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Review of Hu et al. "A baenid turtle shell from the Mesaverde Formation (Campanian, Late Cretaceous) of Park County, Wyoming, USA" (*PCI Paleontology* 2023)

General concept comments

Brief summary:

The current manuscript is a descriptive and comparative morphological study focusing on a nearly complete baenid plastron and marginal carapace, RAM 28750. The completeness of the articulated specimen alone makes it worthy of study, and it is an important find in the context of relatively recent fieldwork by The Webb Schools in the Mesaverde Formation. In addition, a well composed description of the extensive efforts spent preparing the specimen is provided, along with description of some details of deposition (i.e., iron-containing concretions on the exterior of the shell). The study supplements and clarifies previous reports on Mesaverde turtles, which further solidifies the importance of this geological unit for faunal comparisons with the known rich Campanian turtle fauna of Laramidia. This is partially due to its intermediate geographic location between potential northern and southern provinces within Laramidia.

Review:

The reviewed manuscript is well-written and, with few exceptions, provides an excellent description of a large, nearly complete, unilaterally-preserved turtle plastron with articulated carapacial ring. The quality of the preparation is a key feature of this specimen, and it would have remained very fragmentary without this skilled attention. The description detailing the collection and preparation of the specimen was helpful and insightful. I have tried to keep recommended wording changes below to a minimum, as there are more pressing issues at hand, but a few are suggested for clarity.

As correctly interpreted by the authors, RAM 28750 preserves almost all of the key diagnostic features of the well known baenid *Neurankylus baueri* Gilmore 1916. A single feature (the shape of the femoral-anal sulcus) differs from the diagnostic condition of the entire genus where the sulcus is unilaterally straight or curved, but is not omega-shaped bilaterally. This is a trait characterizing the derived clade of Baenidae, Baenodda, of which *Neurankylus* is definitively not a member. While the diagnosis of the genus is quite correct in including this uncontroversial feature, damage to the area prevents the precise shape of the sulcus, as documented by Fig. 2 of RAM 28750, from being determined. What is apparent is that the unilaterally preserved sulcus is curved and not straight, and its shape is perhaps not a simple curve. However, given evidence in *N. baueri* of more substantial variation (i.e., the shape of inframarginal scales), the ambiguity in RAM 28750 is perhaps of less import than the authors present. Further, though I appreciate the bilateral presentation in Figure 2D, the reader must keep in mind that any apparent difference with *N. baueri* is represented by not just a single specimen, but a single xiphiplastron. Given the fragmentary nature of the specimen and the unilateral and unclear nature of the suture, I am not convinced that the true shape of the sulcus can be determined. Unless, perhaps an additional detail photograph under oblique lighting could show the sulcus better. Additionally, I believe RAM 28750 could be accurately referred to cf. *N. baueri* based on the other clear similarities in size, general plastral proportions, and arrangement of gular/intergular scales. Additional discoveries could very conceivably confirm this attribution with a well preserved xiphiplastron. Additional discoveries could also produce a clearly omega-shaped femoral-anal sulcus, which would be evidence of a new taxon.

As more Late Cretaceous baenid discoveries are demonstrating, the utility of *Baenodda* as a concept is limited since it is not phylogenetically defined, and excludes taxa that have a unique combination of baenoid traits, but not the full suite (e.g., “*Trinitichelys maini*”, *Thescelus* spp.).

As a further consideration, *Neurankylus eximius* is typically associated with higher latitudes, and though this would be a relatively northern occurrence of *N. baueri*, its presence at Mesaverde is certainly possible. Further, I am not the only one to follow this reasoning. Though the authors mention that baenid material is known from the Mesaverde, they do not mention that cf. *Neurankylus* sp. is included in the faunal lists of DeMar & Breithaupt 2006, 2008. However, material attributed to cf. *Neurankylus* sp. is not figured or described, which is odd because the remaining turtle referrals in those studies are sound and well-supported. So, in summary, I recommend that the authors show more confidence in the affinity of this specimen with *N. baueri*. The significant contribution remains that the authors can confirm the inclusion of cf. *Neurankylus* on the faunal list of DeMar and Breithaupt 2006, 2008, and provides a well supported description and figure focusing the attribution to cf. *Neurankylus baueri* specifically. The results of the phylogenetic analysis conducted by the authors is not surprisingly unhelpful given the quantity of missing data in RAM 28750. I think a table summarizing the differential traits between *Neurankylus* species or even individual specimens would provide a more robust framework of support for the attribution I advise, to be included in the results or discussion. Further, the discussion could be expanded by a re-evaluation of the specimen in light of what is known about variation within the genus, and potential ecological or depositional insights into the Mesaverde faunal assemblage. Also, the authors should check to see whether the occurrence of *N. baueri* at Mesaverde constitutes any sort of geographical range extension for the species.

