

(Revised: March 2025)

Instructions to authors of the South African Journal of Animal Science

ISSN 2221-4062 (online)

Submissions are done electronically through the online journal management system (OJMS) at www.sasas.co.za.

Scope of the journal

The South African Journal of Animal Science is an open access, peer-reviewed journal for the publication of original scientific articles and reviews in the field of animal science. The journal publishes reports of research dealing with the production of farmed animal species (cattle, sheep, goats, pigs, horses, poultry, and ostriches), as well as pertinent aspects of research on aquatic and wildlife species. Disciplines covered include nutrition, genetics, physiology, and production systems. Systematic research on animal products, behaviour, and welfare are also invited.

Rigorous testing of well-specified hypotheses is expected. In all cases, submissions should represent original contributions to current scientific knowledge of the principles, and application of principles, governing the functioning of animals and their relationship to the social or physical environment. Details of requirements for different categories of manuscripts and of the peer-review process are given below. Prospective authors should adhere strictly to the guidelines detailed in the instructions to authors.

Manuscripts that are not written with proper English grammar and syntax or that do not fully comply with the style and format of the journal will not be accepted for review.

Electronic publication

The South African Journal of Animal Science is published electronically and can be accessed at the following address: <https://www.sasas.co.za/resources/sa-journal-animal-science/>. One volume is published per year, consisting of twelve issues, published monthly. Accepted articles will be published as soon as the publication fee has been paid and the copy-ready version has been approved by the submitting author. Note that there is no hard-copy publication of the South African Journal of Animal Science.

Publication fees

Authors will receive an invoice and publication agreement upon acceptance of their article. Payment can be made via the OJMS using a credit card. An accepted manuscript will not be edited and published until the fee has been paid and the publication agreement, signed by ALL authors, has been returned.

Authors who wish to take advantage of the discount available for active South African Society for Animal Science (SASAS) members are requested to indicate this in their comments to the editor when submitting their manuscript, and to email their SASAS membership certificate to sajas.eic@gmail.com on manuscript submission. SASAS membership certificates

can be downloaded from the SASAS Member Area (<https://www.sasas.co.za/member-area/download-certificate/>).

Effective 1 January 2025, the publication fees per article published are:

- **Non-SADC international authors (SASAS non-members): USD 750 for a 10-page manuscript + USD 75 per additional page**
- **Non-SADC international authors (SASAS members): USD 600 for a 10-page manuscript + USD 60 per additional page**
- **SADC authors (SASAS non-members): ZAR 10 000 for a 10-page manuscript + ZAR 1000 per extra page**
- **SADC authors (SASAS members): ZAR 8000 for a 10-page manuscript + ZAR 800 per extra page (where the senior or corresponding author on the manuscript is a SASAS member)**

Copyright

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Policy on preprints

The South African Journal of Animal Science allows the submission of manuscripts that have been previously uploaded as preprints. However, authors must clearly indicate this in their comments to the editor during the submission process, and must also provide the full details of the preprint and how it can be accessed. Accepted publications for which preprints have been uploaded will include a statement to this effect, with a link to the preprint, in the final publication.

Policy on plagiarism

(Adapted from <https://www.nature.com/nature-research/editorial-policies/plagiarism>, 13/8/2019).

Plagiarism is unacknowledged copying or an attempt to misattribute original authorship, whether of ideas, text, or results. Plagiarism can include 'theft or misappropriation of intellectual property and the substantial unattributed textual copying of another's work.' Plagiarism can be said to have clearly occurred when large chunks of text have been cut and pasted without appropriate and unambiguous attribution. Such manuscripts would not be considered for publication in the South African Journal of Animal Science.

Aside from wholesale verbatim reuse of text, due care must be taken to ensure appropriate attribution and citation when paraphrasing and summarising the work of others. 'Text recycling' or reuse of parts of text from an author's own previous research publications is a form of self-plagiarism. Here, too, due caution must be exercised. When reusing text, either from the author's own publications or that of others, appropriate attribution and citation are mandatory. Such attribution avoids creating a misleading perception on the part of the reader that the text is a unique contribution by the authors.

