Peer Community In Archaeology

An innovative integration of ethnoarchaeological models with phytolith data to study histories of C4 crop cultivation

Emma Loftus *based on peer reviews by* ***Tanya Hattingh*** *and 1 anonymous reviewer*

Abel Ruiz-Giralt, Alemseged Beldados, Stefano Biagetti, Francesca D'Agostini, A. Catherine D'Andrea, Yemane Meresa, Carla Lancelotti (2023) Sorghum and finger millet cultivation during the Aksumite period: insights from ethnoarchaeological modelling and microbotanical analysis. Zenodo, ver. 3, peer-reviewed and recommended by Peer Community in Archaeology. https://doi.org/10.5281/zenodo.7859673

Submitted: 01 May 2023, Recommended: 25 July 2023

Cite this recommendation as:
Loftus, E. (2023) An innovative integration of ethnoarchaeological models with phytolith data to study histories of C4 crop cultivation. *Peer Community in Archaeology*, 100328. 10.24072/pci.archaeo.100328

Published: 25 July 2023

This article "Sorghum and finger millet cultivation during the Aksumite period: insights from ethnoarchaeological modelling and microbotanical analysis", submitted by Ruiz-Giralt and colleagues (2023a), presents an innovative attempt to address the lack of palaeobotanical data concerning ancient agricultural strategies in the northern Horn of Africa. In lieu of well-preserved macrobotanical remains, an especial problem for C4 crop species, these authors leverage microbotanical remains (phytoliths), in combination with ethnoarchaeologically-informed agroecology models to investigate finger millet and sorghum cultivation during the period of the Aksumite Kingdom (c. 50 BCE – 800 CE).

Both finger millet and sorghum have played important roles in the subsistence of the Horn region, and throughout much of the rest of Africa and the world in the past. The importance of these drought-resistant and adaptable crops is likely to increase as we move into a warmer, drier world. Yet their histories of cultivation are still only approximately sketched due to a paucity of well-preserved remains from archaeological sites - for example, debate continues as to the precise centre of their domestication. Recent studies of phytoliths (by these and other authors) are demonstrating the likely continuous presence of these crops from the pre-Aksumite period. However, phytoliths are diagnostic only to broad taxonomic levels, and cannot be used to securely identify species. To supplement these observations, Ruiz-Giralt et al. deploy models (previously developed

by this team: Ruiz-Giralt et al., 2023b) that incorporate environmental variables and ethnographic data on traditional agrosystems. They evaluate the feasibility of different agricultural regimes around the locations of numerous archaeological sites distributed across the highlands of northern Ethiopia and southern Eritrea.

Their results indicate the general viability of finger millet and sorghum cultivation around archaeological settlements in the past, with various regions displaying greater-or-lesser suitability at different distances from the site itself. The models also highlight the likelihood of farmers utilising extensive-rainfed regimes, given low water and soil nutrient requirements for these crops. The authors discuss the results with respect to data on phytolith assemblages, particularly at the site of Ona Adi. They conclude that Aksumite agriculture very likely included the cultivation of finger millet and sorghum, as part of a broader system of rainfed cereal cultivation.

Ruiz-Giralt et al. argue, and have demonstrated, that ethnoarchaeologically-informed models can be used to generate hypotheses to be evaluated against archaeological data. The integration of many diverse lines of information in this paper certainly enriches the discussion of agricultural possibilities in the past, and the use of a modelling framework helps to formalise the available hypotheses. However, they emphasise that modelling approaches cannot be pursued in lieu of rigorous archaeobotanical studies but only in tandem - a greater commitment to archaeobotanical sampling is required in the region if we are to fully detail the histories of these important crops.

References:

Ruiz-Giralt, A., Beldados, A., Biagetti, S., D'Agostini, F., D'Andrea, A. C., Meresa, Y. and Lancelotti, C. (2023a). Sorghum and finger millet cultivation during the Aksumite period: insights from ethnoarchaeological modelling and microbotanical analysis. Zenodo, 7859673, ver. 3 peer-reviewed and recommended by Peer Community in Archaeology. https://doi.org/10.5281/zenodo.7859673

Ruiz-Giralt, A., Biagetti, S., Madella, M. and Lancelotti, C. (2023b). Small-scale farming in drylands: New models for resilient practices of millet and sorghum cultivation. PLoS ONE 18, e0268120. https://doi.org/10.1371/journal.pone.0268120

Reviews

Evaluation round #1

DOI or URL of the preprint: https://doi.org/10.5281/zenodo.7859674
Version of the preprint: 1

Authors' reply, 17 July 2023

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Decision by Emma Loftus, posted 16 July 2023, validated 17 July 2023

Minor changes requested

Dear Abel,

As you will see, you have received two positive reviews of your submission. Both authors have requested minor changes, including the addition of a broader scale map (perhaps as an inset) and providing definitions of some of your terms. Both reviewers have also highlighted the referencing.