I suggest some particular sources below and am happy to provide PDFs of any references I have mentioned via the email address included at the end of this review.

Specific comments (**bold** indicates higher importance):

Lines 29, 161, 165, 207, 213: In several places, “trapezoidal” is used to describe the shape of the margin of the plastral lobes. This is an atypical term used in plastral descriptions, mainly because many of the (anterior lobes especially) shapes are various proportions of trapezoids. A more helpful way to describe those regions and the shape of the margins is the degree of roundedness. Figure 21.1 in Larson et al. (2013) has a nice comparison of *Neurankylus* specimens. The phrase “squared off” vs. rounded vs. subtriangular is another descriptive option that I have seen.

Speaking of plastral lobes and comparisons, I’ll call the authors’ attention to an interesting finding from a paper that I have currently in review (otherwise I would include it). I came across a nice little dataset in Archibald (1977), his dissertation, in which he has a table of measurements (Table 57, Page 557). In this, for each taxon he samples (many of which are baenids), he has an index of “Ant. Lobe length/Post. Lobe length”. In the process of using this data in an analysis, I found that *Neurankylus eximius*, *N. baueri*, and *N. lithographicus* had a quite constrained ratio range of 0.8-0.9. A great fact about RAM 28750 is that the lengths of the articulated carapace and plastron are preserved and don’t need to be estimated. If the ratio of lobe lengths in the specimen is between 0.8 and 0.9, it would add to the already ample evidence that this is *Neurankylus*. Comparative taxa might need to be added to establish this, but it is an under-reported morphological metric that seems to have some phylogenetic correlation (at least in baenids). In any case, a small comparative assessment of this trait would be interesting for the discussion.

Below it is the Archibald reference. If the authors have a hard time finding it or need other references mentioned herein, please contact me directly and I am happy to share PDFs.

Archibald, D.J. 1977. Fossil Mammalia and Testudines of the Hell Creek Formation, and the Geology of the Tullock and Hell Creek Formations, Garfield County. Ph.D. Thesis, University of California, Berkeley.

Line 45: Campanian sites are named in parentheses, so “other Campanian” should replace “many” added before “formations”.

Line 56: Replace “unit” with “Mesaverde Formation”.

Line 58-61: This paragraph would benefit from more detail. When possible, please identify sympatric genera rather than family. For instance, it is notable that *Boremys* is recognized in the Mesaverde, and even more so because DeMar and Breithaupt attribute cervical vertebrae to *Boremys pulchra* rather than its substantially larger congeneric, *B. grandis*. Not reporting genus level sympatrics loses this detail. It is intriguing that the two baenids represented are apparently a very small derived species and a quite large, more primitive generalist species. Though I don’t recall seeing this in a study, it’s my impression that sympatric baenids, especially as pairs, seem to have body size and locomotor/dietary differences suggestive of niche separation. The presence of two baenid taxa is similar to many pre-Campanian assemblages, and does not approach the richness seen in the most speciose units of the latest Cretaceous (e.g., Hell Creek, which boasts at least 11 baenids).

In locating this information myself in the DeMar and Breithaupt publications, I noticed that the faunal lists include a “cf. *Neurankylus* sp.”, but not much else is mentioned of this taxon. This material should be addressed and differentiated from or related to RAM 28750, if even possible (the material is not figured). Also, if possible, an idea of the sample size of the represented Mesaverde collection would be helpful in the paragraph beginning on line 62. Speaking of the author, it appears that “DeMar” is the correct spelling, so this should be corrected throughout.

Line 83: If “an uncommon record of” is replaced with “few”, it makes the next sentence read more smoothly.

Line 85: Please replace “easterly” with “eastward”.

Regarding Line 99: It is significant that the host matrix of RAM 28750 is siltstone, as most relatively complete baenids are recovered from sandstones and thus had a fluvial deposition. *Neurankylus* has been an exception to this nearly ubiquitous trend, and its presence in non-fluvial or potentially lacustrine deposits suggests a difference in habitat from most baenids.

This is summarized in Adrian et al. (2019) on page 7 with more references therein: “Specifically, fine- to coarse-grained channel sandstone accounts for nearly all deposits from which relatively complete ($\geq 50\%$ of the shell) baenid shells have been recovered (Hutchison, 1980; Hutchison, 1984; Hutchison and Archibald, 1986).”