Duplicate publication occurs when an author reuses substantial parts of their own published work without providing the appropriate references. This can range from publishing an identical paper in multiple journals to adding only a small amount of new data to a previously published paper.

The editor-in-chief of the South African Journal of Animal Science assesses all such cases on their individual merit. Plagiarism detected in the review process will cause the

submitted manuscript to be either rejected or immediately returned to the authors for correction. When plagiarism becomes evident after publication, the original publication may be corrected or retracted depending on the degree of plagiarism, context within the published article, and its impact on the overall integrity of the published study.

Retractions

Procedures as recommended by the Committee on Publication Ethics (COPE) (www.publicationethics.org) will be followed.

Policy on large language models (LLMs)

Large language models, such as ChatGPT, do not currently satisfy our authorship criteria. Notably an attribution of authorship carries with it accountability for the work, which cannot be effectively applied to LLMs. Use of an LLM should be properly documented in the Materials and methods section (and if such a section is not available, in a suitable, alternative part) of the manuscript.

Submission and review process

Please note that all submissions are handled via the OJMS (<http://journals.sasas.co.za/>). Authors should receive prompts and updates from the system on the progress of their submission and should navigate the OJMS to find the required information (e.g., in-press articles, review stage).

- All submissions will be subjected to a peer-review process.
- The data upon which all types of manuscripts are based should be original (except review articles), should not have been published previously in a peer-reviewed scientific journal, and should not be under consideration for publication elsewhere. Submission of a manuscript is understood to imply that these conditions have been met. The context and/or detail of the new findings must be sufficiently different to merit addition to the matrix of knowledge through publication.
- Submission also implies that all authors have approved the submission and are in agreement with its content. **The author list and affiliations will not be changed once the publication agreement has been signed.**
- It is a requirement of the SciELO journal database that **all** authors provide an open researcher and contributor ID (ORCID) from 1 January 2025. All authors are requested to include their ORCIDs in the submitted manuscript, or with the publication agreement. To obtain an ORCID, register on: www.orcid.org/register. The ORCID hyperlinks will immediately follow each author's name in the published article.
- If figures, tables, or parts of other copyright material that are not owned by the authors are included in an article submitted for publication in the journal, it is the sole responsibility of the authors to obtain permission to republish such items.
- A sub-editor, with the assistance of at least two reviewers, will review the manuscript and make a recommendation to the editor-in-chief.
- Authors may suggest a list of experts whom they consider especially suitable to referee their paper, especially if the subject is highly specialised. However, authors must take care to avoid any ethical conflicts when making these recommendations.
- The editor-in-chief, via the OJMS, will advise the corresponding author on the outcome of the review based on the recommendation of the sub-editor.
- Resubmitted manuscripts will be evaluated by the sub-editor for the adequacy of the responses to the reviewers and, if deemed necessary, may again be sent to reviewers for their insight. *Resubmitted manuscripts must be accompanied by a summary of the*

changes made in the revision and a brief response to all recommendations and criticisms. The sub-editor will make a recommendation to the editor-in-chief to either 'provisionally accept' or 'reject' the manuscript.

- Once the paper has been provisionally accepted by the editor-in-chief, an invoice for the publication fee and a publication agreement will be sent to the corresponding author.
- Upon receipt of the publication fee, the manuscript will be edited. The manuscript may be returned to the author at this point for additional revision, if necessary.
- After editing and formatting, the article will be uploaded to the OJMS for final proofing by the authors. Once the corresponding author has confirmed their acceptance of the manuscript, the article will be published online (www.sasas.co.za). Note that there is no hard-copy publication of the South African Journal of Animal Science.

