Injuries and molting interference in a trilobite from the Cambrian Furongian of South China by Zong. Submitted to *PeerJ,* 2020.

Summary

Zong presents an injured specimen of the trilobite *Shergoldia laevigata* from the Sandu Formation (Cambrian:Furongian). The specimen displays two healed injuries to the left side. In the following discussion, Zong considers the injury to have been caused by a predatory radiodont, and to have caused subsequent problems during moulting.

The identification of the healed injuries is sound, however I disagree with the interpretation that a radiodont was the likely cause, and that the healed injury caused problems during moulting. *PeerJ* allows speculation, as long as it is identified as such, and I do not want to stop the author from publishing this work simply because I have a different interpretation. However, I think that these two discussion points need to be expanded upon. This will either make the author's argument more convincing, or it will allow a more open interpretation considering additional factors. I have outlined all my suggested changes point-by-point below, including additional smaller areas where the author may also want to expand their argument slightly and include additional references.

Introduction

30. - The author could consider additional complementary sources of information beyond repaired injuries, such as bromalites. The discovery of trilobite sclerites in cololites and coprolites is arguably more informative for identifying trophic relationships (scavenging and/or predation) in the fossil record than repaired injuries. For further discussion of this topic in relation to trilobites in particular, the author can look to, for example, Babcock 2003 and Bicknell & Paterson 2018. In addition the author may consider specific studies that have demonstrated the presence of trilobite sclerites inside the guts of Burgess Shale animals. Two examples are the euarthropod *Sidneyia inexpectans* (Zacai et al. 2016) and the priapulid *Ottoia prolifica* (Vannier 2012).

35 – A quantitative assessment of the relative frequency of wounds to the thorax and cephalon on trilobites from a single site was undertaken by Pates & Bicknell 2019. The relative lethality of cephalon and thoracic wounds was also discussed. The author may find this study informative for their discussion of the relative lethality of injury to different body parts.

39-40 – I recommend shortening this list of references. Babcock & Robison 1989, Babcock 1993 and especially Nedin 1999 are the best references for this statement. The Bicknell papers do not offer strong support for this statement, and do not use the shape of the wounds in support of a radiodont cause of injury.

42 -- For Cambrian examples, a comprehensive list of injuries and putative predators was compiled by Bicknell & Paterson 2018. The author could consider including this reference here.

Results

The results section is good, and offers an overview of the injuries on the left side of the trilobite. It would benefit from extra details including linear measurements of the injured areas.

- Measurements of the two injured sites would allow more specificity in the description. The author would then be able to state exactly how much shorter the damaged thoracic segments are than undamaged ones (either in a percentage or absolute terms).

- In addition, measurements of how much of the injured thoracic segments has been healed, would allow the author to quantify how much healing has occurred.

- The observations used in the last section (Discussion: Inteference with the molting of trilobite) to argue that the specimen is a problematic moult are not included in the results. The descriptive part of this section should be moved to the results.

90 – the last half sentence of the results is an interpretation. It would be strengthened with a reference to previous work, and would be best in the Discussion section.

Discussion

Possible origin of the wounds

98 – typo here 'Rudkin 1979' not 'Rudkins'. These are not the only studies to consider the healing of trilobite wounds. A pertinent example is McNamara & Tuura 2011. This study considered the developmental basis for the observed sequence of regeneration of segments.

102-106 – The suitability of radiodonts as predators on trilobites has been repeatedly discussed, and is controversial. Whether radiodont frontal appendages and oral cones were able to break trilobite exoskeletons is unknown, and has repeatedly been cast into doubt. This part of the discussion would benefit from a discussion of the level of uncertainty around radiodonts as trilobite predators. See, for example, Daley & Bergstrom 2012; Daley et al. 2013a; Bicknell & Pates 2020.

115-121 – The author argues that the shape of the injury means that it could not have been made by a gnathobase or gnathobase-like structure. The author then concludes that a radiodont frontal appendage is therefore the cause. I recommend stating that the identification of a radiodont as a predator is speculative. This discussion would also benefit from a more detailed consideration of the points below:

- Ruling out gnathobases does not mean that a radiodont is the only remaining option. A more detailed discussion is required, detailing how the radiodont frontal appendage may have caused the injury. An appreciation of the varied morphologies of radiodont frontal appendages would allow the author to consider some families and rule out others (see for example: Daley & Budd 2010; Pates & Daley 2019 for panels showing the variety of forms in the Burgess Shale and Kinzers Formation respectively, and Pates et al. 2019a for a comparison of the genus *Anomalocaris*). Pates et al. 2019b fig. 1 gives a schematic overview of the organization of endites belonging to different radiodont families. This may be of further use for a refinement of the schematic appendage in Fig. 3A, which as it stands does not show the organization of any radiodont family. Also, note that the term 'ventral spine' has been superseded by 'endite' in more recent radiodont studies.
- This discussion would greatly benefit from a consideration that no radiodonts are (yet) known to cooccur with *Shergoldia laevigata,* though soft-bodied fossils are known from near Guole (e.g. Zhu et al. 2016).
- Consider radiodonts in a temporal context. Most radiodonts of Drumian and younger belong to the family Hurdiidae, which do not have endites of alternating size. All members of this family are considered to be sediment sifters or suspension feeders (Daley et al. 2013a, b; Lerosey-Aubril & Pates 2018; Van Roy et al. 2015). All Ordovician radiodonts currently described are hurdiids (e.g. Van Roy et al. 2015; Pates et al. 2020). The youngest *Anomalocaris* (and anomalocaridid) known are from the Weeks Formation, Utah, USA (Guzhangian) (Lerosey-Aubril et al. 2014).

