Peer Community In Zoology

Physiological Adaptations to Arid Conditions in South African Rodents: A Comparative Study of Rhabdomys Species

Vincent Foray *based on peer reviews by 2 anonymous reviewers*

Hamilcar S. Keilani, Nico L. Avenant, Pierre Caminade, Neville Pillay, Guila Ganem (2024) Negative impact of mild arid conditions on a rodent revealed using a physiological approach in natura. bioRxiv, ver. 9, peer-reviewed and recommended by Peer Community in Zoology. https://doi.org/10.1101/2024.03.11.583554

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Understanding how organisms are affected by environmental variations is a central question in ecophysiology and evolutionary ecology, particularly in the context of global changes(Fuller et al., 2016). Environmental variations challenge organisms' ability to maintain homeostasis leading to divergent adaptations between habitat specialists and generalists (Kawecki and Ebert, 2004). The article by (Keilani et al.) (2024) presents an original contribution to this field by focusing on the response to dry conditions in two rodent species from semi-arid regions of South Africa. The two species, *Rhabdomys bechuanae* and *R.dilectus dilectus*, have different environmental niches : *R.dilectus dilectus* occurring in mesic habitats while *R. bechuanae* is found in semi-arid and arid habitats. Previous studies highlighted morphological and behavioral adaptations to arid conditions in *R. bechuanae* (Dufour et al., 2019), the current study focuses on the physiological responses of the two species to seasonal dry conditions. By analyzing body condition, markers of kidney and liver functions, and habitat characteristics the authors aim to understand how aridity impacts parapatric populations of the two species. They hypothesize that i) the aridity of the habitat tend to increase during the dry season, ii) both species can adjust their physiology to dry conditions thanks to phenotypic plasticity, and iii) *R. bechuanae*, having evolved in arid environments, will cope better with dry conditions than *R. d. dilectus*.
Consistent with their prediction, Keilani et al (2024) found physiological divergence between the two species. They also observed six blood markers (out of 12 tested) showing significant temporal changes, indicating resource depletion as the dry season progressed, even though the year of study was influenced by a relatively mild La Niña event (i.e. wet year). Both species displayed similar physiological responses to the dry conditions, such as reduced blood albumin level by the end of the dry season, confirming albumin as a reliable indicator

of malnutrition and nutrient deficiency (AL Eissa et al., 2012). In terms of interspecific differences, *R. bechuanae* exhibited better water regulation, with lower sodium, potassium, and total bilirubin levels, which may indicate adaptation to drier environments. The study concludes that *R. bechuanae* appears better adapted to cope with arid conditions, highlighting the importance of physiological studies in understanding species' responses to climate change, and suggests that harsher dry seasons could further challenge *R. d. dilectus*, particularly in semi-arid zones. This study underscores the value of studying species in their natural environments to fully understand the scope and limitations of their responses to environmental changes.

References:

Dufour, C.M.S., Pillay, N., Avenant, N., Watson, J., Loire, E., and Ganem, G. (2019) Habitat characteristics and species interference influence space use and nest-site occupancy: implications for social variation in two sister species. Oikos128: 503-516.
https://doi.org/10.1111/oik.05357

AL Eissa, M.S., Saad, A., Al Farraj, S.A., Saud, A.A., Al Dahmash, B., and Hamad, A.Y. (2012) Seasonal variation effects on the composition of blood in Nubian ibex (Capra nubiana) in Saudi Arabia. Afr J Biotechnol 11: 1283-1286.
https://doi.org/10.5897/AJB11.2004

Fuller, A., Mitchell, D., Maloney, S.K., and Hetem, R.S. (2016) Towards a mechanistic understanding of the responses of large terrestrial mammals to heat and aridity associated with climate change. Climate Change Responses 3: 10.
https://doi.org/10.1186/s40665-016-0024-1

Hamilcar S. Keilani, Nico L. Avenant, Pierre Caminade, Neville Pillay, Guila Ganem (2024) Negative impact of mild arid conditions on a rodent revealed using a physiological approach in natura. bioRxiv, ver.9 peer-reviewed and recommended by PCI Zoology
https://doi.org/10.1101/2024.03.11.583554

Reviews

Evaluation round #2

DOI or URL of the preprint: https://doi.org/10.1101/2024.03.11.583554
Version of the preprint: 8

Authors' reply, 27 September 2024

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Decision by Vincent Foray, posted 30 August 2024, validated 02 September 2024

Minor revisions

Dear Authors,

I have reviewed the revised manuscript and am pleased to see that you have addressed most of the reviewers'

comments. I have, however, one significant observation and a few minor suggestions that should be considered before the manuscript can be fully recommended.