Types of articles

Research articles: Contributions should be based on original, unpublished experimental data that have been analysed using statistical methods.

Short communications: Results of limited investigation, work in progress, and new techniques can be submitted as short communications. Short communications should not exceed five printed pages.

Reviews: Reviews should have as their main aim the synthesis or application of new principles, hypotheses, or future research directions from the re-interpretation and scrutiny of existing, published scientific data. It is normal practice for authors to include some of their own new, but previously unpublished data, in support of the concept that is synthesised. Syntheses and applications from technical reports, surveys and other unpublished, but scientifically justifiable, sources of information can also be used in support. Reviews aimed at distilling existing published information into a form that will contribute to a clearer understanding or more widespread application of research findings by generalist extension officers and non-scientists are also welcomed. Reviews are normally solicited by the editor-in-chief, but suggestions for topics or authors are welcomed. Reviews are subjected to the same peer-review process as is applied to all other submissions.

Article structure

Research articles

The organisational structure for a **research article** to be submitted to the South African Journal of Animal Science is as follows:

- **Title:** An informative and brief (maximum 120 characters, including spaces) topic statement that draws attention to the paper.
- **Authorship:** The initials and surnames of the author(s), and the addresses of the institutions where the work was done must follow the title. Superscripts ^(1,2,3) should be used in cases where authors are from different institutions. A superscript (#) should be appended to the author to whom correspondence should be addressed, and this should be indicated as such, together with an email address, in the line immediately following the keywords. The present postal addresses of authors, if currently different from that of the institution, should also be superscripted appropriately and inserted in the lines following that of the corresponding author's details. All authors are requested to submit their ORCID with either the manuscript or the publication agreement. To obtain an ORCID, register on: www.orcid.org/register. The ORCID hyperlinks will immediately follow each authors name in the article that is published.

- **Abstract:** The abstract should provide the following information: the purpose of the study, the experimental treatments, the results (preferably in quantitative data), the significance of the findings, and the conclusions. This should not exceed 250 words. Abbreviations and significance levels (e.g., $P < 0.05$) should not be included in the abstract.
- **Keywords:** Keywords should be listed in alphabetical order, and separated by commas, not semicolons. Words in the title of the article should not be listed as keywords.
- **Introduction:** The introduction serves to motivate the reading of the article. It should include i) a statement of why the subject under investigation is considered to be of importance, ii) a concise indication of the status quo of published research in this field, and iii) why this article is considered to be an original contribution to current scientific knowledge of the principles, or the application of principles, governing the functioning of animals, production aspects of their products, and their relationship to the social or physical environment. Appropriate references supporting these arguments should be cited. The last sentence of the introduction should contain a declaration of the aims of the experiment, i.e., the hypothesis. The introduction should not exceed one page in length.
- **Materials and methods:** Animal experimentation must be conducted within standard ethical norms. A statement indicating the review of the project by an appropriate institutional animal care and use committee or an equivalent ethical review must be included as the first paragraph in the Materials and methods section. Authors should include the ethical clearance number. The methodology and descriptions of the materials that were used should be concise but of sufficient detail to enable the experiment to be replicated by an outside party. Statistical methods used must be clearly stated (see details in the 'Notes on statistics' section).
- **Results and discussion:** Integrity in reporting requires that no inconsistent data are omitted or fabricated data presented. Results presented in tables or figures should not simply be repeated in the text. The discussion should include references to relevant literature, to place the results of the study in the context of the pre-existing research, and to clearly indicate the practical relevance of the results. This section should end with a paragraph discussing the limitations of the study and avenues for future research.
- **Conclusions:** This single, short paragraph should consist of an integration of results that refer directly to the stated aims of the experiment and a statement on the practical implications of the results. Do not summarise the discussion here.
- **Acknowledgements:** Do not include titles of persons; use only initials and surnames. Acknowledge all financial support. Include the National Research Foundation (NRF) project GUN number, as required by the NRF. State and acknowledge any additional sponsors, including private companies.
- **Authors' contributions (this section is compulsory):** All scientific publications to be published in the South African Journal of Animal Science must include appropriate attribution of authorship and disclosure of relevant affiliations of those involved in the work. Authorship should be limited to those individuals who have contributed in a meaningful and substantive way to the manuscript's intellectual content. Each author should have participated sufficiently in the work to take public responsibility for its content. All co-authors should have been directly involved in all three of the following: i) planning and contribution to some component (conception, design, conduct, analysis, or interpretation) of the work that led to the paper or interpreting at least a portion of the results; ii) writing a draft of the article or revising it for intellectual content; and iii) final

