RESEARCH ARTICLE

Decay experiments on shrimps provide insight into the fossilisation potential of arthropod appendages

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Decay experiments on organisms under controlled laboratory conditions provide a powerful tool for understanding the preservation potential of organisms in the rock record. These experiments have been applied to numerous animal groups, including but not limited to echinoderms, annelids, priapulids, chordates, and arthropods. However, little work has focused on the degradation of arthropod appendages, despite their abundance in many fossil sites. Here, we compare the decay of appendages in freshwater and saltwater shrimps. Setae on these appendages are preserved in minute detail and do not exhibit signs of degradation, even after the appendages have separated from the body. The results are then compared to appendage preservation patterns in the fossil record with a particular focus on radiodonts since their taxonomy and palaeoecology largely rely on the shape and fine details of their frontal appendages. We suggest that radiodont appendages with differences in setal number are unlikely to represent taphonomic variations of the same species but are more likely to belong to different taxa.

Experimental taphonomy | Cambrian | Ordovician | Arthropoda | Decay | Radiodonta

Received: 24 March 2025; Accepted: 22 July 2025; Published: 18 August 2025

Introduction

The description of fossil species is a challenging task since fossilisation is a complex process during which anatomical information can either be retained or lost (Briggs and McMahon, 2016; Purnell et al., 2018), but in the absence of genetic information, the taxonomy of fossil organisms is entirely based on morphology alone. Loss of anatomical information mainly occurs during the first days to weeks following the death of an organism, as it is exposed to environmental factors such as bacteria and scavengers (Briggs and McMahon, 2016; Purnell et al., 2018; Saleh et al., 2021b). Internal conditions specific to each carcass, such as pH levels and the gut microbiome, can also influence decay (Butler et al., 2015; Clements et al., 2022; Purnell et al., 2018). If degradation is not halted, it can lead to the complete loss of morphological features, particularly in non-biomineralised remains, which are more prone to decay than bones and shells (Saleh et al., 2020a).

Arthropods are the most abundant animal phylum on Earth today, as they were in the early eumetazoan-dominated communities of the Cambrian Explosion (Daley et al., 2018). Some Early Palaeozoic fossil sites preserve arthropods in exceptional detail, such as the middle Cambrian Burgess Shale in Canada (Butterfield, 1995, 1990; Caron and Jackson, 2008; Izquierdo-López and Caron, 2022; Moysiuk and Caron, 2019, 2022; Nanglu et al., 2020; Yochelson, 1996), the early Cambrian Chengjiang Biota in China (Cong et al., 2014; Hou et al., 2017; Ma et al., 2012; Schmidt et al., 2021, 2024; Zhao et al., 2010), and the Early Ordovician Fezouata Biota in Morocco (Laibl et al., 2023; Lustri et al., 2024; Perez-Peris et al., 2021; Saleh et al., 2021b; Van Roy et al., 2015). However, even in sites where non-biomineralised arthropods are preserved, body fragments are far more common than complete specimens (Daley and Budd, 2010; Pates et al., 2021; Potin and Daley, 2023; Saleh et al., 2022a, 2024a; Whittington and Briggs, 1985; Zhang et al., 2023). This is the case in the Burgess Shale (Collins, 1996; Daley and Edgecombe, 2014; Daley and Peel, 2010; Whittington and Briggs, 1985), and in other Burgess Shale-type assemblages such as the Fezouata, Chengjiang, and Qingjiang biotas (Fu et al., 2019; Potin et al., 2023; Saleh et al., 2021a; Wu et al., 2021b, 2024a, 2024b). These isolated body fragments are often used to describe new taxa, even in the absence of whole body specimens, with the most complex example of this coming from Radiodonta (Fig. 1), stem lineage euarthropods whose fossil remains have a tendency to disarticulate into separate specimens of frontal appendages, mouth parts, head carapaces, eyes, lateral flaps and setal blades (Briggs, 1979; Collins, 1996; Daley et al., 2018; Potin and Daley, 2023; Whittington and Briggs, 1985). For radiodonts, the appendages in particular have been most often used to define new taxa, but if these fragments have undergone decay, how confidently can we use them to assign new fossil taxa?

To address similar questions, decay experiments are usually conducted under controlled laboratory conditions. By quantifying post-mortem information loss of modern taxa under different environmental conditions (e.g., Allison, 1988; Briggs et al., 1995; Briggs and Kear, 1993, 1994; Butler et al., 2015; Clements et al., 2017, 2022; Corthésy et al., 2024, 2025a, 2025b; Fraga and Vega, 2025; Hancy and Antcliffe, 2020; Iniesto et al., 2015, 2016, 2017; Klompmaker et al., 2017; Murdock et al., 2014; Naimark et al., 2018, 2016; Newman et al., 2019; Palmer et al., 2024; Sagemann et al., 1999; Sansom, 2014; Sansom et al., 2010, 2013), these experiments help reconstruct the potential degradation sequence of extinct animals. Many previous decay experiments have focused on arthropods (Baas et al., 1995; Briggs and Kear, 1994; Butler et al., 2015; Corthésy et al., 2024, 2025b; Klompmaker et al., 2017; Naimark et al., 2018; Plotnick, 1986; Wilson and Butterfield, 2014).