Regarding the vegetation data, you have chosen to maintain your approach based on principal component analysis (PCA), contrary to the advice of both reviewers. Unfortunately, the justification for this choice remains unclear and unconvincing. You argue that this method allows for the transformation of data distribution for subsequent statistical analyses. However, in the results section (Lines 386-394), you present descriptive statistics on these data directly (not on the principal components) suggesting that these data can be handled without transformation. Moreover, there seems to be a contradiction in your objectives: in the manuscript, you state that your goal is to reduce the number of variables (Lines 282-283), while in your response to the reviewers, you assert that reducing variables is not your primary aim. I encourage you to clarify this inconsistency, either by modifying your approach or by providing a stronger justification for its purpose and relevance.

Line 118: Please revise this sentence, as the genus Rhabdomys has not yet been introduced in the manuscript at this point.

Lines 125-131: The reordering of this section is unclear. It may be more effective to restore this part to its original position.

Lines 215-217: I recommend removing the parentheses and restructuring the sentence, notably start a new sentence after “testis”.

Figure 1: It is still difficult to distinguish between the translucent and fully colored dots. Consider using two different shapes (e.g., circular and triangular) for better differentiation.

Figures 5 and 6: It is regrettable that only significant results are highlighted in these figures. Additionally, it seems feasible to combine Figures 5 and 6 into a single figure, perhaps as reaction norms for each species across the 12 physiological markers. This would also address the reviewers’ concerns about the large number of figures.

Evaluation round #1

DOI or URL of the preprint: https://doi.org/10.1101/2024.03.11.583554
Version of the preprint: 4

Authors’ reply, 02 August 2024

Download author’s reply
Download tracked changes file

Decision by Vincent Foray, posted 03 July 2024, validated 03 July 2024

Major revision

Dear authors,

Your manuscript has been reviewed by two reviewers, both of whom have expressed positive feedback about your paper. However, they have also highlighted several issues that need to be addressed before we can accept it for recommendation. I agree with the two primary concerns raised by the reviewers: (1) the need for clarification and justification of the methodology and statistical analyses, and (2) the reorganization of certain sections and the removal of secondary results. These concerns are well articulated by the reviewers.

Therefore, I recommend revising your manuscript in accordance with the reviewers' comments before it can be considered for recommendation.

Yours sincerely,

Dr Vincent Foray

Reviewed by anonymous reviewer 2, 18 June 2024

Download the review

Reviewed by anonymous reviewer 1, 30 May 2024

————————————- General questions ——————————————

Title and abstract

Does the title clearly reflect the content of the article? **Yes**.

Does the abstract present the main findings of the study? **Yes**.

Introduction

Are the research questions/hypotheses/predictions clearly presented? **No**. As the authors will see below in my comments, I think their question and assumptions are hidden in the large amount of information at the end of the introduction.

Does the introduction build on relevant research in the field? **Yes**.

Materials and methods

Are the methods and analyses sufficiently detailed to allow replication by other researchers? **No**. I think that certain points need to be clarified concerning the number of samples per condition that are considered (see comments below) in order to better understand the protocol.

Are the methods and statistical analyses appropriate and well described? **No**. A number of points remain to be clarified with regard to statistical analysis (see comments below).

Results

In the case of negative results, is there a statistical power analysis (or an adequate Bayesian analysis or equivalence testing)? **I don't know**

Are the results described and interpreted correctly? **Yes**.

Discussion

Have the authors appropriately emphasized the strengths and limitations of their study/theory/methods/argument? **Yes**.

Are the conclusions adequately supported by the results (without overstating the implications of the findings)? **Yes**.

————————————- Comments ——————————————-

The authors studied two species of rodents (genus Rhabdomys) living in the semi-arid zone of South Africa, one arid and the other mesic. The aim is interesting and was to study the impact of food and water scarcity during periods of seasonal drought, in order to better understand the possible effect of climate change (more severe arid conditions) on these two species. I am convinced that results obtained in this study could contribute to improving knowledge on this topic.

Major comments:

1. They are a lot of tables and figures in the scientific article proposed, either in the results or in the supplementary documents. I think the choice of which figures to include in the article itself or in the supplementary documents needs to be reviewed. It is also important to legend the figures and tables properly to make them easier to understand. Beware also of the organization of figure titles (below) and tables (above).

2. I suggest that the authors rearrange a little the introduction section. I detail my request below.

a. Lines 40 - 47: the authors talk about short- and long-term changes and their possible effects on organisms, which it may be interesting to assess in order to understand the impact of climate change on organisms.