approval of the version to be published. All authors should review and approve the manuscript before it is submitted for publication.

- **Conflict of interest declaration (this section is compulsory):** A conflict of interest exists when financial or other personal considerations may compromise, or have the appearance of the potential to compromise, a researcher's professional judgment in conducting or reporting research. Such conflicts of interest do not preclude publication of the work; however, they must be disclosed. In the event that there are no conflicts of interest, this section must contain the following statement: 'The authors have no conflicts of interest to declare.'
- **References:** The existing relevant literature must be cited appropriately and fairly (see below for examples). In this respect, ensure that reference is made to the original report of a finding rather than to a later elaboration. DOI addresses are required, if available, for ALL references.

Short communications

The organisational structure for a **short communication** to be submitted to the South African Journal of Animal Science is as follows:

- See the guidance relevant to a research article for information that pertains to the **Title, Authorship, Abstract, and Keywords**.
- **Body of the paper:** Text for the body of a short communication consists of a short introduction, materials and methods, results and discussion, and conclusion as a single section. This section is not divided by sub-headings. It is not more than five (5) pages in length, including the tables and figures.
- See the guidance relevant to a research article for information that pertains to the **Acknowledgements, Author contributions, Conflict of interest declaration, and References**.

Style and form

The manuscript must be written in English, using the **UK English spell check**. Submissions are to be typed in MS Word and saved as a .docx file, and are submitted electronically through the South African Journal of Animal Science OJMS (<http://journals.sasas.co.za/>). It is up to the authors to make sure there are no typographical errors in the manuscript. The contents must be arranged in an orderly way with suitable

Manuscripts will not be admitted to the peer-review process until they are fully compliant with the style and form detailed in the instructions to authors and are written using correct English grammar and syntax. Authors are advised to adhere strictly to the following directives and to consult the downloadable MS Word template and most recent editions of the journal for issues not specifically mentioned here.

headings for each subsection.

English editing services

Authors for whom English is a second language may choose to have their manuscript professionally edited before submission to improve the quality of the English used. All services are paid for and arranged by the author, and the use of one of these services does not guarantee acceptance or preference for publication.

You will find details on English editing services by following the links (in alphabetical order) below:

- <https://authorservices.springernature.com/>
- <https://www.editage.com/services/english-editing/english-language-editing-and-proofreading-services>
- <https://www.enago.com/>
- <https://www.pnas.org/author-center/language-editing>
- <https://wileyeditingservices.com/en/>
- <https://paperpal.com/preflight>

You can also make use of free artificial intelligence (AI)-based language editing tools to scan your manuscript and make suggestions to help improve the quality of your writing. The tools apply machine learning, trained on millions of published scientific articles, and suggest improvements to grammar, spelling, and academic language.

- <https://www.writefull.com/students-researchers-3>
- <https://paperpal.com/preflight>

Formatting (MS Word)

Page layout:

Page size: A4

Line numbering: ON (restart on each page)

Margins: top: 2.5 cm, bottom: 2.5 cm, left: 2.5 cm, right: 2.5 cm

Gutter: 0 cm, header: 1 cm, footer: 1.4 cm

Page numbering: ON (position: top right, Arial 9 pt)

Line spacing: multiple (1.08), no spaces between paragraphs

Please see the MS Word template available in the 'downloads' section for a complete guide to formatting.

