recommendations on statistics are applied, the key reporting requirements will be integrated into the presubmission checklist, and submissions not meeting the requirements may be rejected or sent back to authors for revision.

Ethics approval

Not applicable.

Data and model availability statement

Not applicable.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) did not use any AI and AI-assisted technologies.

Author ORCIDs

B. Ampe: https://orcid.org/0000-0002-8223-2870.
C. Montoya: https://orcid.org/0000-0001-6953-8624.
E. Paquet: https://orcid.org/0000-0001-9194-1655.
I. Ortigues-Marty: https://orcid.org/0000-0002-0399-013X.
H. Stryhn: https://orcid.org/0000-0002-4284-9999.

CRediT authorship contribution statement

I. Ortigues-Marty: Writing – review & editing, Writing – original draft, Project administration, Conceptualization. **H. Stryhn:** Writing – review & editing. **E. Paquet:** Writing – review & editing. **B. Ampe:** Writing – review & editing. **C.A. Montoya:** Writing – review & editing. **J. Fenlon:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of interest

None.

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