- It should be acknowledged that an amplectobeluid or anomalocaridid cause for the injury (or future discovery in the Furongian) would extend the known stratigraphic range of these families (youngest amplectobeluid is from the Wheeler Formation, Utah, USA – Drumian in age – Lerosey-Aubril et al. 2020).
- Upon reading the conclusions, it seems that the author does not think that a radiodont necessarily caused the injuries, but instead favours a 'predatory frontal appendage with variable-sized ventral spines'. This part of the Discussion could reflect this broader interpretation of a putative predator (which includes some radiodonts) and also identify other possible culprits.

136 – Bicknell & Paterson 2018 review this topic in detail, and should be cited here.

Interference with the molting of trilobite

The author argues that the injury has disturbed the moulting behaviour of the trilobite. This is noted as speculative, and the PeerJ guidelines state that speculation is encouraged, as long as it is identified as such. This speculative part of the discussion would benefit from considering a number of additional points.

- What is known about the depositional environment? Are broken sclerites common in this layer or other layers? Pratt 1998 has a discussion of this very issue, considering possible biotic and abiotic causes for the prevalence of broken trilobite sclerites in the Rabbitkettle Formation. A similar in depth discussion of possible causes would be beneficial in this study.
- The anterior of the cranidium shows damage as it does not line up with the broken margin of the rock. Is it possible that the exoskeleton has been transported and/or damaged abiotically? If so, this should be acknowledged, and the potential for transport in slightly disturbing the thoracic segments also acknowledged.
- As the free cheeks are not preserved alongside the specimen (as is expected in an undisturbed moulting configuration, see e.g. Drage 2019) have they been transported away? If so, could the same effect that transported away the free cheeks have also slightly disturbed the thoracic segments?
- Asymmetry in moult configurations and disrupted thoracic segments have been observed in trilobites lacking evidence of healed injuries (for examples see figures in Daley & Drage 2016; Drage et al. 2018, 2019). The amount of disruption in this exoskeleton is very small. How sure is the author that it was more problematic to exit this exoskeleton than for an uninjured trilobite?

160 – The author may wish to consider additional cases in the fossil record where ecdysozoans have been 'caught in the act' of moulting. For example Yang et al. 2019 (*Alacaris mirabilis*), and additional examples listed in Drage & Daley 2016.

As the extent of disruption to the molt configuration is very small, it may have been disturbed by abiotic processes, and uninjured trilobite specimens show an arguably greater asymmetry and disruption to thoracic segments, I would caution that there is not strong support for suggesting that the injury to this specimen resulted in problems undertaking moulting.

References cited in this review

Babcock, L.E. and Robison, R.A., 1989. Preferences of Palaeozoic predators. *Nature*, *337*(6209), pp.695-696.

Babcock, L.E., 1993. Trilobite malformations and the fossil record of behavioral asymmetry. *Journal of Paleontology*, pp.217-229.

Babcock, L.E., 2003. Trilobites in Paleozoic predator-prey systems, and their role in reorganization of early Paleozoic ecosystems. In *Predator—prey interactions in the fossil record* (pp. 55-92). Springer, Boston, MA.

Bicknell, R.D. and Paterson, J.R., 2018. Reappraising the early evidence of durophagy and drilling predation in the fossil record: implications for escalation and the C ambrian E xplosion. *Biological Reviews*, *93*(2), pp.754-784.

Bicknell, R.D. and Pates, S., 2020. Exploring abnormal Cambrian-aged trilobites in the Smithsonian collection. *PeerJ*, *8*, p.e8453.

Daley, A.C. and Budd, G.E., 2010. New anomalocaridid appendages from the Burgess Shale, Canada. *Palaeontology*, *53*(4), pp.721-738.

Daley, A.C. and Bergström, J., 2012. The oral cone of *Anomalocaris* is not a classic ''*Peytoia*''. *Naturwissenschaften*, *99*(6), pp.501-504.

Daley, A.C., Paterson, J.R., Edgecombe, G.D., García-Bellido, D.C. and Jago, J.B., 2013a. New anatomical information on *Anomalocaris* from the Cambrian Emu Bay Shale of South Australia and a reassessment of its inferred predatory habits. *Palaeontology*, *56*(5), pp.971-990.

Daley, A.C., Budd, G.E. and Caron, J.B., 2013b. Morphology and systematics of the anomalocaridid arthropod Hurdia from the Middle Cambrian of British Columbia and Utah. *Journal of Systematic Palaeontology*, *11*(7), pp.743-787.