Terminology, abbreviations, and formulae

Use the SI (International System of Units) metric system for units of measurement, and use a decimal point, not a comma. For numbers less than 1, use a leading zero before the decimal point (e.g., 0.5). Spell out numbers from one to nine, but use numerals for larger numbers, groups of numbers, fractions, or units, for example: four, 8–16 (note the use of an en-dash to indicate range), 0.64, 4 kg/ha, 42 ewes, 67%. For litres, use the abbreviation L or mL. Note the spacing in the following text: *P* <0.05 with *P* in italics, and 5 min.

When reporting the concentrations of the chemical components of diets, use g/kg and not %, mg/kg and not ppm, and mg Cu/kg and not mg/kg Cu. Do not use the word 'content' when specifying a concentration in terms of g/kg or %. Use % mainly to indicate relative changes. Express nutrient concentrations of feeds preferably on a dry matter (DM) basis, and clearly indicate the basis used.

When abbreviations are used, they must be explained in full the first time they are used in the text (e.g., '...South African Mutton Merino (SAMM) ...'), and the abbreviation should be used consistently thereafter. The abstract, body of the text, tables, and figures should all be interpretable in the absence of the rest of the manuscript. This means that abbreviations must be provided in full and defined independently in each of these sections. Use abbreviations sparingly, and only for terms used at least three times in the text, as too many abbreviations create confusion. Do not start a sentence with an acronym or abbreviation.

Formulae are to be prepared using the MS Word equation editor in Cambria Math 11 pt font, and are not to be presented as images. Formulae should be shown alone and centred on a line without other punctuation. For example:

$$y_{ij} = \mu + t_i + e_{ij}$$

where: y_{ij} = an observation from the j th animal that was subjected to the i th treatment; μ = the grand mean that is common to all observations; t_i = the i th treatment; and e_{ij} = the random error that is attributable to the j th animal.

Tables

Tables are to be created in MS Word, numbered consecutively in bold Arabic numerals (e.g., **Table 1** *note that there is no following colon or full stop*), and should bear a short, yet adequately descriptive caption that would be sufficient for the interpretation of the data presented if the table and caption were to be separated from the text. For example:

Inadequate: '**Table 1** Feed intake effects'

Correct: '**Table 1** Mean (\pm standard error) voluntary intake (g/d) of two diets differing in crude protein content by early weaned (21 d) piglets'

The caption should be in 10 pt Arial font with the word 'Table' and its number (only) in bold. Tables should be inserted at the appropriate place in the text and not appended at the end of the article. The body of the table is to be set in 9 pt Arial font with the row and column headings in bold, but without any bold entries in the body of the table. Tables must fit on a single page and should not straddle a page break. Tables may be entered in landscape mode to accommodate a greater number of columns, if necessary.

Metric units are required and their symbols and abbreviations must be in accordance with international procedure. Explanatory notes to table elements are designated by superscripts. These notes appear on the lines directly below the table, in 9 pt Arial font. Means presented in tables are to be accompanied by their standard error (\pm SE). Use of multiple range tests (i.e., Duncan's, Tukey's, Student's t -test) for mean separation is discouraged. Use of pre-planned contrasts of means is encouraged.

Tables should be centred on the page. Authors should pay special attention to the format for tables regarding lines: no vertical lines and 1½ pt font horizontal lines before and after the heading and the last row of data only. Place each entry in a separate cell in the table. Align decimal points in columns of means.

