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Comment on "Chronostratigraphic ranges of Early–Middle Miocene larger benthic foraminifera calibrated by planktonic foraminiferal assemblages (Sierra de Marmolance, Granada, SE Spain)" by Bolivar-Feriche et al. (2025)

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Abstract. Bolivar-Feriche et al. (2025) conducted an integrated biostratigraphic study of some stratigraphic sections cropping out at the Sierra de Marmolance (SE Spain), proposing a significant extension of the chronostratigraphic ranges of several well-established Paleogene larger benthic foraminifera (LBF) into the Neogene (Middle Miocene; Langhian–Serravallian). While we agree with the taxonomic attributions of the planktonic foraminifera, we just underline the fact that their sampling locations and stratimetric correlation, although crucial in the general rationale, remain rather vague. Our main concern is with regards to the interpretation of the LBF assemblages as autochthonous. We suggest the most plausible interpretation, i.e., the reworking of LBF within a prograding ramp system, thus rebutting the newly proposed biostratigraphic ranges, which are both implausible and also in conflict with well-constrained ranges calibrated in all sections measured elsewhere in the Tethyan realm and beyond.

1 Introduction

Bolivar-Feriche et al. (2025) report new data from the Subbetic Domain, dating the sedimentary succession of Sierra de Marmolance (Spain) to the late Burdigalian–early Serravallian based on planktonic foraminifera (PF). The authors claim that several key Oligocene and/or Early Miocene larger benthic foraminifera (LBF) persisted into the Langhian and Serravallian, in contrast with the widely accepted scheme of Cahuzac and Poignant (1997), further corroborated today by numerous studies from the Tethyan realm and nearby areas (e.g., Benedetti et al., 2018; Less et al., 2018; Parente and Less, 2019). Given the importance of these claims, their robustness is crucial. However, in our opinion, the evidence presented appears to be more consistent with sedimentary reworking than with an actual extension of the LBF ranges.

While PF are likely to be correctly identified, the main issue concerns the autochthony of LBF specimens, which cannot be resolved solely through preservation (see, e.g., Hohenegger and Yordanova, 2001; Seddighi et al., 2015).

2 Hints for reworking

We think that, before proposing range extensions, the possibility of reworking and subsequent transport into much younger sediments should be excluded beyond reasonable doubt.

The Sierra de Marmolance limestones are described as bioclastic limestones formed on a prograding ramp within the nowadays Betic Cordillera, an active thrust belt (Sanz de Galdeano and Alfaro, 2004), subjected to tectonic uplift during the Neogene. Such conditions favor erosion, transport, and redeposition, making bioclastic deposits prone to taphonomic mixing (e.g., Dorsey and Kidwell, 1999). Robust forms such as *Nummulites* and Lepidocyclinidae are particularly resistant (Hohenegger and Briguglio, 2012; Briguglio et al., 2017) and can be eroded from older rocks, transported downslope, and incorporated into younger sediments as allochthonous clasts (e.g., Jorry et al., 2006).

The LBF assemblages illustrated in Fig. 15 in Bolivar-Feriche et al. (2025) are consistent with the SBZ 22 (A–B) from the mid-Oligocene, except for the supposed “Serravallian” assemblage, where *Nephrolepidina tournoueri* would indicate SBZ 25 (Burdigalian). Some inconsistencies are in the reported co-occurrence of *Nephrolepidina* ex. interc. *morgani* et *praemarginata* together with *N. tournoueri* (see Fig. 3 – section II and Fig. 4 – sections IV–V) and in the position of *N. tournoueri* in the Langhian–Serravallian according to Figs. 3–4 (Fig. 3 – section II and Fig. 4 – sections IV–V), whereas, in Fig. 15, the species is apparently limited to the Serravallian.

A careful check of the article allowed us to notice that the samples with PF were not collected directly within LBF-bearing limestone successions but come about 1 km away from the closest section (see, e.g., the position of MARMO-5 and section III in Fig. 2c). Apparently, MARMO-M1 could be part of section V (Fig. 2b), but the stratigraphic column of Fig. 4 does not report the position of this sample.

The authors claim lateral continuity of strata; in their words, they could see “bedding surfaces traceable for hundreds of metres to kilometres”, but they also acknowledge that “Quaternary materials and debris cover the succession [...] making it difficult to follow the lateral continuity of strata [...] and precluding the systematic sampling of the marls”, introducing at least partial contradictions. No PF data are reported from the marly intercalations (in the stratigraphic columns of limestones, the PF taxa are never reported).