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Managing Editor: Thomas Wong Hearing; Handling Editor: William Gearty; Peer reviewers: Jane Reeves, Silvina Slagter; Typesetter: Farid Saleh

https://doi.org/10.26034/la.opal.2025.7073

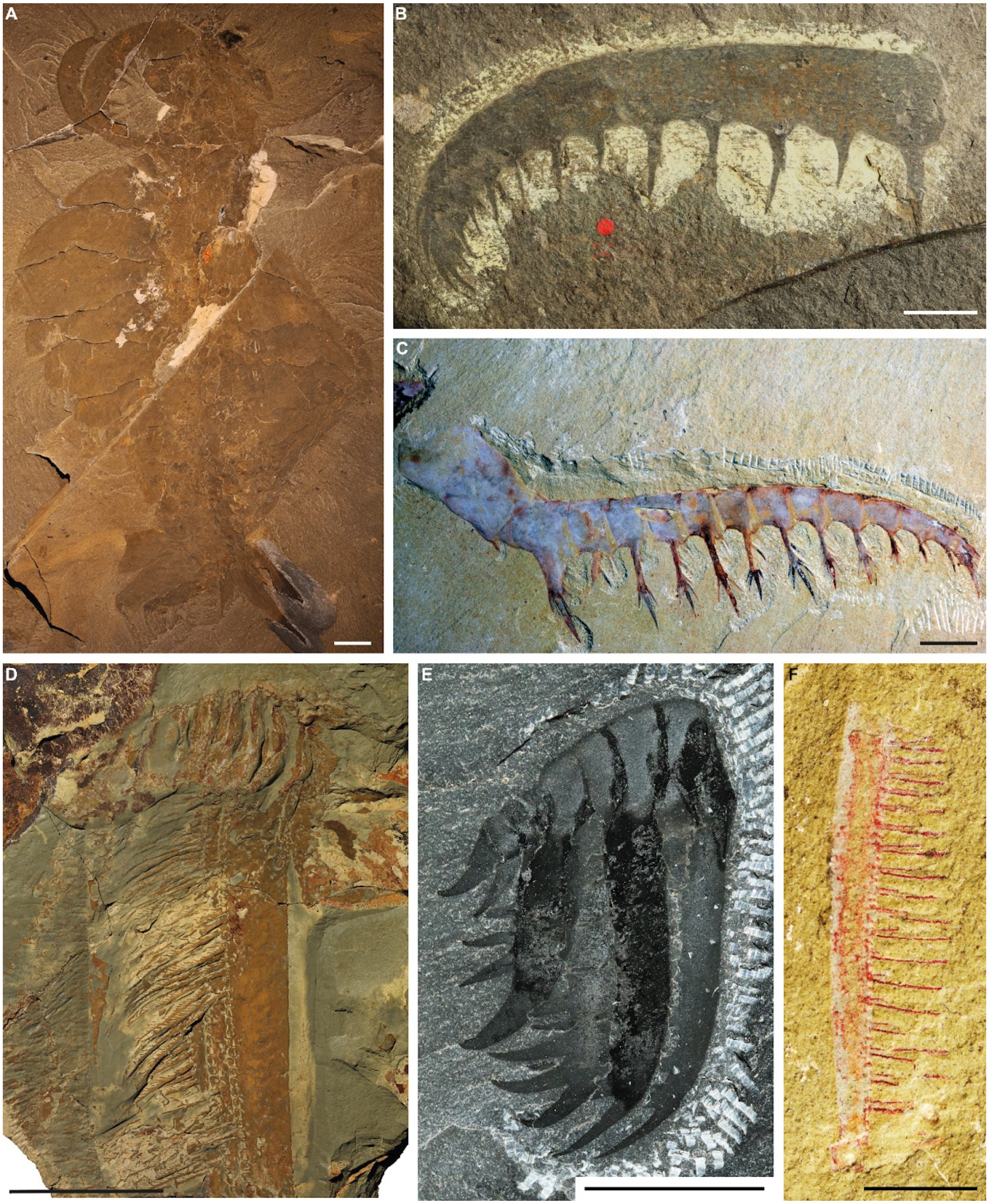

Figure 1. Example of radiodont fossils. Full body of *Anomalocaris canadensis* from the Burgess Shale, ROMIP 51214 (A); *Anomalocaris canadensis* frontal appendage from the Burgess Shale, GSC 3418, holotype (B); *Houcaris saron* frontal appendage from the Chengjiang Biota, YKLP 13459 (C); *Aegirocassis benmoulai* frontal appendage from the Fezouata Biota, YPM IP 527125, paratype (D); *Hurdia* sp. frontal appendage from the Burgess Shale, USNM 213880 (E); and *Pseudoangustidontus izdigua* from the Fezouata Biota, MGL 103603, paratype (F). Scale bars: 1 cm (A, B, C, E), 10 cm (D), 0.5 cm (F). ROMIP: Royal Ontario Museum Invertebrate Paleontology, Toronto; GSC: Geological Survey of Canada; YKLP: Yunnan Key Laboratory for Palaeobiology; YPM IP: Yale Peabody Museum Invertebrate Paleontology; USNM: United States National Museum of Natural History; MGL: Muséum Cantonal des Sciences Naturelles, Département de Géologie, Lausanne. Image credits: (A) A. Daley, (B, E, F) G. Potin, (C) P. Cong & S. Pates, (D) A. Daley & P. Van Roy.