Sample tables are shown below:

Table 3 Means (\pm standard errors) of feed intake, weight gain, and feed conversion ratio of commercial broilers fed aluminosilicates and yeast-based mycotoxin binders

Treatments ¹	Feed intake (g)	Weight gain (g)	Feed conversion ratio
NC	3171 \pm 10.9	1904 \pm 49.4	1.67 \pm 0.04
C	2951 \pm 19.3	1369 \pm 71.5	2.17 \pm 0.11
Z1	3117 \pm 19.1	1963 \pm 19.0	1.59 \pm 0.01
Z2	3123 \pm 19.6	2078 \pm 46.3	1.50 \pm 0.03
TX1	3190 \pm 42.1	1959 \pm 69.2	1.63 \pm 0.06
TX2	3178 \pm 29.1	2042 \pm 44.8	1.56 \pm 0.04
P-value	<0.01	<0.01	<0.01

¹NC: negative control; C: control; Z1: 1 g zeta plus; Z2: 2 g zeta plus; TX1: 1 g Toxfin Dry; TX2: 2 g Toxfin Dry

Table 3 Means (\pm standard errors) for the effects of time during lactation and parity on the energy balance (MJ per day) of lactating sows

	Estimated energy intake		Estimated energy requirement		Energy balance	
	CG	EG	CG	EG	CG	EG
Day of lactation						
Day 1 to 7	40.1 \pm 1.7	48.0 \pm 1.9	47.6 \pm 1.8	46.0 \pm 2.3	-7.5 \pm 2.1	-1.9 \pm 3.2
Day 8 to 14	49.2 \pm 1.6	60.2 \pm 1.5	55.2 \pm 2.0	57.1 \pm 2.5	-6.1 \pm 2.3	3.5 \pm 3.4
Parity						
1st	40.1 \pm 2.3	55.4 \pm 3.3	51.9 \pm 2.6	57.1 \pm 3.0	-9.1 \pm 2.9	-2.1 \pm 3.9
2nd	45.8 \pm 2.8	53.3 \pm 2.7	53.0 \pm 2.8	56.8 \pm 3.2	-8.3 \pm 3.1	-3.6 \pm 4.1
3rd to 5th	45.5 \pm 2.9	56.2 \pm 2.9	62.5 \pm 3.0	60.6 \pm 3.4	-10.8 \pm 3.3	-2.8 \pm 4.3

CG: control group; EG: supplemented group

Figures

Figures are to be numbered consecutively in bold Arabic numerals (e.g., **Figure 1** *note that there is no following colon or full stop*), bear a short, yet adequately descriptive caption, and inserted into the text at the appropriate position. The caption is to be in 10 pt Arial with the word 'Figure' and its number (only) in bold. Scanned illustrations from other sources are not acceptable. Bitmap images should be sized to fit on a portrait mode page and have a resolution of not less than 600 dpi. All lettering and numerals that appear in figures should be in Arial 9 pt font in 'regular' not 'bold'. Point means should be accompanied by standard error bars. Tick marks on axes should face towards the inside of the graph. Place the title underneath the figure, but not as part of the inserted section. Do not 'block' the figure with lines surrounding it. Ensure that lines, including axes and graphs, are of sufficient thickness and contrast to be clear.

In-text references

Cite references by name and date. In the case of two authors, use an ampersand (&) and not 'and' (e.g. Smith & Harrison, 1998). The abbreviation '*et al.*' must be used in all cases where more than two authors are quoted (e.g. Jones *et al.*, 1999). Note that the comma after '*et al.*' is not in italics.

Multiple references within parentheses in the text should be cited in **chronological** order, e.g. 'Apart from the work of Chevallier & Smith (1971), Veary (1991), and Lewis *et al.* (1997), little data'... **or** '... and has been shown to increase the pH (Chevallier & Smith, 1971; Veary, 1991; Lewis *et al.*, 1997).'

When citing a reference that is not the primary report, put: 'original authors (1991, cited by citing authors, 1997)' in the text, and the original work followed by the statement 'cited by' parenthetically in the list of references. For example: '... as reported by Scott (1947, cited by Tainton, 1999)' in the text, **and** 'Scott, J.D., 1947. Veld management in South Africa. Bull., Dept. Agric. S. Afr. No. 28. (cited by Tainton, 1999)' in the list of references.