Lines 48 - 70: the various local adaptations are presented, and in particular the importance of physiology to study the impact of environmental variations.

Lines 71 - 83: the authors discuss climate change and its possible impact on semi-arid organisms, linked to food and water scarcity, with a possible distinction in responses between arid and mesic species.

Lines 84 - 92: the importance of physiology to understand the ability of species to adapt to environmental change is discussed.

All the ideas are there, but I suggest that the different paragraphs be reorganized to make the article easier to read and understand. For example, start by talking about short- and long-term changes in organisms, and in particular drought conditions and their importance in understanding the possible impacts of climate change on these organisms. Then, for example, talk about the adaptive capacities of organisms and finish with physiological adaptations, which may be of interest.

b. Lines 50 – 61: "For example, adaptive variation in lethal temperature [...] different latitudinal niches (Somero, 2010)". I suggest that the authors develop this idea in order to make the link with the previous sentences: why is it interesting to present adaptations to lethal temperatures in marine invertebrates?

c. Lines 92 – 94: the problematic of the study is given.

Lines 94 – 108: the ecology of the two rodents used for the study is given. At lines 100 – 102: questions addressed by the study are presented.

Lines 110 – 118: Physiological responses of *R. pumilio* face to dry season are introduce.

Lines 119 – 138: the authors discuss the lack of study in natural condition and their advantages and give details on measurements that will be conducted in the study, as well as the hypotheses.

In these last paragraphs, the problematic of the study seems to me to be hidden among the abundance of information. However, it is important that it should appear clearly and prior to the hypotheses. Certain sections concerning the ecology of the species studied or the physiological responses of *R. Pumilio* to dry conditions could, for example, appear earlier in the introduction.

3. Table 1: I do not understand the last part of the table entitled "aseasonal differences: predictions" (Lines 906 – 912).

4. Supplementary material section: "PET by Thornthwaite method [REF] was calculated", what is the reference in question? I suggest to reorganize the part from "with exponent c" until the formula for PETi(0) to make it more clearer. The last sentence "This was the final value [...] which was divided over annual precipitation to obtained aridity index" is not correct and causes confusion. If I understood correctly, it is annual precipitation that is divided by PETi(L), not the contrary.

5. The other sections of supplementary material is not used and referred in the main text of the article. I suggest that authors either remove these sections if they are not necessary, or make good use of them by referencing them in the main text.

6. Lines 162 – 163: "They were placed approximatively every 15m along roughly 150 to 300m transects". There were how many transects per site?

7. Line 176: "until we reached our target of 20 adult individuals". Is it the number per species or per site? Only for physiological analyses? Because it is mentioned later that "273 adult mice were euthanized" (Line 197).

8. Lines 187 – 188: "We characterized 236 quadrats of each type (100m² and 4m²)". Is this for each site or in total? How many quadrats of each type were there for each site and each species?

9. I have some questions about statistical analysis. Could the authors explain their choice of doing a permanova on the 5PCs rather than on the 7 variables directly for vegetation composition? Why not on 2PCs if the aim is to reduce the number of explanatory variables? Regarding the physiology section, I do not really understand the statistical analyses that have been carried out. Perhaps there are some elements missing to better understand the work done.

10. I would like to point out that the authors have done a remarkable effort in the discussion section to

interpret their results. Nevertheless, I suggest that the authors reorganize a little this section to make it more comprehensible. For example, the authors divided their discussion into two parts: "seasonal variation in physiology" and "interspecific differences". However, some physiological results are presented before the relevant section.

Minor comments:

1. Line 166: please, replace "sassessed" by "were assessed"

2. Line 170: "trapping effort was 9688 trap nights". Does this mean that 9688 traps were set overnight? Then, were they checked twice a day, as indicated in line 164? In addition, I suggest to the authors to put this sentence before "Since Rhabdomys is mostly diurnal [...]".

3. Line 194: I did not find the supplementary table 3 (only the title). In addition, supplementary table 2 is not mentioned in the text of the article. So, is it necessary?

4. Supplementary Table 1: title is not placed correctly.

5. Supplementary table 4: the title should appear before the table. I suggest to add a legend to explain the different abbreviations (ALB, ALP, ALT, AMY, etc).

6. Line 247: the paragraph about "age classes" should be appear before the section about "body condition" because it is considered as explanatory variable for body condition of individuals by the authors.

7. Figure 2 is not used in the article.

8. Lines 316: "A post-hoc Tukey [...] showed that all sites had a significantly lower NDVI in September compared to May (Figure 4)". In Figure 4, statistical results are not visually indicated.

9. Line 352: please, indicate the figure.

10. A lot of tables and figures are not mentioned and used (in supplementary section).