

## Peer Review File

**Manuscript Title:** Bizarre tail weaponry in a transitional ankylosaur from subantarctic Chile

### Reviewer Comments & Author Rebuttals

#### Reviewer Reports on the Initial Version:

Referee #1 (Remarks to the Author):

##### A. Summary of the key results

This manuscript describes a rare and exciting new ankylosaurian dinosaur skeleton from southern Chile. The specimen is important for a number of reasons. (1) It is very well-preserved, partially articulated, and nearly complete. (2) It clearly represents a new species with an extraordinary Aztec war club-like/frond-like tail club. (3) It is relatively small-sized (for an ankylosaur, especially compared to many species from North America and Asia) and yet appears to be skeletally mature (based on the fusion of sutures). (4) It is only the third named Gondwanan ankylosaur, and shows close anatomical and biogeographical affinities with species of ankylosaur from Antarctica (Antarctopelta) and Australia (Kunbarrasaurus). (5) The authors successfully demonstrate that all three Gondwanan ankylosaurs form a clade (Parankylosauria) distinct from Asian/European/North American ankylosaurs (Euankylosauria).

This manuscript is certain to serve as an essential and popular resource for palaeontologists interested in the Mesozoic, as well as biogeographers and evolutionary biologists. Further, this work is likely to generate considerable interest in science among members of the general public, especially those from South America.

##### B. Originality and significance (if not novel, please include reference)

This specimen is significant for all the reasons listed above. Ankylosaurs are rare from Gondwana and, to the best of my knowledge, otherwise unknown from Chile; the only other ankylosaur material from South America is a fragmentary partial skeleton collected from Argentina.

This specimen is a nearly complete, partially articulated, and has a highly distinctive (and arguably charismatic) morphology. Most notably, this specimen has an uniquely shaped tail club skeleton – less of a club and more of a hatchet (the authors accurately describe it as a 'macuahuitl', an Aztec war club). Given the phylogenetic position of this specimen (see below), it also indicates that the presence of a tail weapon arose at least two (or even three times, depending on the phylogenetic position of Jinyunpelta) among ankylosaurs, and at least once independently among stegosaurs.

Analysis of this material results in a novel reorganization of Ankylosauria, with one clade of Gondwanan species (Parankylosauria, which includes the specimen being described – Stegouros) and a second including all remaining ankylosaurs (Euankylosauria).

##### C. Data & methodology (validity of approach, quality of data, quality of presentation)

The quality of data and presentation is exceptional. The fossil is partially articulated and well-preserved, and the interpretation of the anatomy is sound. The figures, including those in the supplementary information, are outstanding and readily demonstrate all the key features. Further, they are beautifully arranged and easy to follow.

##### D. Appropriate use of statistics and treatment of uncertainties

The phylogenetic analyses and estimation of divergence times are appropriate for this type of study. While the phylogenetic analysis discovers a new clade of Gondwanan ankylosaurs, it also recovers the classic groupings of Nodosauridae and Ankylosauridae.

#### E. Conclusions: robustness, validity, reliability

Overall, the conclusions/interpretations are well-supported and consistent with the data presented. The description has the necessary level of detail included in the main text (with additional information provided in the Supplementary files), and documents all the necessary features identifying this specimen as an ankylosaur. The methodology is well-reported, and will be useful for future investigations.

#### F. Suggested improvements (experiments, data for possible revision)

##### Very minor

- use of the term 'primitive' (e.g., p.1) should be avoided as this may become confused as a feature that is evolutionarily inferior or less complex. Perhaps replace with plesiomorphic or ancestral when used in the context of characters.
- p.2 – in the Holotype description the specimen number is missing
- p.3 – in the Diagnosis it should be clarified that the "...small sized (180-200 cm)..." refers to total body length (body + tail)
- p.4 – the term 'laminar' is confusing as an adjective to describe lacrimals. Please revise
- I could not find any information about the 3D digital reconstructions or CT scanning (type of scanner used, digital reconstruction software, etc...)
- some of the abbreviations used in the figures (and extended data/supplementary figures) are not defined in the figure captions (e.g., Fig. 1: sv, sob, hd, tb fr, fb fr, ca...)
- the scale bar for figure 1a is incorrect (it is not 1 cm)
- extended data figures 5l,m; extended data figures 6a,e,g,I; extended data figures 9a-d; all appear to be digital reconstructions – this should be noted in the figure caption

#### G. References (appropriate credit to previous work)

##### Appropriate

#### H. Clarity and context (lucidity of abstract/summary, appropriateness of abstract intro and conclusions)

Overall, this is an excellent manuscript – it is an exciting and unexpected specimen, with a distinctive morphology, and important evolutionary and biogeographical implications. The text, including abstract, intro, and conclusions, are well-written and easy to follow. In addition, the figures are informative and beautiful.

#### Referee #2 (Remarks to the Author):

Important discovery!! Very much a unique form of tail weaponry that I agree was independently developed relative to other thyreophorans. I agree with *Antarctopelta* being a close relation. However, I do not agree with the linkage to *Kunbarrasaurus*, for example it has a much derived ankylosaur style pelvis; and has cervical rings, as does *Scelidosaurus*.