Personal communications and unpublished work may be cited in the text, giving the initials, name, and date. Personal communications do not appear in the list of references. Personal communications appear only in the text as, e.g. 'According to Brightguy (2005, A.B. Brightguy, Pers. Comm., Centre of Wisdom, P.O. Box 100, Pretoria, 0001)'. Sufficient detail should be provided so that the person can be contacted.

All references cited in the text, other than personal communications, should be listed alphabetically by first author surnames at the end of the paper, under the heading, 'References'.

It is the FULL responsibility of the authors to cross-check references in the text of the article with those in the list of references.

Formatting the reference list

- The list of references is to be arranged alphabetically by the first author. When there is more than one reference by the same first author, these are to be arranged first by the number of authors and then within a group of references having the same number of authors, in chronological order, oldest first.
- List all authors for each reference. Do not use abbreviated conventions, or *et al.*
- Titles of references are to be written in sentence case (i.e., only the first word and proper nouns are capitalised).
- Journal names must be provided in full and italicised.
- Pay particular attention to the syntax used in the reference list. References in the text must correspond completely and exactly with those in the reference list. In all cases, a reference must provide sufficient information to enable the reader to obtain a copy of the cited work.
- DOIs should be provided for ALL references cited, if available.
- References to unpublished congress presentations are NOT acceptable.
- References to the original work are preferred over the citation of textbooks.
- References to internet articles are permissible. Supply the full html address for the source material and the date on which the material was most recently accessed; for example: (<https://www.grandin.com/meat/dkcut.html>); accessed 10 October 2019).

Examples of references: (hanging indent, 1 cm)

- AOAC, 2019. Official Methods of Analysis of AOAC International (21st ed.), Volume 1. Ed. Latimer, G.W. AOAC International, Gaithersburg, Maryland, USA.
- Cloete, S.W.P., Engelbrecht, A., Olivier, J.J., & Bunter, K.L., 2008. Deriving a preliminary breeding objective for commercial ostriches. *Australian Journal of Experimental Agriculture*, 48:1247–1256. DOI: 10.1071/EA08135
- Qwabe, S.O., van Marle-Koster, E., Maiwashe, A., & Muchadeyi, F.C., 2013. Evaluation of the BovineSNP50 genotyping array in four South African cattle populations. *South African Journal of Animal Science*, 43(1):64–67. DOI: 10.4314/sajas.v43i.7
- Read, M.V.P., 1984. Animal performance from natural pastures and the effects of phosphorus supplementation. MSc (Agric) thesis, University of Stellenbosch, South Africa.
- Sanchez, M.S.S., Nascimento, M.S., & Hisano, H., 2016. Substituição do milho pelo sorgo em dietas para juvenis de pacu. *Pesquisa Agropecuaria Brasileira*, 51:1–8. DOI: 10.1590/S0100-204X2016000100001 (in Portuguese, English abstract).
- Tainton, N.M., 1999. The ecology of the main grazing lands of South Africa. In: Veld Management in South Africa. Ed: Tainton, N.M., University of Natal Press, Pietermaritzburg, South Africa. pp. 48.

Notes on statistics

Following Lush (1933; <https://academic.oup.com/jas/article-abstract/1933/1/15/4771465>), statistical methods are used for two main purposes. The first is to describe the particular sample of data under scrutiny. The second is to test the significance of a difference between that sample and some other actual sample or some theoretically

expected value. The two purposes of description and of testing significance are not independent of each other but they are far from being identical.

A comparison between two groups can result in one of three outcomes:

1. A difference may be observed, and shown to be significant at some predetermined level of probability.
2. A difference may be observed, but its test does not rise to the predetermined threshold for statistical significance.
3. No difference may be observed.