However, little research has investigated the decay of arthropod appendages at high resolution, despite appendages being one of the most abundant body fragments of non-biomineralised arthropod groups such as radiodonts (Guo et al., 2019; Pates and Daley, 2019; Potin et al., 2023; Potin and Daley, 2023; Wu et al., 2021a, 2021b) (Fig. 1).

Here, we compare the degradation of shrimp appendages in saltwater and freshwater conditions, since arthropods can tolerate and get preserved in different environments with contrasting salinities. More importantly, although most arthropods from the Cambrian and Ordovician inhabited fully marine environments, some lived in settings influenced by freshwater input, such as deltas (Gaines, 2014; Gaines et al., 2024; Saleh et al., 2020c, 2022b). Since freshwater input in palaeodeltas cannot be easily quantified, we use purely freshwater and marine conditions to investigate if the degradation sequences are similar or significantly different between these environments. We also compare the degradation of appendages to patterns observed in the fossil record, with a particular focus on radiodonts since the morphological characteristics of their appendages are often used for taxonomic and palaeoecological purposes.

Materials and methods

Five adult marine shrimps [*Palaemon varians* (Caridea); 30 mm long] and sixteen adult freshwater shrimps [*Neocaridina davidi* (Caridea); 15 mm long] were used for this study, which took place at the Animal Origins and Morphology Lab (ANOM Lab) at the Institute of Earth Sciences of the University of Lausanne, Switzerland. Shrimp populations were bred and housed in the Aquarium Research Lab at the University of Lausanne. The *N. davidi* population was maintained at 25℃ in non-saline water, while the *P. varians* population was maintained at 22℃ with a specific gravity (SG) of 1.024 using Aquarium Systems Reef Crystals (Code 216029; www.aquariumsystems.eu). Specimens were selected randomly from their respective populations. Shrimps were used because of their availability in the aquariums in Lausanne.

All specimens were euthanised by fully submerging them in a solution of magnesium chloride (two parts water to one part $MgCl_2$). The euthanised shrimps were then extensively washed in reverse osmosis deionised water to remove any residuals and debris covering their surface, such as microalgae from the aquarium, without introducing any damage to the surface of the shrimps. *N. davidi* individuals were placed in sterilised polyester boxes of dimensions 6.5 x 4.5 x 2.3 cm, containing fully oxygenated reverse osmosis deionised freshwater and *P. varians* individuals were placed in boxes containing artificial seawater [fully oxygenated reverse osmosis deionised water with with a specific gravity (SG) of 1.024 using Aquarium Systems Reef Crystals (Code 216029; www.aquariumsystems.eu)]. All boxes were filled with water to $\sim$80% of their height. The use of reverse osmosis water, which is mostly free of bacteria and has a neutral pH of 7, implies that most bacteria in the experiment originated from the shrimps themselves. All shrimps were allowed to decay for ten days and were stored in a dark chamber to prevent the influence of light on the decay process. The time frame of ten days was chosen since some characters became difficult to monitor after 10 days, which is a typical timeframe for shrimp decay (Corthésy et al., 2024, 2025b). Shrimps were maintained at a stable room temperature between 21℃ and 22℃ for the duration of the experiment. Shrimps were photographed every 24 hours, and changes in their anatomical characters were noted using an Olympus Life Science Solutions SC50 5-megapixel camera and the software Olympus Stream Basic 2.2 (Olympus Soft Imaging Solutions).

Three distinct taphonomic characters were investigated: breaking of appendages, detachment of appendages, and detachment of setae. Breaking of appendages describes appendages that broke in the middle of the limb, usually at joints between podomere segments. Appendage detachment refers to appendages that separate from the body at their base while retaining their overall structure. The detachment of setae describes the loss of the fine setal structures found on all appendages. To quantify the decaying state of each of the aforementioned characters, taphonomic scores ranging between 0 and 3 were attributed. A score of 0 means that the taphonomic character is not observed and that appendages did not break or detach and setae are still intact. A score of 1 means that the taphonomic character was observed in less than 50% of the appendages. In other words, less than 50% of the appendages broke, detached, and started to lose their setae. A score of 2 means the taphonomic character was observed in 50% or more of the appendages. A score of 3 means the taphonomic character was observed in all appendages. Overall, an increase in taphonomic scores means an increase in appendage decay (Fig. 2). Each individual shrimp was given a taphonomic score for each of these characters for the ten days of observation (refer to Supplementary Database for further details).