I consider your submssion accepted, pending these minor corrections, which will not require that the manuscript is returned to the reviewers for their approval - let me know if you think you cannot accommodate these changes.

Thank you, and best wishes,
Emma

Reviewed by Tanya Hattingh, 24 May 2023

Summary of work and overall impressions

This article highlights the problems archaeologists face when trying to trace the origins and spread of agriculture. It gives a clear and concise overview of the Aksumite period and gives valuable information about the subsistence strategies used by Aksumite communities. It also gives information on the environmental changes that occurred prior to and during the sites' occupation.

This article explores the use of models which can accurately predict the areas and extent of finger millet and sorghum cultivation at Aksumite sites in the horn of Africa. These models were developed using data from various sources, for example ethnographic fieldwork and literature on modern day farming practices, as well as published GIS environmental data. The authors show the accuracy of the models used for the study and shares new information on factors that influence where crops were cultivated. Phytolith analysis is used to give information about which crops may have been cultivated, as well as give information about whether or not irrigation was used by Aksumite communities.

Overall I find this article to be well written, with simplistic language that makes it easy to read and understand. The goals of the article are clear. The authors are well informed on current literature and methods, and the data is well presented and discussed.

Comments:

- A - Is the subject matter:
  - Suitable for publication?
    Yes
  - Sufficiently significant to warrant publication?
    Yes
  - Sufficiently original to merit publication?
    Yes
- B - Is the title appropriate?
  Yes
- C - Is the paper:
  - Well organised?
    Yes
  - The correct length for the material and information discussed?
    Yes
  - Clearly and concisely summarised in the abstract?
    Yes
  - Well informed on current research?
    Yes

- Are the illustrations necessary?
  Yes, see notes for additional comments.
- Are the illustrations of adequate quality?
  Yes
- Are the tables necessary?
  Yes
- Are the tables well laid out?
  Yes
- Is the paper appropriately referenced?
  Yes, see additional comments.

- D - Can the paper be published:

  - As it stands?
    No
  - With minor revisions? (please specify)
    Yes, minor additions and fixes specified in comments below.
  - With major revisions? (please specify)
    No

These items need attention:

- Abstract-Include Scientific names for Sorghum and Finger millet
- Line 52 and 53- Add e.g. before list of references.
- Suggestion- Add a map showing the location of study area in Africa (for people unfamiliar with African geography). Alternatively add an inset in Figure 2 showing the location of the study area within Africa.
- Line 122- Define masl for people unfamiliar with the term.
- Line 134- Replace “the” with “a”.
- Line 135- Replace “Whereas” with a more appropriate word.
- Line 220- “Larger buildings”. Please rephrase for clarity.
- Line 245- “De” should not be capitalized. Check throughout article. It’s capitalized in some places and not capitalized in others.
- Line 250- Define casual, extensive and intensive agriculture for clarity.
- Line 267- Fix spelling of Nenzen.
- Line 337- Define topsoil.
- Line 388- Explain why length of growth cycle was used as a significant variable for SB but not FM.
- Suggestion- Define terms extensive rainfed and intensive rainfed. It is unclear what the difference is between the two.
- References- The referencing needs extensive work. Breton 2018; D’Andrea et al. 2008; Harrower et al. 2019; Lucarini et al. 2016; Gonzalez-Rabanal et al. 2022 are included intext, but not in the reference list.

- Several sources are included in the reference list, but not intext. This includes Cantor et al. 1999; Fick and Hijmans 2017; Lancelotti et al. 2019; Oliver 1980; Manel et al. 2001; Shangguan et al. 2014 and Young and Thompson 1993.

- Other referencing issues- De Contenson is referenced Contenson, H.de. Hagos et al. is references as 2021 in the reference list, but 2019 intext. Intext Vavilov is referenced as 1925 and in the reference list it is referenced as 1926.

Download the review

Reviewed by anonymous reviewer 1, 12 July 2023

I read Ruiz-Giralt et al.'s work with much pleasure. It is a well-written and comprehensive paper, also respectful of the work already done in this area of extraordinary environmental interest.

According to an original methodology, the authors have skillfully declined cross-cultural modelling, ethnoarchaeology and phytolith analysis to propose and test hypotheses about past agricultural practices, mainly focused on finger millet and sorghum agriculture, in the northern Horn of Africa region during the Aksumite Kingdom.