Assessing new biostratigraphic ranges with such poorly constrained data should be considered very carefully.

Additionally, PF sample content is poorly detailed and not clearly ordered, often coinciding with stage boundaries, such as the Burdigalian–Langhian (Fig. 3) or the Langhian–Serravallian (Fig. 4). These issues weaken the reliability of First-Occurrence (FO) and Last-Occurrence (LO) interpretations.

3 Biometry and taxonomy

LBF chronospecies identification relies heavily on subtle biometric parameters, requiring statistically significant populations and well-oriented equatorial sections (e.g., De Mulder, 1975; Less et al., 2018; Parente and Less, 2019; Benedetti and Schiavinotto, 2023, and references therein). Populations include primitive and advanced morphotypes, making single specimens unreliable for biostratigraphy (e.g., Schiavinotto, 2016).

Bolivar-Feriche et al. (2025) use very few oriented sections to identify *Nephrolepidina tournoueri* and *Eulepidina formosoides*. Thus, the use of *exemplum intercentrale* when a single specimen of *Eulepidina* from the sample M5-S4 of section IV is measured is unfortunately not rigorous. In addition, the specimen figured in Fig. 11C is not a well-oriented section and is therefore unsuitable for measurements.

The same is valid for the *Nummulites* species, with no good equatorial sections figured, even if cited in the text. Despite these limitations, based on the detailed descriptions in Sect. 7 and in the figures, the taxonomic identifications appear to be acceptable overall.

4 Conflict with the established Mediterranean Shallow Benthic Zonation (SBZ)

Cenozoic shallow-water biostratigraphy relies largely on the Shallow Benthic Zones (SBZs: Cahuzac and Poignant, 1997; Serra-Kiel et al., 1998).

In particular, LO of *Nephrolepidina* and miogypsinids defines the base of SBZ 26, whereas the extinction of the reticulate *Nummulites fichteli* marks the top of SBZ 22B (early Chattian; see Cahuzac and Poignant, 1997). Extending taxa such as *Nummulites fichteli* into the Langhian implies a range extension exceeding 10 Myr, unsupported by other Tethyan records. The reported survival of Oligocene-restricted species (*N. fichteli*, *N. vascus*, *Eulepidina dilatata*) into the Langhian–Serravallian requires careful evaluation of possible reworking. Usually, Mediterranean Miocene assemblages show low diversity and are dominated by calcarinids, miliolids, and alveolinids.

The cited occurrence of *Nephrolepidina aquitaniae* Silvestri from an “unknown locality” of the Serravallian of Spain by BouDagher-Fadel and Price (2010) is debatable (Benedetti and Schiavinotto, 2023) and therefore not decisive. In this respect, Schiavinotto (2016) stated the following: (1) the attribution of this species to the Serravallian is a quite unusual age for Mediterranean lepidocyclinids, and (2) this interpretation requires a backward evolutionary change underlined by its low level of embryo-nepionic acceleration compared to their supposed ancestors (i.e., *N. tournoueri*). Originally, *N. aquitaniae* was described by Silvestri (1912) on a specimen previously reported from the Aquitanian of Spain by Lemoine and Douvillé (1904), whose inner biometric values are consistent with *N. morgani*, differing in terms of only a few characters of the surface. To summarize, the occurrence of *N. aquitaniae* in the Serravallian likely reflects reworking or misidentification.

As concerns *Eulepidina*, the authors refer to Özcan and Less (2009) and Özcan et al. (2009a, b) for the occurrence of this genus in the Miocene (Burdigalian). However, Özcan and Less (2009) clearly pointed out that this is the result of a migration event to the eastern Tethys from the Indo-Pacific bioprovince before the Europe–Africa collision, dated to the earliest Serravallian (Bialik et al., 2019). We underline that, in the western Indo-Pacific domain, *Eulepidina* went extinct at the top Te boundary, i.e., Aquitanian (Lunt and Luan, 2022).