In investigating the decay of marine shrimps to freshwater shrimps, which is the only investigation relying on comparing two datasets with different sample sizes (i.e., comparing sixteen freshwater shrimps with five marine shrimps), a Mann-Whitney U test was performed to compare the values of taphonomic scores between freshwater and saltwater shrimps. Since the results of this test indirectly account for differences in sample size, a significant p-value would imply that differences in decay between the two shrimp species are not only due to sample sizes (Feltovich, 2003). Then, ordinal logistic regressions (OLR) were chosen to analyse the data, as the taphonomic score is an ordinal qualitative variable (Harrell, 2015). A first OLR and a contrast analysis were performed to test whether the decay of each taphonomic character was significantly different between saltwater and freshwater species, with the taphonomic score as the response variable and the water conditions and the taphonomic character as the explanatory variables. The same OLR was used to do another contrast analysis to determine whether the decay is different between taphonomic characters of the same environment (e.g., detachment vs breaking of appendage in marine conditions), also using the water conditions and the taphonomic characters as explanatory variables. Data of all individual shrimp were represented by boxplots (Figs. 3, 4). Statistical analyses and graphs were implemented on the software R 4.2.1 (R Core Team, 2021).

Results

When comparing appendage decay through time, the overall taphonomic scores slowly increase (Fig. 3A, B), except for the taphonomic character "detachment of setae" where almost no evidence of decay was observed (Fig. 3C). For the taphonomic characters "breaking of appendages" and "detachment of appendages", the decay rate is significantly higher for freshwater shrimps than for marine shrimps (Contrast analysis of OLR; Breaking of appendages, $p = 0.0037$, z-ratio = 2.899; Detachment of appendages, $p < 0.0001$, z-ratio = 4.713; Tab. S2). On the other hand, for the

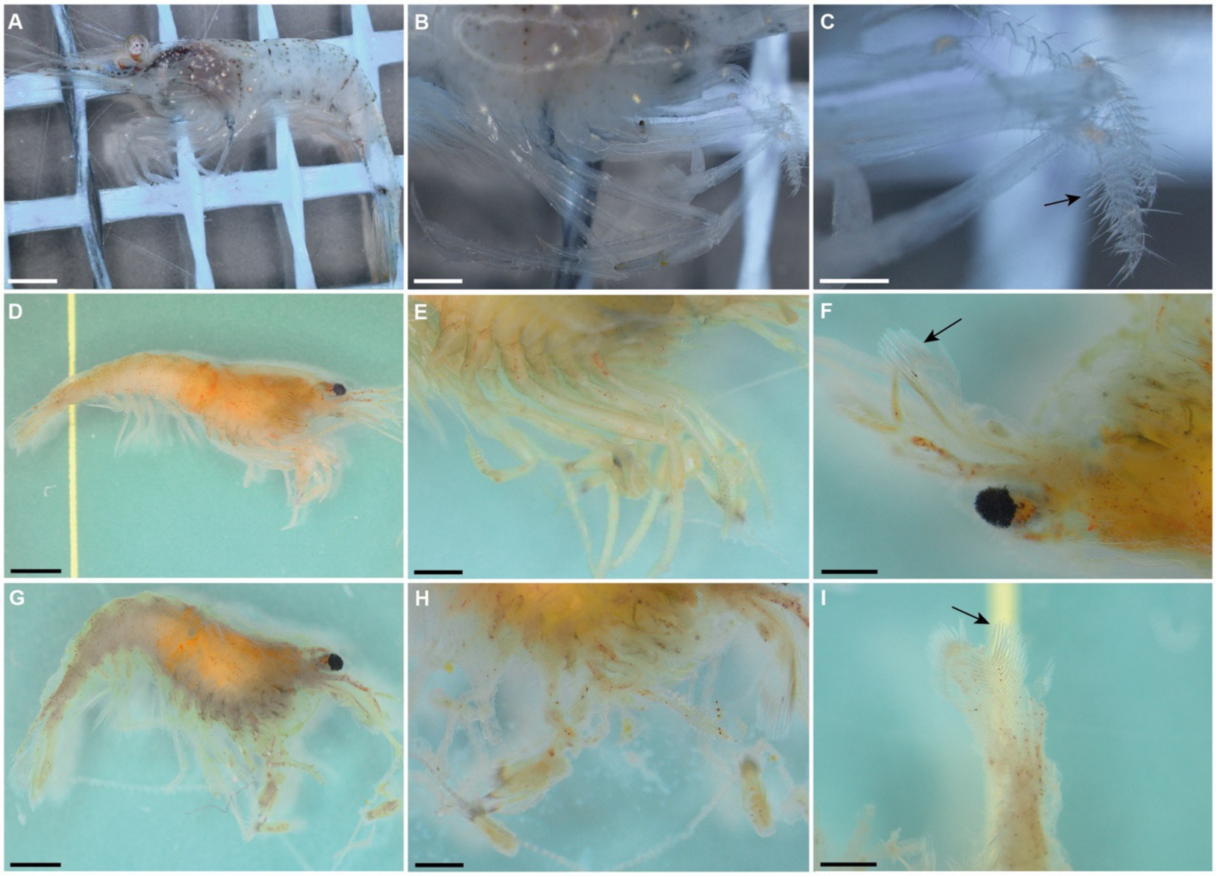

Figure 2. Examples of shrimp decay over time. On day 0, shrimp body (A), appendages (B), and setae (C) are intact and the three taphonomic characters have a taphonomic score of 0. After five days, appendages start to break (D, E), and setae are still intact (F). After ten days, almost all appendages are detached and broken (G, H), and setae are still intact (I). The setae are stable on the different part of the shrimp body (C, F, I). Scale bars: 1 mm (A-E, G, H), 2 mm (F, I). Image credit: (A-C) O. Bath-Enright, (D, H, I) A. Roland, (E) B. Pioger, (F, G) I. Quintas.