Reference for Adrian et al. (2019):

Adrian, B., Smith, H.F., Noto, C.R., and Grossman, A. 2019. A new baenid, "*Trinitichelys*" *maini* sp. nov., and other fossil turtles from the Upper Cretaceous Arlington Archosaur Site (Woodbine Formation, Cenomanian), Texas, USA. *Palaeontologia Electronica*, 22.3.81:1-29. <https://doi.org/10.26879/1001>

This should be mentioned in the discussion because though *Neurankylus* is a well known genus both phylogenetically and morphologically, the number of relatively complete described specimens other than types is low, and variation is poorly understood. Larson et al. (2013) discusses variation in the genus and provides some additional insights into its paleoecology. This is particularly relevant to RAM 28750, as the shape of the femoral-anal sulcus is the only preserved trait differing from *N. baeuri*. Compared to the apparent variability of inframarginal shape noted in *N. baueri*, the slight variation seen in the present femoral-anal sulcus seems to be within a similarly modest range of variability. Another helpful reference for paleoecology and a good review of the taxonomic history of the genus is provided in:

Lichtig, A.J., and Lucas, S.G. 2018. *Neurankylus*, a Cretaceous-Paleocene baenid turtle from North America. *New Mexico Museum of Natural History and Science Bulletin*, 79:323-361.

Line 107: Please move "also" to after "were".

Line 109: This is partially out of self interest, but are the authors able to provide any more insight about the iron concretions around and on the bone? I have encountered iron-rich deposits on baenids before. Similar concretions were prevalent on the type specimen of the recently described baenid *Edowa zuniensis* from the Turonian of the San Juan Basin in New Mexico. Similarly, a complete shell of "*Trinitichelys*" *maini* was totally infilled with sand/ironstone from the Cenomanian Lewisville Formation in Texas (paper is now in review). I don't know much about the underlying geochemistry, but I have wondered if the iron content in these concretions could be related to anoxic conditions or the presence of brackish water. Do the authors have any further observations? Are these concretions present widely in the Mesaverde or certain deposits, and do they affect any other fossils? There actually doesn't need to be any change made, but any additional insight into this phenomenon might be of interest to some readers. One additional question- I presume the concretions were removed mechanically?

Paragraph beginning at line 123 (Phylogenetic analysis): I understand the rationale for choosing the character matrix of Rollot et al. (2022). Unfortunately, the baenid phylogenetic matrix has become somewhat of a Frankenstein cobbled together from several iterations of analyses by different authors. Due to missing data, the phylogenetic analysis was unable to provide any clarification beyond Baenidae, which could be gleaned by the fusion of the plastron and the lack of ornamental texture. A more informative approach that might summarize the traits better is a table comparing the characters (plastral lobe shape/proportions, sulcus shape, etc.) of Campanian baenids mentioned in the differential comparisons. An example of what I mean is Table 21.1 in Larson et al. (2013).

Line 152-153: In the caption for Figure 3, anterior and posterior "pleural" lobes should be changed to anterior and posterior "plastral" lobes. Pleurals are carapacial scales.

Discussion section (beginning at line 204):

Line 206: There are several observations stating that RAM 28750 is relatively large, but it should be specified that this is compared to other baenids, as only a certain subset are above about 40 cm.

Line 209-210: I agree that due to incompleteness and preservation (to some extent), this would not make a clearly diagnosable type specimen for a new taxon. However, I don't think that a skull is necessary (though it would be ideal) to define a new species, but that doesn't apply here.

Lines 211-221: I appreciate the description of the margin of taxonomic uncertainty regarding RAM 28750. However, I think somewhat more certainty is warranted in this case. RAM 28750 is indeed almost identical to *Neurankylus* (cf. *N. baueri*). The omega-like shape of the femoral-anal sulcus is the only differentiating character. However, there is some variation between straight and curved femoral-anal sulci known in *Neurankylus*, though sexual dimorphism isn't known for the genus (to my knowledge). In any case, this sort of variation has been noted for other baenids (as noted in the manuscript), and there is evidence of dimorphism in other baenids. A close look at the high resolution version of Figure 2B doesn't clearly show the sulcus, though it seems to be curved. In any case, there is a lot of damage in this area, so the precise shape is not clearly defined. There is also a possibility that the sulcus could be something intermediate between curved and omega-shaped, as depicted in Fig. 21.3b in Larson et al. (2013).

Line 224-225: Please add "the" before "strong", and replace "taxa" with "discoveries". The authors don't make a case for a new taxon, and evidence hasn't been presented that RAM 28750 is the first recognition of *Neurankylus* in the unit (see faunal lists of DeMar & Breithaupt 2006, 2008).

Line 307: Larson et al. (2013) is out of alphabetical order at the end of the "L" refs.

In summary, I consider this an important contribution that should be published pending revisions I have outlined here. I refrain from using the terms "major" or "minor", hoping that revisions not require enormous additional effort, since the study is fundamentally sound and simply needs more clarity in the taxonomic referral and additional discussion as relevant. I thank the authors for their work and look forward to seeing this study in publication. They may contact me with further questions at brentonadrian@gmail.com.

Best regards,

A handwritten signature in black ink that reads "Brent Adrian". The signature is written in a cursive, flowing style.

Brent Adrian