

Response to the editor and reviewers for “A new tuna specimen (Genus *Auxis*) from the Duho Formation (Miocene) of South Korea”

Response to the Editor

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.

Revised as suggested. Added labels and 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.

Revised as suggested. We included an explanation of why *Auxis* fossils are rare, along with detailed information on invalidated *Auxis* taxon. We also expanded on the paleoenvironmental discussion. Regarding the paleogeographic discussion, since our discussion is only within the scope of paleoecology, we removed references to paleogeography in our Introduction to avoid misleading the readers.

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*?

To clarify, the notochordal foramen in our specimen arises from the fossilization process and is not an anatomical trait. The vertebrae were compressed between two slabs of rock that later disintegrated, leaving imprints. The rocks then fused, until it was split off-center along a parasagittal plane. It is the non-symmetrical split that reveals the notochordal foramen in this instance. We revised the *Results: Description* section to increase clarity and prevent confusion regarding the notochordal foramen. Based on the width and length of the centrum, GNUE322001 has a larger vertebra than *Auxis rochei* but a similarly sized vertebra to *Auxis thazard* (Uchida, 1981; Jawad et al., 2013). Full references are in the manuscript.

Response to the Reviewers

To Reviewer #1

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.

Revised as suggested. Simply replaced citation from Yemmen and Gargouri (2022) to Collette and Nauen (1983) since Collette and Nauen (1983) covers all information in the original sentence. Below are excerpts from Collette and Nauen (1983) that correspond to the information in the original sentence.

Original sentence: “The family Scombridae includes mostly epipelagic marine fishes, such as tunas, a large, epipelagic predator (Collette and Nauen, 1983).”

Collette and Nauen (1983) Page 3: “The Scombridae is a family composed of 15 genera and 49 species of mostly epipelagic marine fishes, the mackerels, Spanish mackerels, bonitos, and tunas...Being at least tertiary, if not top predators, large tunas (Thunnini) are less numerous and are landed in lesser quantities than the mackerels (Scombrini).”

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.

Revised as suggested. Included a paragraph with this information in the 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).

Revised as suggested. Drawings are not to scale; therefore, instead added the statement “Size not to scale”.

To Reviewer #2

General

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

We revised the abstract based on both the comments on the pdf and our revisions to the manuscript.

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.

Revised as suggested. We included an explanation of why *Auxis* fossils are rare, along with detailed information on invalidated *Auxis* taxon. We also expanded on the paleoenvironmental discussion. Regarding the paleogeographic discussion, since our discussion is only within the scope of paleoecology, we removed references to paleogeography in our Introduction to avoid misleading the readers.

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.

Corrected as suggested. Included a table (Table 1) of fish fossils reported from the Duho Formation. Revised Figure 1 to indicate which formations comprise the Yeonil Group.

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

Corrected as suggested.

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 Thunnini I recommend adding a Figure showing it.

To clarify, the notochordal foramen in our specimen arises from the fossilization process and is not an anatomical trait. The vertebrae were compressed between two slabs of rock that later disintegrated, leaving imprints. The rocks then fused, until it was split off-center along a parasagittal plane. It is the non-symmetrical split that reveals the notochordal foramen in this instance. In vertebrae split along the midline, the notochordal foramen is absent. This applies to all taxa of Thunnini and is not unique to our specimen. We revised the *Results: Description* section to increase clarity and prevent confusion regarding the notochordal foramen.

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 Thunnini. Also, I recommend the authors to describe in detail, include a photograph or indicate in the figure 3 the trellis pattern they describe for other genera of Thunnini (that is be absent in the new specimen as well as in *Auxis*).

The specimen is too fragmentary for sequential classification as Scombridae or Thunnini. However, the bifurcated inferior antero-zygapophysis with a long pedicle and the absence of a trellis pattern is a clear diagnostic feature unique to *Auxis*. Therefore, we were able to identify this specimen as *Auxis*, even though it was impossible to carry out the standard classification steps. Regarding the trellis pattern, we revised and expanded the description of the trellis pattern in *Discussion: Anatomical comparisons*. We also added a description at the end of the Figure 3 caption detailing how the inferior foramen forms the trellis pattern in *Euthynnus* and *Katsuwonus*.

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

We expanded on the paleoenvironmental discussion. Regarding the paleogeographic discussion, since our discussion is only within the scope of paleoecology, we removed references to paleogeography in our Introduction to avoid misleading the readers.

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

A native English speaker read and corrected this article.

Specific suggestions

Pg.1, line 16: completely articulated. they might be partially preserved

Revised “partially articulated” to “partially preserved”.

Pg.1, line 18: and in the world

Corrected as suggested.

Pg.1, line 20-21: Actually, the specimen is not assigned to a new or existing *Auxis* species due to the discussed differences with both living species and because it corresponds to an unknown part of the body of the extinct *Auxis* species and thus, it is not comparable. (not due to poor preservation and lack of diagnostic features)

Rewrote the sentence as suggested.

Pg.1, line 21-23: Please revise. The finding of a new specimen of *Auxis* (that could correspond to the already known fossil species *Auxis koreanus*, but more specimens are needed to compare) does not indicate a high marine biodiversity.

Revised the word “supports” to “aligns with” to avoid misinterpretation. Now the text should clearly communicate that the finding of a new specimen of *Auxis* **does not** indicate a high marine biodiversity but is an example of a diverse fossil record that corroborates the theory that marine biodiversity increased after the opening of the East Sea.

Pg.2, line 40: Please revise. Few fossil specimens do not mean an unreliable fossil history

Revised “unreliable fossil history” to “sparse fossil history”.