"detachment of setae", there is no significant difference in decay between marine and freshwater shrimps (Contrast analysis of OLR; Detachment of setae, p = 0.8523, z-ratio = 0.186; Tab. S2), since the decay is almost non-existent for this character (Fig. 3C). None of these comparisons between freshwater and saltwater shrimps is influenced by differences in sample size as the result of the Mann-Whitney U test was significant as well (Tab. S1 in Supplementary Material). Moreover, differences in sample sizes have no impact on subsequent comparisons between the different taphonomic characters (Fig. 4), as these comparisons do not involve comparing freshwater to saltwater conditions and are conducted separately for each environmental condition.

When comparing the decay between the three taphonomic characters in freshwater, the decay is fastest for "breaking of appendages", then "detachment of appendages" and it is slowest for "detachment of setae" (Fig. 4A). In freshwater, "breaking of appendages" has a decay rate significantly higher than "detachment of appendages" (Contrast analysis of OLR; $p < 0.0001$, z-ratio = 6.703; Tab. S2) and "detachment of setae" (Contrast analysis of OLR; $p < 0.0001$, z-ratio = 12.409; Tab. S2). The decay rate of "detachment of appendages" in freshwater is significantly higher than "detachment of setae" (Contrast analysis of OLR; $p < 0.0001$, z-ratio = 8.293; Tab. S2). In saltwater, the taphonomic scores slowly increase for "breaking of appendages", while the values remain around zero for "detachment of appendages" and "detachment of setae" (Fig. 4B). The decay is significantly more pronounced for "breaking of appendages" than "detachment of appendages" (Contrast analysis of OLR; $p < 0.0001$, z-ratio = 5.468; Tab. S2). However, the taphonomic scores of "breaking of appendages" are not significantly different from "detachment of setae" (Contrast analysis of OLR; p = 0.9715, z-ratio = 0.229; Tab. S2).

Discussion

The major observations regarding shrimp decay are that the appendages of freshwater shrimps detach and/or break more rapidly than saltwater shrimps (Fig. 3A, B); and the setae remain relatively stable even when appendages break or detach from the body (Fig. 3C; 4A, B). The slower decay of saltwater shrimps compared to freshwater shrimps cannot be attributed to the different environmental conditions in which they were placed, even though salt is known to be a natural preservative and can act as a conservation agent at high concentrations (Wijnker et al., 2006). Salt is even considered a catalyst for the replication of non-biomineralised morphologies in authigenic minerals (Corthésy et al., 2025b). The role of increased salinity in the fine-scale preservation of arthropod bodies can be observed in sites like the Jurassic Solnhofen Lagerstätte in Germany, which preserved a large number of arthropods with their appendages attached, particularly shrimps (Pazinato et al., 2021; Winkler, 2014). Numerous taphonomic models and experiments