Daley, A.C. and Drage, H.B., 2016. The fossil record of ecdysis, and trends in the moulting behaviour of trilobites. *Arthropod Structure & Development*, *45*(2), pp.71-96.

Drage, H.B. and Daley, A.C., 2016. Recognising moulting behaviour in trilobites by examining morphology, development and preservation: Comment on Błażejowski et al. 2015. *BioEssays*, *38*(10), pp.981-990.

Drage, H.B., Holmes, J.D., García-Bellido, D.C. and Daley, A.C., 2018. An exceptional record of Cambrian trilobite moulting behaviour preserved in the Emu Bay Shale, South Australia. *Lethaia*, *51*(4), pp.473-492.

Drage, H.B., Vandenbroucke, T., Van Roy, P. and Daley, A.C., 2019. Sequence of post-moult exoskeleton hardening preserved in a trilobite mass moult assemblage from the Lower Ordovician Fezouata Konservat-Lagerstatte, Morocco. *Acta Palaeontologica Polonica*, *64*(2), pp.261-273.

Drage, H.B., 2019. Quantifying intra-and interspecific variability in trilobite moulting behaviour across the Palaeozoic. *PALAEONTOLOGIA ELECTRONICA*, *22*(2).

Lerosey-Aubril, R., Hegna, T.A., Babcock, L.E., Bonino, E. and Kier, C., 2014. Arthropod appendages from the Weeks Formation Konservat-Lagerstätte: new occurrences of anomalocaridids in the Cambrian of Utah, USA. *Bulletin of Geosciences*, *89*(2), pp.269-282.

Lerosey-Aubril, R. and Pates, S., 2018. New suspension-feeding radiodont suggests evolution of microplanktivory in Cambrian macronekton. *Nature communications*, *9*(1), pp.1-9.

Lerosey-Aubril, R., Kimmig, J., Pates, S., Skabelund, J., Weug, A. and Ortega-Hernández, J., 2020. New exceptionally preserved panarthropods from the Drumian Wheeler Konservat-Lagerstätte of the House Range of Utah. *Papers in Palaeontology*.

McNamara, K.J. and Tuura, M.E., 2011. Evidence for segment polarity during regeneration in the Devonian asteropygine trilobite *Greenops widderensis*. *Journal of Paleontology*, *85*(1), pp.106-110.

Pates, S. and Bicknell, R.D., 2019. Elongated thoracic spines as potential predatory deterrents in olenelline trilobites from the lower Cambrian of Nevada. *Palaeogeography, Palaeoclimatology, Palaeoecology*, *516*, pp.295-306.

Pates, S. and Daley, A.C., 2019. The Kinzers Formation (Pennsylvania, USA): the most diverse assemblage of Cambrian Stage 4 radiodonts. *Geological Magazine*, *156*(7), pp.1233-1246.

Pates, S., Daley, A.C., Edgecombe, G.D., Cong, P. and Lieberman, B.S., 2019a. Systematics, preservation and biogeography of radiodonts from the southern Great Basin, USA, during the upper Dyeran (Cambrian Series 2, Stage 4). *Papers in Palaeontology*.

Pates, S., Daley, A.C. and Butterfield, N.J., 2019b. First report of paired ventral endites in a hurdiid radiodont. *Zoological letters*, *5*(1), p.18.

Pates, S., Botting, J.P., McCobb, L.M. and Muir, L.A., 2020. A miniature Ordovician hurdiid from Wales demonstrates the adaptability of Radiodonta. *Royal Society Open Science*, *7*(6), p.200459.

Pratt, B.R., 1998. Probable predation on Upper Cambrian trilobites and its relevance for the extinction of soft-bodied Burgess Shale-type animals. *Lethaia*, *31*(1), pp.73-88.

Van Roy, P., Daley, A.C. and Briggs, D.E., 2015. Anomalocaridid trunk limb homology revealed by a giant filter-feeder with paired flaps. *Nature*, *522*(7554), pp.77-80.

Vannier, J., 2012. Gut contents as direct indicators for trophic relationships in the Cambrian marine ecosystem. *PloS one*, *7*(12), p.e52200.

Yang, J., Ortega-Hernández, J., Drage, H.B., Du, K.S. and Zhang, X.G., 2019. Ecdysis in a stem-group euarthropod from the early Cambrian of China. *Scientific Reports*, *9*(1), pp.1-9.

Zacaï, A., Vannier, J. and Lerosey-Aubril, R., 2016. Reconstructing the diet of a 505-million-year-old arthropod: Sidneyia inexpectans from the Burgess Shale fauna. *Arthropod Structure & Development*, *45*(2), pp.200-220.

Zhu, X., Peng S., Zamora, S., Lefebvre, B. and Chen, G., 2016. Furongian (upper Cambrian) Guole Konservat-Lagerstätte from South China. *Acta Geologica Sinica-English Edition*, *90*(1), pp.30-37.