The genus *Spiroclypeus* is mainly a Priabonian–Chattian genus, with few reports from the Aquitanian SBZ 24 of central Türkiye (Özcan et al., 2009b; Less et al., 2018; Parente and Less, 2019). The extinction of *Spiroclypeus* marks the top Te boundary in the Indo-Pacific domain (Lunt and Luan, 2022), and its LO corresponds to the base of ABZ 23 zone of the Americas, i.e., lower–middle Aquitanian (Mitchell et al., 2024). Indeed, the youngest record of *Spiroclypeus* in the Tethys was reported by Hottinger (1966) from the Burdigalian of Morocco (Bolivar-Feriche et al., 2025, reported Hottinger, 1977, where the original record is correctly attributed to the article of 1966). All of the other occurrences cited come from Türkiye, Oman, and Socotra Island, well out of the western Tethys area.

Although, recently, Benedetti et al. (2025) fixed the range of the genus *Risananeiza* to the Chattian and, possibly, the upper Rupelian, the total range of this genus is still unknown. Anyway, the extension of *Risananeiza crassaparies* into the Serravallian appears to be highly unlikely.

5 Taphonomic vs. biological signals

PF constrain the age of sediments and not necessarily the biological range of LBF. Given the Oligocene and Lower Miocene strata that must exist in the Betic source area, the purported Langhian occurrence of *N. fichteli* is more simply explained by reworking. Bolivar-Feriche et al. (2025) dismiss reworking based on the "autochthonous–parautochthonous" nature of the facies. However, sedimentological autochthony does not imply biological autochthony. In a prograding ramp fed by erosion, the incorporation of well-preserved bioclasts from older, lithified platform carbonates into younger sediments is a common process (see e.g., Schiavinotto and Benedetti, 2021).

High-diversity intervals described in the section likely reflect increasing reworking rather than survival of older taxa. Notably, the authors themselves interpret – in our opinion, with good reason – the orthophragmines recovered at the base of section I as reworked.

6 Paleobiogeography

Bolivar-Feriche et al. (2025) argue that the *Nummulites* in the Langhian of SE Spain "partly fills the stratigraphic gap" between the last fossils in the Oligocene and the modern representatives in the Indo-Pacific. However, this record should occur after the closure of the Tethyan Seaway (Bialik et al., 2019). Any isolated Mediterranean population would represent a local refuge without phylogenetic continuity with Indo-Pacific species.

While some taxa, such as *Heterostegina* spp., *Operculina* spp. (including the recent genus *Neoassilina* and *Planoperculina* as very similar morphotypes), *Cycloclypeus* spp., and *Operculinella cumingii* show continuity, a clear lineage connecting fossil *Nummulites* and modern *N. venosus* is lacking. Moreover, the modern species is often identified as *Palaeonummulites venosus*. Such uncertainty raises serious doubts about the purported "missing gap".

Overall, Neogene paleogeography supports faunal divergence between Mediterranean and Indo-Pacific bioprovinces, except for *Heterostegina* and *Nephrolepidina*, which are commonly reported up to the Upper Miocene in the Indo-Pacific domain (Briguglio, 2018; Lunt and Luan, 2022).

The ranges of LBF in Caribbean (Mitchell et al., 2024) and Indo-Pacific (Matsumaru, 2017; Lunt and Luan, 2022) domains are different but not connected with the case under consideration.

In summary, the reworking of Oligocene tests into the Spanish Neogene basin remains the most parsimonious hypothesis, including with reference to paleogeography.

7 Conclusions

While PF data provided by Bolivar-Feriche et al. (2025) convincingly date the marls to the Early–Middle Miocene, the LBF assemblages are more consistent with a mid-Oligocene age. This discrepancy is best explained by reworking of the limestone content within more recent material. The proposed survival of LBF species over 10–15 Myr is unlikely, given typical lifespans of 2–3 Myr for Cenozoic LBF species. The interpretation of extended ranges in Bolivar-Feriche et al. (2025) should therefore be reconsidered.

We suggest alternative dating approaches, e.g., to search for nannofossils in the marly intercalations inside the limestone (and to consider if reworked Oligocene species co-occur); another option could be Sr isotope stratigraphy to obtain absolute ages of individual specimens vs. bulk carbonate material.

At present, with the data presented by Bolivar-Feriche et al. (2025), reworking remains the most parsimonious explanation, and the proposed chronostratigraphic revisions require stronger supporting evidence to be accepted.

Data availability. No data sets were used in this article.

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