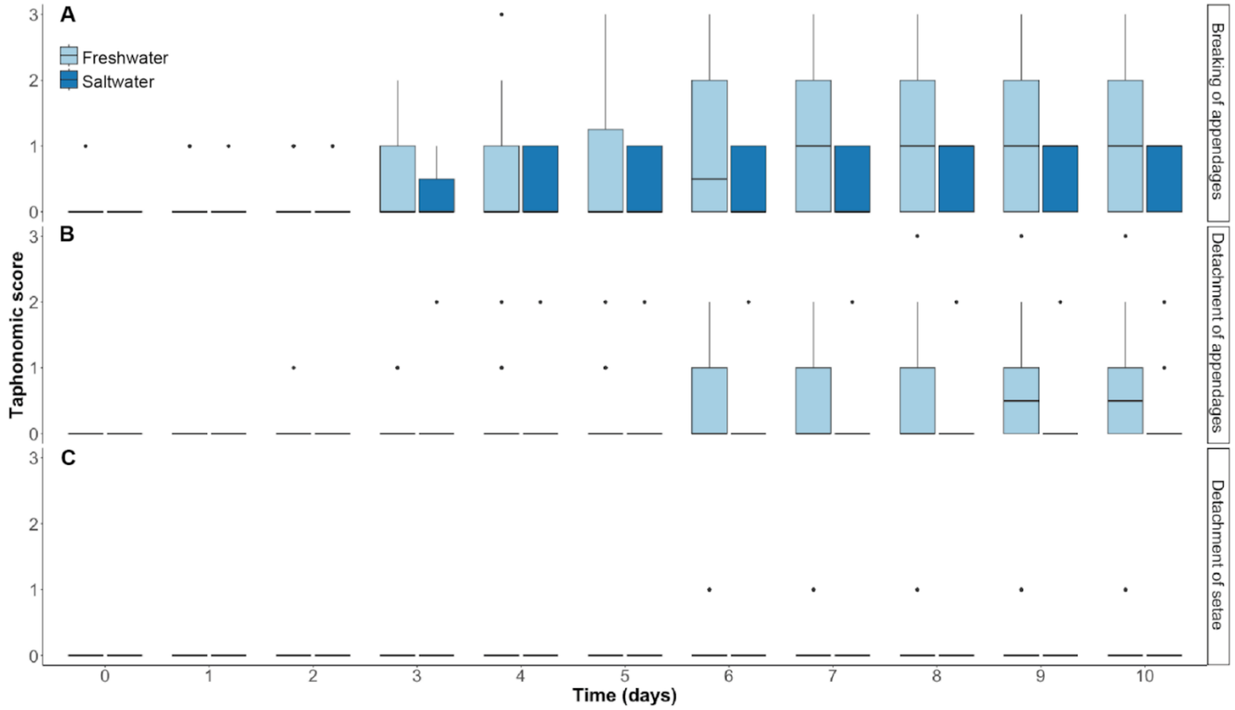

Figure 3. Decay comparisons between freshwater and saltwater shrimps. Taphonomic scores through time for breaking of appendages (A), detachment of appendages (B), and detachment of setae (C). Boxplots represent the observations of all specimens at each time point, with the median as the bold bar, the edges of the rectangles as the first and third quartiles, the whiskers as the minimum and maximum values of the data, and the dots as the outliers of the data.

developed to explain preservation in Solnhofen attribute the high degree of articulation in fossils to elevated salinity levels (Gäb et al., 2020; Gerschermann et al., 2021). However, salt is also known to increase the degradation rate of proteins under normal salinities (Corthésy et al., 2025a). As such, the relationship between salinity and decay rates is not linear. For these reasons, and because the experiments were not designed to investigate the role of salinity in the decay process, we attribute the differences in decay rates between freshwater and marine shrimps to variations in their organic composition rather than to differences in salinity. For instance, considering that calcium is more limited in freshwater compared to saltwater, it is possible that freshwater shrimp appendages contain fewer biominerals and are, therefore, more prone to decay and disarticulation than marine shrimp appendages. Additionally, the thickness of the freshwater shrimp cuticle may be lower than that of marine shrimps, making the latter more resistant to degradation. Other factors, such as the quantity of polysaccharides in the cuticle, may also influence decay, as this material is not easily recyclable by bacteria (Corthésy et al., 2024). It is also worth noting that factors other than salinity and the nature of the organic matter also influence decay rates. These include pH, oxygen concentration among other parameters (Allison, 1988; Clements et al., 2017, 2022; Corthésy et al., 2024; Fraga and Vega, 2025; Hancy and Antcliffe, 2020; Mähler et al., 2023).

The detachment and breakage of appendages in both freshwater and saltwater experiments explain patterns observed in the fossil record (Fig. 4A, B). Although fossil carideans often preserve appendages both in marine water (Bravi et al., 1999; Garassino and Bravi, 2003; Winkler, 2013) and in freshwater (Barros et al., 2021; de Mazancourt et al., 2022; Feldmann et al., 1981; Garassino et al., 2002), most of them do not preserve all of their appendages. For instance, cretaceous freshwater caridean showed that the cephalothoracic appendages were poorly preserved or absent in many specimens, while abdominal appendages were visible in almost all samples (Garassino, 1997). However, this pattern is not observed in all decapods. For example, in an astacidean taxon from the same locality, cephalothoracic appendages were relatively well-preserved and attached to the body in most specimens, while abdominal appendages were only observed in a few (Garassino, 1997). This indicates that different appendages are lost to varying degrees before the stabilisation of the carcass and its fossilisation.

The detachment/breakage of appendages from the body is not limited to Cretaceous arthropods; similar patterns can also be observed as far back as the Cambrian. For instance, complete carcasses of animals such as *Anomalocaris* and *Hurdia* are rare. Fossils of this taxon are primarily represented by frontal appendages, mouthparts, and head carapaces (Daley et al., 2009, 2013; Daley and Edgecombe, 2014; Saleh et al., 2021a) found in isolation or in disarticulated assemblages (Daley et al., 2009, 2013; Daley and Budd, 2010; Daley and Edgecombe, 2014). In the Chengjiang Biota, over 800 isolated frontal appendages of *Amplectobelua symbrachiata* have been discovered, yet only one nearly complete body has been found (Wu et al., 2021b). In this sense, isolated radiodont appendages are the norm rather than the exception, with articulated bodies being extremely rare (Paterson et al., 2023, p. 202; Wu et al., 2024a, 2024b), and it is even possible to distinguish between detached from broken appendages in the fossil record. For example, in *Anomalocaris*, some appendages display 13 podomeres instead of the typical 14, which is a result of breakage between the most proximal podomeres (Daley and Edgecombe, 2014; Whiteaves,

