

Design animal experiments with statistical power: “pwr4exp” – An R-based user-friendly tool supporting 3R principle

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Robust experimental design in animal nutrition research requires rigorous power analysis to ensure valid and reproducible findings. However, a review of 4,376 animal nutrition publications (1995–2023) revealed that only 4.73% reported power analysis, with 59% lacking methodological details and most relying on non-open-source tools like SAS. While SAS-based approaches (e.g., Stroup, 1999, 2002) are versatile, they lack **automated** degrees-of-freedom (DF) approximation, a limitation for models requiring covariance adjustments, making them challenging to implement effectively. To address these gaps, we introduce **pwr4exp** (<https://cran.r-project.org/web/packages/pwr4exp/index.html>), an open-source R package enabling model-oriented power analysis. Built on linear mixed model theory, **pwr4exp** automates DF approximation and enables power calculations for standard designs (e.g., randomized block, split-plot, and Latin Square) while supporting custom experimental designs tailored to diverse study objectives. This package provides actionable sample size estimates, guiding decisions on experimental logistics - e.g., prioritizing primary objectives in large commercial herds or detailed multi-variable sampling in smaller trials. Validation against SAS confirmed accuracy, with **pwr4exp** resolving DF challenges and offering an intuitive interface. By enabling precise power approximation, **pwr4exp** advances the **3R** principles by reducing animal use (Reduction) while maintaining statistical rigor. Integration into research workflows enhances statistical robustness, minimizes Type II errors, and improves translational relevance, aligning ethics with scientific impact. In the EAAP presentation, we will introduce **pwr4exp** with validated examples and discuss its implementation as an integral tool in experimental design before conducting animal trials.

Keywords: Power analysis, Experimental design, R package, **pwr4exp**, 3R principle