Peer Community In Paleontology

Rare Miocene tuna fossil unearthed in South Korea

Adriana López-Arbarello *based on peer reviews by 2 anonymous reviewers*

Dayun Suh, Su-Hwan Kim, Gi-Soo Nam (2025) A new tuna specimen (Genus *Auxis*) from the Duho Formation (Miocene) of South Korea. bioRxiv, ver. 5, peer-reviewed and recommended by Peer Community in Paleontology.
https://doi.org/10.1101/2024.07.29.605724

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Published: 12 February 2025

A newly discovered fossil of a tuna fish from the Miocene has been identified in the Duho Formation in Pohang City, South Korea (Suh et al., 2025). The new find, attributed to the genus *Auxis*, represents only the second valid fossil record of this genus globally, thus contributing to the understanding of evolutionary history within the Scombridae family (Collette and Nauen, 1983; Nam et al., 2021).

The partially skeleton GNUE322001 consists of a few articulated caudal vertebrae preserving diagnostic features of the genus *Auxis* (Suh et al., 2025). Although it is not possible to compare the new find with the only fossil species known to date, †*A. koreanus* Nam et al., 2021, the significant difference in size suggests that it could be a different species. The fossil, preserved in fine-grained mudstone, also offers insights into taphonomic processes, suggesting that the specimen underwent significant decomposition in a low-energy sedimentary environment before burial.

The new record of *Auxis* supports interpretations of the Duho Formation as a pelagic and subtropical marine habitat, shaped by upwelling activities during the Miocene (Graham and Dickson, 2000; Kim and Paik, 2013; Nam et al., 2021). This discovery emphasizes the significance of upwelling zones in fostering biodiversity and highlights the value of fossil records in reconstructing prehistoric marine ecosystems (Lalli and Parsons, 1997; Wang and Lee, 2019).

References:

Collette, B. B., and Nauen, C. E. (1983). *Scombrids of the world: An annotated and illustrated catalogue of tunas, mackerels, bonitos, and related species known to date*. Food and Agriculture Organization of the United Nations.

Graham, J. B., and Dickson, K. A. (2000). The evolution of thunniform locomotion and heat conservation in scombrid fishes: New insights based on the morphology of *Allothunnus fallai*. Zoological Journal of the Linnean Society, 129(4), 419–466. https://doi.org/10.1111/j.1096-3642.2000.tb00612.x

Kim, J., and Paik, I. S. (2013). Chondrites from the Duho Formation (Miocene) in the Yeonil Group, Pohang Basin, Korea: Occurrences and paleoenvironmental implications. Journal of the Geological Society of Korea, 49(3), 407–416. https://doi.org/10.14770/jgsk.2013.49.3.407

Lalli, C. M., and Parsons, T. R. (1997). *Biological oceanography: An introduction* (2nd ed). Butterworth Heinemann.

Nam, G.-S., Nazarkin, M. V., and Bannikov, A. F. (2021). First discovery of the genus *Auxis* (Actinopterygii: Scombridae) in the Neogene of South Korea. Bollettino Della Società Paleontologica Italiana, 60(1), 61–67. https://doi.org/10.4435/BSPI.2021.05

Suh, D., Kim, S.-H., and Nam, G.-S. (2025). A new tuna specimen (Genus *Auxis*) from the Duho Formation (Miocene) of South Korea. bioRxiv, 605724, ver. 5 peer-reviewed by PCI Paleo. https://doi.org/10.1101/2024.07.29.605724

Wang, Y.-C., and Lee, M.-A. (2019). Composition and distribution of fish larvae surrounding the upwelling zone in the waters of northeastern Taiwan in summer. Journal of Marine Science and Technology, 27(5), article 8. https://doi.org/10.6119/JMST.201910_27(5).0008

Reviews

Evaluation round #2

DOI or URL of the preprint: https://doi.org/10.1101/2024.07.29.605724
Version of the preprint: 2

Authors' reply, 26 January 2025

Thank you so much for your insightful comments. We revised our manuscriped based on your specific comments and also edited the English throughout.