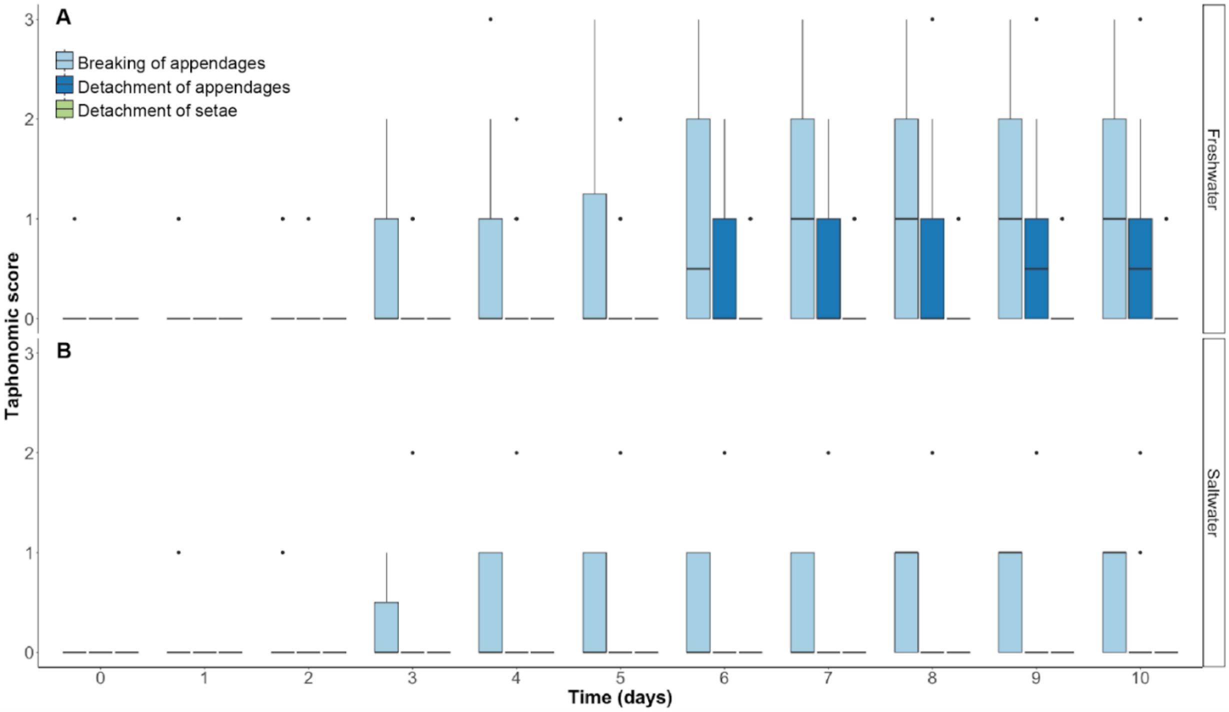

Figure 4. Decay comparisons between the three taphonomic characters. Taphonomic scores through time for breaking of appendages, detachment of appendages, and detachment of setae in freshwater (A), and saltwater (B). Boxplots represent the observations of all specimens at each time point, with the median as the bold bar, the edges of the rectangles as the first and third quartiles, the whiskers as the minimum and maximum values of the data, and the dots as the outliers of the data. Note that no green boxplots representing setae detachment are shown in the figure, as the taphonomic scores for this character did not increase significantly enough to warrant representation in a boxplot.

1892; Whittington and Briggs, 1985). Isolated appendages with 14 podomeres likely represent those that detached from the body, with those showing fewer podomeres corresponding to appendages that broke apart between segments. This taphonomic pattern is not exclusive to *Anomalocaris* and other radiodont taxa, such as *Hurdia*, *Peytoia*, *Pseudoangustidontus*, and *Tamisiocaris*, exhibit similar trends, with both broken and detached appendages frequently observed in the fossil record (Briggs, 1979; Collins, 1996; Daley et al., 2009, 2013; Daley and Legg, 2015; Daley and Peel, 2010; Potin et al., 2023; Potin and Daley, 2023).

Interestingly, the setae in both freshwater and saltwater showed minimal degradation (Fig. 4A, B), which is consistent with data from the fossil record. For example, setae are found preserved in crustaceans from the Cambrian "Orsten" fauna (Garm and Watling, 2013; Müller and Walossek, 1985, 1988; Walossek, 1993). This degree of minute preservation of setae is also observed in decapod fossils (Audo et al., 2021; Jauvion et al., 2017; Moreau et al., 2022). Setae can also be preserved when the rest of the body has suffered from pronounced degradation. For instance, radiodont appendages can be significantly decayed yet still show setae [Plate 81, Fig. 11 in Briggs (1979); Fig. 5 in Wu et al. (2022)]. This stability of setae is particularly relevant in palaeontological and palaeoecological research. The absence of setae on a particular radiodont frontal appendage was used to describe *Lenisicaris* (Wu et al., 2021b), which shares many morphological similarities with *Houcaris magnabasis* [previously referred to as *Anomalocaris magnabasis*; Pates et al. (2021)]. The most distinguishing feature between the two taxa is the absence of setae in *Lenisicaris* compared to *H. magnabasis*, which might imply that *Lenisicaris* material represents a taphonomic variant that underwent greater decay than *H. magnabasis* material (Pates et al., 2021). The results of our study do not support this hypothesis and suggest that *Lenisicaris* and *H. magnabasis* are indeed distinct taxa.