The latter two should not be confused. We cannot honestly leave the impression that no difference was found when we really did find one, but it was not statistically significant. We can only declare outcomes to be similar when the number of replications ensures adequate power-of-the-test. Even if one does not find a significant difference, it should always be kept in mind that the difference most likely to be found if the experiments were repeated is the observed difference and not zero.

The experimental unit may be defined as the object independently treated in an experiment. The experimental unit may be an individual animal or a pen of animals. Independence among experimental units is an essential feature of an experiment aimed at establishing cause and effect. The word 'independently' also aids in the identification of the experimental unit, as treatments applied independently to animals in a group make the animals the experimental units, but treatments applied to a group of animals together makes the entire group a single experimental unit. Variation among experimental units that are treated alike (i.e., variation among replicates) provides the basis for testing treatment effects. Misidentification of the experimental unit can lead to grossly inflated Type-1 error rates in hypothesis testing (Blair, 1983; <https://doi.org/10.1177/001316448304300110>). This is not an uncommon mistake.

The term 'pseudoreplication' was coined by Hurlbert to refer to 'the use of inferential statistics to test for treatment effects with data from experiments where either treatments are not replicated (though samples may be) or replicates are not statistically independent.' Heffner *et al.* distinguishes a pseudoreplicate from a true replicate, which they characterise as "the smallest experimental unit to which a treatment is independently applied.' Most models for statistical inference require true replication. True replication permits the estimation of variability within a treatment. Without estimating variability within treatments, it is impossible to do statistical inference. Consider, for example, comparing two drugs by trying drug A on person 1 and drug B on person 2. Drugs typically have different effects in different people. So this simple experiment will give us no information about generalising to people other than the two involved. But if we try each drug on several people, then we can obtain some information about the variability of each drug, and use statistical inference to gain some information on whether or not one drug might be more effective than the other on average. True replicates are often confused with repeated measures or with pseudoreplicates.

Appropriate statistical methods should be used in all reports, although the biology should be emphasised. Referring only to the software that is used for analysing the data is not sufficient. The significance threshold used to declare the effect to be real must be stated. For example, 'Treatment effects were assumed to be real when the probability of finding the observed difference by chance was less than 5% (i.e., $P < 0.05$).'

Results from the statistical analyses should justify the interpretations and conclusions. The means of all variables measured should be presented in a table, together with their respective standard errors (i.e., mean \pm standard error). Note that for data analysed using an analysis of variance, it is assumed that the variances are homogeneous within classes of the independent variables. Thus, the standard errors should be calculated from the estimated error variance and not from the variance calculated separately for each level of an independent variable.

Do not use the word 'significantly' where the level of significance is declared: e.g., use 'Treatment A was different to treatment B ($P < 0.01$)' or 'The difference between treatment A and treatment B was substantial' **but not** 'The difference between treatment A and treatment B was highly significant ($P > 0.01$)'. Where means do not differ significantly, the appropriate level of probability can be stated, e.g., '...did not differ ($P > 0.05$)'. Note the following syntax: 'variables differ between treatments,' not 'variables differ among treatments'.

It is important that the variability of the estimated effects be properly indicated. The standard error of a mean is an estimate of how far that mean is likely to be from its true value, whereas the standard deviation of the sample is the degree to which individuals within a sample differ from the sample mean. The standard errors for a set of means are directly relevant to the comparisons between them.

When the treatments have a natural underlying quantitative basis, it is not appropriate to treat them as though they were categorical. In this situation, regression methods or orthogonal polynomial contrasts of the means are more appropriate. To illustrate these results, the actual means for each level of the factor should be displayed, and not the fitted means, and the continuous function fitted to the data should be drawn through these means. Coefficients of the curve fitted to the data need to be displayed together with their standard errors.

For experiments in which variation may be attributable to more than one independent variable, a test of each potential interaction effect is expected. When the interaction effect is significant, tabular or graphic presentation of the interacting effects is expected, and interpretation of the interaction must have priority over the interpretation of the main effects that interact.