Download tracked changes file

Decision by Adriana López-Arbarello, posted 10 January 2025, validated 10 January 2025

Dear authors,

thank you for the thoroughly revised version of your manuscript, which addresses all the points raised by the two reviewers and myself. At this point I would like to request several, but very minor revisions before recommending your pre-print for publication. You will find them in the attached pdf file.

Please notice that the term Tertiary is no longer in use and the substaged of the Miocen have been formalized in the most recent Chronostratigraphic chart (https://stratigraphy.org/ICSchart/ChronostratChart2022-02.pdf). Therefore, they should be capitalized.

Generally, the English style could be improved, but it is well understandable. I have only made a few suggestions in places where I felt it was really necessary.

Best regards,

Adriana López-Arbarello **Download recommender's annotations**

Evaluation round #1

DOI or URL of the preprint: https://doi.org/10.1101/2024.07.29.605724
Version of the preprint: 1

Authors' reply, 14 November 2024

Uploaded a PDF file containing our responses.
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Decision by Adriana López-Arbarello, posted 17 September 2024, validated 17 September 2024

Dear Mr. Kim,

Although the review process took longer than desired, I'm glad to let you know that I have now received two positive reviews of your manuscript "A new tuna specimen (Genus *Auxis*) from the Duho Formation (middle Miocene) of South Korea". Both reviewers provide very constructive criticisms which will help you to increase the scientific value of your manuscript. Although you should address every comment made by the two reviewers, I would like to emphasize some issues which I find particularly relevant.

Among the recommendations made by the first reviewer I would like to emphasize the addition of labels to your figure 3. If possible, scale bars should be added as well. Alternatively, please add the statement "Size not to scale" in the figure caption.

Reviewer 2 has been more critical, and I find their comments regarding the biogeography and ecology of these fishes are especially helpful. Expanding the discussions to answer the questions regarding the extremely restricted fossil record compared to the current worldwide distribution of the genus *Auxis,* and its potential paleogeographic and palaeoecological implications would certainly enhance the impact of your paper.

The second reviewer also highlights the very peculiar wide notochordal foramen in GNUE322001 compared to other Thunnini. This seems to be a very important feature that deserves further discussion. Are the vertebrae of other *Auxis* species, including the fossil *A. koreanus*, also perforated by a wide notochordal foramen? Although the vertebrae of GNUE322001 are significantly larger than the vertebrae of the only fossil specimen of *Auxis*, the holotype of *A. koreanus*, could the presence of such a wide notochordal foramen indicate a juvenile stage of the specimen? How does the size of the vertebra of GNUE322001 compare with other species of *Auxis*?

I'll expect you'll find no difficulties incorporating the reviewers' recommendations, but let me know if you have any questions.

I look forward to receiving the revised version of your manuscript.

Best regards,

Adriana López-Arbarello

Reviewed by anonymous reviewer 1, 28 August 2024

Overall, this paper is well written and the taxonomic attribution of the fossil specimen seems well-supported.

I have few minor comments:

- Yemmen and Gargouri (2022) is a bizarre citation choice for the first sentence of the Introduction introducing the family Scombridae. More systematics-focused publications, such as Collette and Nauen (1983) which is actually cited in the following sentences, would be more appropriate.

- The first mention of the fact that the fossil vertebrae are interpreted as caudal vertebrae comes in the Remarks subsection of the Results (line 162). However, the reason why the authors attribute these vertebrae

to the caudal region comes later in the Discussion (lines 199-202). I would suggest to mention the main reason for the caudal attribution (decreasing length of ventral processes) first in the Description or Remarks.

- This is just a suggestion: I think that Fig.3 will greatly improve in clarity with the addition of few labels (for example, anterior and posterior branches of inferior antero-zygapophyses, inferior foramen for Euthynnus and Katsuwonus). This will make the anatomical comparison easier to follow. Also, scale bars for the drawings would be appreciated (the same goes for Fig. 4).