However, running your beast through several established phylogenies was a strong tool in

supporting (establishing) your hypotheses. A long and what will clearly be, an interesting, ghost lineage of Gondwanan thyreophorans is a strong take home message from this report.

Looking forward to this publication, so we can incorporate these data into our own phylogenetic hypotheses.

I have only a few suggestions for improvement of your supplemental information.

Sup. Fig. 1, What is scale of grid??

Sup. Fig. 1B. Shades of grey are very difficult to distinguish.

A photograph of fossils in situ would be significant supportive information.

Very much looking forward to this publication!

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Overall, the manuscript is well written, and I think the publication of this article will add considerable attribution and new information to the evolution of the ankylosaurians.

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P1:

"~2m": There should be a space between the number and the unit.

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Is "posterior limbs" mean "hindlimbs"?

P3, line 1:

"...greater trochanter" should be "...greater trochanters"

P3, Diagnosis section: "180–200 cm", En dash not hyphen between numbers.

P10, Line 3: North American.

P10 last line:

I suggest using a simpler and more readable term for the tail structure "macuahuitl" like the tail club, such as tail frond.

Fig.1. o, Articulated left foot. Is it the right foot?

I think the absence of ossified tendons in the *Stegouros* specimen may also be due to the specimen preservation.

I suggest the authors can provide separate tnt/nexus dataset files in the supplementary material.

## **Author Rebuttals to Initial Comments:**

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R1:

Very minor

- use of the term 'primitive' (e.g., p.1) should be avoided as this may become confused as a feature that is evolutionarily inferior or less complex. Perhaps replace with plesiomorphic or ancestral when used in the context of characters.

Thanks, this is good advice. We have replaced as suggested for "ancestral", which we think will be more easily grasped by a broader readership, rather than "plesiomorphic".

- p.2 – in the Holotype description the specimen number is missing

Thanks, the holotype number has been re-added (it was inadvertently edited out)

- p.3 – in the Diagnosis it should be clarified that the "...small sized (180-200 cm)..." refers to total body length (body + tail)

Done, thanks

- p.4 – the term 'laminar' is confusing as an adjective to describe lacrimals. Please revise

Thanks, by "laminar" we meant thin and flat. We have omitted the term and the phrase now reads "The maxillae are seamlessly fused and posteriorly inclined" . Explaining would have been lengthy considering fusion with no clear maxilla-lacrima boundary; further, the omitted description has no significance for phylogenetic analysis or any of the conclusions in this paper

- I could not find any information about the 3D digital reconstructions or CT scanning (type of scanner used, digital reconstruction software, etc...)

Thanks, this information has now been added to the methods section

- some of the abbreviations used in the figures (and extended data/supplementary figures) are not defined in the figure captions (e.g., Fig. 1: sv, sob, hd, tb fr, fb fr, ca...)

Thanks, these have now been added

- the scale bar for figure 1a is incorrect (it is not 1 cm)

Thanks, the scale bar is 50 cm, this has now been corrected

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Thanks, this has been corrected

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Looking forward to this publication, so we can incorporate these data into our own phylogenetic hypotheses.

Thanks for these comments, we are assuming no action is required. Cervical rings in Kunbarrasaurus and Scelidosaurus are mentioned in the supplementary information as possibly ancestral for Ankylosauria

I have only a few suggestions for improvement of your supplemental information.

Sup. Fig. 1, What is scale of grid??

Thanks, the scale is 20 cm. We have now included a 50 cm scale in the figure

Sup. Fig. 1B. Shades of grey are very difficult to distinguish.

Thanks, this has been corrected

A photograph of fossils in situ would be significant supportive information.

A photograph has been added to the supplementary information. In situ photographs are not too informative, since we extracted large blocks without exposing many bones at the field. We have therefore also included photos of the preparation process where the articulated skeleton can be better appreciated

Very much looking forward to this publication!

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Thanks, this has been corrected

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Is “posterior limbs” mean “hindlimbs”?+

Thanks, this has been corrected for "hindlimbs"

P3, line 1:

“...greater trochanter” should be “...greater trochanters”

Thanks, this has been corrected

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P10 last line:

I suggest using a simpler and more readable term for the tail structure "macuahuitl" like the tail club, such as tail frond.

We understand the suggestion. However, paleontologists do not usually shy away from complex terminology derived from ancient languages, and at least one reviewer expressed enthusiasm for the comparison to the Aztec club. We think using this term is a good way of highlighting the spectacular nature of the tail weapon, and it is also a tip of the hat to our

Latin American culture. Although we appreciate the reviewer's good intentions, we would like to keep "macuahuitl".

Fig.1. o, Articulated left foot. Is it the right foot?

Thanks, yes it is the right foot, the legend has been corrected (in a previous version both feet were shown, the legend was edited incorrectly)

I think the absence of ossified tendons in the Stegouros specimen may also be due to the specimen preservation.

We agree this is possible. Out of caution, we have eliminated this character from the diagnosis.

I suggest the authors can provide separate tnt/nexus dataset files in the supplementary material.

Thanks, these have now been added in a dryad link