The aforementioned case of *Lenisicaris* vs *H. magnabasis* is not the only one where decay information may provide insights into the preservation potential of radiodont appendages in the fossil record. For example, the first *Tamisiocaris borealis* appendage material was described as having only a pair of thin endites (Daley and Peel, 2010). However, material subsequently discovered and assigned to *T. borealis* was found to have setae attached to the endites (Vinther et al., 2014). Given the relative stability of setae observed in our experiment, it seems unlikely that the appendages with and without setae both belong to the same *Tamisiocaris* species. It further suggests that the absence of setae in the possible counterpart (*Tamisiocaris* aff. *borealis*) from the Kinzers Formation (Pates and Daley, 2019) may reflect a taxonomic differentiation rather than a taphonomic bias. However, we do not rule out the taphonomic explanation, as decay experiments do not replicate natural environments, and generalisations about natural systems should be made cautiously (Purnell et al., 2018). Taphonomic processes operating over geological time are far more complex than those observed in laboratory decay experiments (Purnell et al., 2018; Sansom, 2014), and Cambrian radiodonts have an anatomy that is very different from modern shrimps.

Factors other than decay can influence the preservation potential of anatomical features in the fossil record. For instance, some transport processes are known to fragment skeletal elements while only slightly affecting the preservation of certain taxa, such as annelids (Bath Enright et al., 2017, 2021) and arthropods (Allison, 1986). Authigenic post-mortem mineralisation could also play a role, with some structures being more prone than others to replication by aluminosilicates, pyrite, or phosphate (e.g., Anderson et al., 2018, 2020; Barling et al., 2023; Butterfield, 1990, 2003; Corthésy et al., 2025a, 2025b; El Khoury et al., 2025a, 2025b; Gabbott et al., 2004; Gaines et al., 2008; McNamara et al., 2009; Nielsen et al., 2022; Orr et al., 1998; Saleh et al., 2019, 2020b, 2023, 2024b; Schiffbauer et al., 2014; Slagter et al., 2024). A limitation of our work might be the choice of the model organism, as shrimp appendages are likely to be less sclerotised than radiodont appendages and their morphology is different in almost every aspect. Radiodonts also had unsclerotised bodies, given a large contrast in material hardness between their frontal appendages and the soft body to which they attach, and this difference is less pronounced between the shrimp appendages and body. Despite this discrepancy in the degree of sclerotisation, which certainly impacts decay and influences preservation (Saleh et al., 2020a, 2022c), there is no reason to expect that more heavily sclerotised appendages, such as those observed in Cambrian radiodonts or modern lobsters and crabs, would decay more rapidly than the less sclerotised appendages of shrimps. In other words, if shrimp appendages demonstrated some resistance in retaining their setae (Figs. 3, 4), the more sclerotised appendages of other taxa would probably be even more resistant to degradation and retain their setae better than the investigated shrimp taxa, as it has been previously shown that animals like lobsters and crabs have a higher preservation potential than shrimps (Klompmaker et al., 2017). Experiments on the brachyuran *Callinectes sapidus* showed that the claws, mandibles, and certain partial spines of this taxon are very resistant to degradation (Mutel et al., 2008). Considering the different abiotic and biotic conditions that can influence decay and preservation, the results presented here should not be automatically generalised to all preserved arthropod appendages in the fossil record. Instead, they can serve as a baseline for assessing the likelihood of certain palaeontological scenarios.

Data availability

All data necessary to replicate this work are available in the main text and the supplementary material files.

Acknowledgements

The team thanks various members of the AnomLab (Lausanne) for helpful discussions. We are grateful to D. Rudkin, P. Fenton, J.-B. Caron (ROM), H. Gene (USNM), and M. Coyne (GSC) for the curatorial assistance during ACD and GJMP collection visits to take photos. We also thank P. Cong (Yunnan University) and S. Pates (University of Exeter) for sharing the picture of *Houcaris saron*. Orla Bath Enright (State Museum of Natural History Stuttgart), Alexandre Roland, and Blanche Piogier are thanked for helpful discussions and for providing images of marine shrimps.

Author contributions

Conceptualization FS, ACD, GJMP, IQ; Formal analyses IQ, AT, NC, GJMP; Funding acquisition FS, ACD; Investigation NC, GJMP, AT, IQ, YW, SL, ACD, FS; Methodology NC, GJMP, IQ, AT; Supervision FS, ACD; Visualization NC, GJMP; Writing original draft NC, GJMP, AT, FS; Writing review and editing NC, GJMP, AT, IQ, YW, SL, ACD, FS.

Competing interests

FS is a Steering Committee member at Open Palaeontology.

Ethics and AI use

Artificial intelligence powered by a large language model was used to check for grammatical errors. Unlike some other decapods such as crabs and lobsters, experimental work on shrimps in Switzerland does not require any special permission. Nevertheless, shrimp individuals were euthanised ethically, and the experiments adhered to the 3Rs principle of research (Replacement, Reduction and Revision).

Funding

NC and FS work is funded by an SNF Ambizione Grant (PZ00P2-209102). GJMP work is funded by the Canton of Vaud (Switzerland). YW work is supported by a Swiss Government Excellence Scholarship and the National Science Foundation of China (42202011). SL work is supported by an SNF Sinergia Grant (198691) awarded to ACD and three other co-PIs.

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