Title and abstract

Does the title clearly reflect the content of the article? [X] Yes, [ ] No (please explain), [ ] I don't know

Does the abstract present the main findings of the study? [X] Yes, [ ] No (please explain), [ ] I don't know

Introduction

Are the research questions/hypotheses/predictions clearly presented? [X] Yes, [ ] No (please explain), [ ] I don't know

Does the introduction build on relevant research in the field? [X] Yes, [ ] No (please explain), [ ] I don't know

Materials and methods

Are the methods and analyses sufficiently detailed to allow replication by other researchers? [X] Yes, [ ] No (please explain), [ ] I don't know

Are the methods and statistical analyses appropriate and well described? [X] Yes, [ ] No (please explain), [ ] I don't know

Results

In the case of negative results, is there a statistical power analysis (or an adequate Bayesian analysis or equivalence testing)? [ ] Yes, [ ] No (please explain), [X] I don't know

Are the results described and interpreted correctly? [X] Yes, [ ] No (please explain), [ ] I don't know

Discussion

Have the authors appropriately emphasized the strengths and limitations of their study/theory/methods/argument? [X] Yes, [ ] No (please explain), [ ] I don't know

Are the conclusions adequately supported by the results (without overstating the implications of the findings)? [X] Yes, [ ] No (please explain), [ ] I don't know

Reviewed by anonymous reviewer 2, 13 September 2024

Dear Recommender and Authors

The manuscript entitled "A new tuna specimen (Genus *Auxis*) from the Duho Formation (middle Miocene) of South Korea" is an original contribution. The authors present a description of a new specimen of the fish genus *Auxis* form the Middle Miocene Duho Formation in South Korea, represented by a portion of the vertebral column, and provide taxonomical, paleoenvironmental and taphonomic discussions regarding their finding.

Here I expose some issues I consider should be attended.

Title

The title clearly reflects the content of the article.

Abstract

Please review and rewrite the abstract according to the comments on the pdf as well as the remarks exposed below.

Introduction

In their introduction, they state that the fossil record of the genus is really scarce and only represented by the extinct species *Auxis koreanus* and their new finding (*Auxis* sp.), both coming from the Duho Formation. However, they mention that other fossil specimens were previously assigned to the genus and are currently

invalid. Due to the cosmopolitan condition of the genus Auxis, which at present inhabits tropical and subtropical oceans worldwide it is surprising that its fossil record comes only from one formation in South Korea. Thus, I suggest to broaden this explanation and to give more details on why the other fossils should not be considered part of the genus. Besides, at the end of the Introduction, the authors indicate that they give a discussion on the paleogeographic and palaeoecological implications of tunas in the middle Miocene of South Korea, but they barely include a paleogeographic discussion and I suggest this discussion should be expanded.

Geological setting

In this section the authors indicate that other fish groups have already been reported for the Duho Formation and I recommend that they include a list of the fish groups. This information is relevant to understand why the authors consider their new finding as a tune fish and not a taxon belonging to the others known groups. Also, I suggest indicating in the text or in Figure 1 the Formations that are comprised in the Yeonil Group, so that the reader can easily understand and follow the text.

Materials and methods

Please include the information of the material and in which collection it is housed

Results: Description

In general, the description of the new specimen is written in detail and the photographs and drawings are good. However, the authors describe for the vertebral centra of this specimen that "each counterpart was split along a parasagittal plane, making both cones appear strongly connected by a wide notochordal foramen" and they remark that this trait is rare for the Tribe Thunnini, where the centra are generally not pierced by a notochordal foramen. The described trait is not clearly seen in their Figure 2 and because this trait exhibits a difference with the other taxa of Thunini I recommend adding a Figure showing it.

Discussion

In the subsection Anatomical comparisons I suggest the authors including a sentence on why they consider the new specimen as a Scombridae and also which characteristics suggest it would belong to the Tribe Thunini. Also, I recommend the authors to describe in detail, include a protograph or indicate in the figure 3 the trellis pattern they describe for other genera of Thunini (that is be absent in the new specimen as well as in *Auxis*).

Besides, in the following section of the discussion I suggest separating the paleonvironmental part form the taphonomic interpretation and broadening the paleogeographic discussion.

Finally, I suggest that a native English speaker read and correct the article.

Please find attached the revised version of the manuscript with comments and suggestions.

Download the review