Pg.2, line 42: specimens

Corrected as suggested.

Pg.2, line 42: taxonomic changes?

Corrected as suggested.

Pg.2, line 43-45: Being such a cosmopolitan fish genus, it is surprising that the fossils are found only in one Formation worldwide. I recommend the authors to give a broader explanation of why the other fossil specimens do not correspond to the genus *Auxis*. Also, it would be interesting to know where the invalid fossil *Auxis* taxa come from as well as their age.

Revised as suggested. Included explanation of why *Auxis* fossils are rare, along with detailed information on invalidated *Auxis* taxon.

Pg.2, line 50-51: and the second valid fossil specimen in the world as well

Added “and the second valid *Auxis* specimen in the world” at the end of sentence.

Pg.2, line 52: Please indicate here this diagnostic characters

Corrected as suggested.

Pg.2, line 53: Please expand the paleogeographic discussion below

We expanded on the paleoenvironmental discussion. Regarding the paleogeographic discussion, since our discussion is only within the scope of paleoecology, we removed references to paleogeography in our Introduction to avoid misleading the readers.

Pg.3, line 64: It would be good to indicate the Formations that are comprised in the Yeonil Group, so that the reader can easily understand. Maybe the authors can include this information in the stratigraphic references of fig 1

Revised Figure 1 to indicate which formations comprise the Yeonil Group. Also added a sentence in the geological setting section describing the five formations that comprise the Yeonil Group.

Pg.3, line 64: includes

Corrected as suggested.

Pg.3, line 65: are characterized

Corrected as suggested.

Pg.4, line 73: It would be interesting for the reader to know which other fish groups are found within the Formation. Based on this information the author could clearly indicate in their results why they consider that the material belongs to Scombridae and not to another fish group known for the Formation.

Included a table (Table 1) of list of fish taxa from the Duho Formation.

Pg.4, line 84: Please indicate here why the authors consider a Middle Miocene age for the formation

We realized that we initially referred to the Duho Formation as corresponding to the "middle Miocene" in our title and main text, which implied agreement with this interpretation of the Duho Formation's age. To maintain neutrality on this debated topic, we have removed "middle" from the manuscript and now only refer to the varying interpretations.

Pg.4, line 88: Please indicate here the information on the material and where it is housed

Corrected as suggested.

Pg.4, line 95-96: are these species other members of the Tribe Thunnini?

Yes. The species *Euthynnus* and *Katsuwonus* are other members of the tribe Thunnini. Added "of the tribe Thunnini" at the end of sentence to increase clarity.

Pg.6, line 118: it is referred as neural spine below

Corrected "neural spine" in line 139 to "dorsal spine".

Pg.6, line 128: please indicate body region

Corrected as suggested.

Pg.6, line 131-132: Could the authors include a photograph showing this trait? As it is different from all other members of the Thunnini I think it is important to show it

To clarify, the notochordal foramen in our specimen arises from the fossilization process and is not an anatomical trait. The vertebrae were compressed between two slabs of rock that later disintegrated, leaving imprints. The rocks then fused, until it was split off-center along a parasagittal plane. It is the non-symmetrical split that reveals the notochordal foramen in this instance. We revised the *Results: Description* section to increase clarity and prevent confusion regarding the notochordal foramen.

Pg.6, line 139: the base of its neural spine

Corrected as suggested. Also revised “neural spine” to “dorsal spine” based on previous suggestion.

Pg.7, line 142: above referred as neural spine

Corrected “neural spine” in line 139 to “dorsal spine”.

Pg.7, line 160-161: Are caudal vertebrae preserved in this extinct species?

Along with the cranial elements, only 14 articulated abdominal vertebrae are preserved in this extinct species.

Pg.7, line 163: remove “a character”

Corrected as suggested.

Pg.8, line 169: anterior caudal?

Corrected as suggested.

Pg.8, line 177: is this trait associated to the position of anal fin?

No, the bifurcation is not a trait associated with the position of the anal fin. In *Euthynnus* and *Katsuwonus*, the bifurcation starts in the posterior abdominal vertebrae, while in *Auxis*, it starts in the anterior caudal vertebrae (Kishinouye, 1923; Godsil, 1954; Yoshida, 1979).

Pg.8, line 179: trait is found

Corrected as suggested.

Pg.8, line 185: could the authors describe this trait so that the reader can easily understand why it is absent in the new specimen?

Revised and expanded the description of the trellis pattern in *Discussion: Anatomical comparisons*. Also added a description at the end of the Figure 3 caption detailing how the inferior foramen forms the trellis pattern in *Euthynnus* and *Katsuwonus*. This trait is scarce in *Auxis* vertebrae and is absent in our specimen.

Pg.10, line 211: was

Corrected as suggested.

Pg.10, line 211: in

Corrected as suggested.

Pg.10, line 230: in

Corrected as suggested.

Pg.10, line 231: the

Corrected as suggested.

Pg.10, line 233-234: was the biodiversity lower before the Middle Miocene?

Yes. Although no marine strata from before the opening of the East Sea explicitly indicate lower biodiversity, it is theoretically definite that biodiversity would have increased after the opening of the East Sea. Therefore, the biodiversity would have been comparatively lower before the Middle Miocene. We revised the *Discussion: Paleoenvironmental perspectives* section to make this idea more apparent.

Pg.10, line 234: It would be interesting to indicate and discuss here which of the paleoenvironmental interpretations (stated in the introduction) is supported by the occurrence of *Auxis*.

Included a paragraph in the *Discussion: Paleoenvironmental perspectives* section explaining which of the paleoenvironmental interpretations of the Duho Formation was supported by the occurrence of *Auxis*.