They produce an excellent paper highly relevant to Aksumite archaeology that will be much cited in the future. The text is well written, the methodology is well presented, and the results are of great interest, also given the poor environmental data available for this region and chronology that luckily are expanding considerably in recent years.

The structure of the paper (Introduction, Study area, Study case, Materials and methods, Results, Discussion, and Concluding remarks) is formally correct. The figures and tables are correct, as well as the Supplementary materials.

I suggest revising the list of references and some inline references. The following inline references are missing in the reference list at the end of the paper:

- line 77: Lucarini et al. 2016

- line 154: D'Andrea et al. 2008

- line 171: Breton 2018;

- lines 172-173: Schmidt et al. 2008b

- line 281: Harrower et al. 2019

- González-Rabanal et al. 2022

The following papers are listed in the reference list at the end but their inline references are missing:

- Cantor, S.B., Sun, C.C., Tortolero-Luna, G., Richards-Kortum, R., Follen, M., 1999. A Comparison of C/B Ratios from Studies Using Receiver Operating Characteristic Curve Analysis. Journal of Clinical Epidemiology 52, 885–892. https://doi.org/10.1016/S0895-4356(99)00075-X

- Fick, S.E., Hijmans, R.J., 2017. WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. Int. J. Climatol 37, 4302–4315. https://doi.org/10.1002/joc.5086

- Lancelotti, C., Biagetti, S., Zerboni, A., Usai, D., Madella, M., 2019. The archaeology and ethnoarchaeology of rain-fed cultivation in arid and hyper-arid North Africa. Antiquity 93, 1026–1039. https://doi.org/10.15184/aqy.2019.109

- Manel, S., Williams, H.C., Ormerod, S.J., 2001. Evaluating presence-absence models in ecology: the need to account for prevalence: Presence-absence modelling. Journal of Applied Ecology 38, 921–931. https://doi.org/10.1046/j.1365-2664.2001.00647.x

- Oliver, J.E., 1980. Monthly Precipitation Distribution: A Comparative Index. The Professional Geographer 32, 300–309. https://doi.org/10.1111/j.0033-0124.1980.00300.x

- Shangguan, W., Dai, Y., Duan, Q., Liu, B., Yuan, H., 2014. A global soil data set for earth system modeling. Journal of Advances in Modeling Earth Systems 6, 249–263. https://doi.org/10.1002/2013MS000293

If the cited papers have to be listed in alphabetical order and from the more recent to the older in the reference list at the end, as it seems to me, you should move:

- Schimdt, P.R., Curtis, M.C., Teka, Z., 2008. The Archaeology of Ancient Eritrea. The Red Sea Press, Asmara.

after

- Schmidt, P.R., 2009. Variability in Eritrea and the Archaeology of the Northern Horn During the First Millennium BC: Subsistence, Ritual, and Gold Production. Afr Archaeol Rev 26, 305–325. https://doi.org/10.1007/s10437-009-9061-5

Some typos are present:

- Line 52: (Vavilov 1925) is "Vavilov, N.I., 1926. Studies on the origin of cultivated plants. Bulletin of Applied Botany and Plant Breeding, Leningrad." in the reference list;

- Line 56: (Winchell et al. 2018) is Winchell, F., Stevens, C.J., Murphy, C., Champion, L., Fuller, DorianQ., 2017. in the reference list;

- Line 120: (Hagos et al. 2019) is "Hagos, H., Abrha, H., Hadgu, M., 2021. Agroclimatic zonation of Tigray region of Ethiopia based on aridity index and traditional agro-climatic zones. J. Agrometeorol. 21, 176–181. https://doi.org/10.54386/jam.v21i2.229", in the reference list

- (R Core Team 2022) is "R Core Team, 2021. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria". in the reference list.

- Line 132 Tierney and de Menocal in 2013. Erase "in"

- Line 195: According to Sulas (2009, 2014). Is the first (et al. 2009)?

- Vavilov, N.I., 1951. The Origin, Variation, Immunity and Breeding of Cultivated Plants. Chronica Botanica 13, 1–366. https://doi.org/10.2134/agronj1952.00021962004400020016x

I think you can erase the doi, it links to a review of the work of Vavilov.

Please revise these. Some other useful references should be added:

- D'Andrea et al. 2011, Stable isotopic analysis of human and animal diets from two pre-Aksumite/Proto-Aksumite archaeological sites in northern Ethiopia. Journal of Archaeological Science 38 (2011) 367e374.

- Delle Donne 2021, Cereal ears on Aksumite coins: Reflections between numismatics and archaeobotany. Rassegna di Studi Etiopici, 3° serie, 5 (LII): 269-311.

In my opinion this paper can be published, provided the author solves the formal problems in the inline references and the References at the end.

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