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How should I publish my digital fossil? Recommendations for the publication of comprehensive 3D datasets in palaeontological studies

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Abstract: Data sharing is essential to scientific progress, and 3D datasets are no exception. Sharing fosters transparency, reproducibility and confidence in the scientific and publication processes, including peer-review, and it improves the global availability of scientific data. While it lies within the responsibility of the authors to generate, share, archive and manage their 3D datasets, scientific journals and repositories can facilitate their accessibility by providing clear guidelines and data policies. However, it is often not clear how a 3D dataset needs to be composed to be comprehensive and re-usable. The commonly used FAIR Data Principles provide a good standard for such a dataset, but are not specific towards the different 3D file types. Authors, editors and repositories play a key role in ensuring data FAIRness, which is essential for proper data management and stewardship. In this work, we want to demonstrate (more standardized) ways for researchers and scientific journals to make the 3D datasets of their research projects accessible following FAIR Data Principles. To do so, we review the main points of the data cycle, and point out how data sharing benefits not only researchers, but the scientific community as a whole. A study of the data policies of 137 journals with a palaeontological focus revealed that none fully comply with 3D data requirements, indicating that there is room for improvement. After this data policies comparison, but also taking into account those of the repositories, we hope that this work can help authors to follow best practices in sharing 3D datasets.

Key words: 3D model, data, metadata, FAIR Data Principles, palaeontology, digital fossil.

DATA sharing is a prevalent topic in academic discussions (Alsheikh-Ali *et al.* 2011, and references therein; Hahnel *et al.* 2024), independently of the type of the dataset itself. Academic research is greatly enhanced by shared data, as it facilitates and speeds up science and lowers barriers for accessing information. When researchers have access to complete datasets, they can pursue different project ideas and methodologies in order to answer new questions and explore related or new hypotheses (Vision 2010; Piwowar & Vision 2013; Warren 2016; Hahnel *et al.* 2024).

Data sharing is especially beneficial with regard to concentration of natural history collection objects and related research in Europe and North America (Raja *et al.* 2022; Kaiser *et al.* 2023).

Sharing full sets of data means making them available to the entire and global academic community, in particular with regard to the still existing variable barriers for accessing research data for scientists (Blackburn *et al.* 2024; Hahnel *et al.* 2024).

Moreover, data sharing is beneficial for the ethics of the larger scientific community, as it helps to identify errors and malpractice, discourages fraud, and increases the efficient use of funding resources by avoiding duplicate data collection (Piwowar & Vision 2013). Furthermore, it allows the reproducibility of measurements and experiments. The importance of data sharing is also demonstrated by the fact that collected, but unpublished (digital) data, are likely to be lost to science (Rowe & Frank 2011; Faulwetter *et al.* 2013; Kochetkov 2024). However, a diffuse data sharing culture is unlikely to be achieved without policy guidance (Piwowar & Chapman 2008), as well as straightforward storage and sharing procedures.

Stieglitz *et al.* (2020) provide an accurate definition of what open data should be: ‘open data is the idea that researchers and practitioners – such as governments and other institutions – should not only publish their findings in the form of articles or reports, but also share the

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corresponding raw data sets'. But how, and when, should this associated data be shared in the journal submission process of a manuscript? And what falls into the mentioned 'corresponding raw data', in particular when it comes to three-dimensional (3D) datasets? The process of composing a comprehensive set of 3D data can appear confusing, especially for researchers inexperienced with some of the specific file formats, or when journal guidelines are not keeping pace with the data sharing practice improvements. The process of sharing 3D data together with research in a publication is furthermore aggravated by the lack of common or unspecific standards for data sharing for scientific journals (Rousi & Laakso 2020). Instead, there is a wide variation in journal requirements and policies related to public availability and sharing of data in general (Alsheikh-Ali *et al.* 2011; Hrynaszkiewicz *et al.* 2017). Often, publication requirements do not explicitly include transparent, open, and reproducible science (Simmons *et al.* 2011; Asendorpf *et al.* 2013; Ioannidis *et al.* 2014; Miguel *et al.* 2014; Nosek *et al.* 2015).

As a medium for publishing research output to the scientific community, scientific journals have, in collaboration with other actors in the research ecosystem (see Main Actors of the Data Cycle, below; Hahnel *et al.* 2024), major potential to initiate a change in research practices related to open science (Lin & Strasser 2014; Kim & Adler 2015). If scientific journals manage to provide clear author guidelines related to the deposition/long time storage, accessibility and easy display of the supporting data (Naughton & Kernohan 2016), they can contribute to standardizing and harmonizing the current research data policy ecosystem. This will help researchers and authors to comprehend better what, and how, they need to prepare before submission. In reality, the current lack of standardization leads to numerous or even conflicting policy requirements (Naughton & Kernohan 2016; Christian *et al.* 2020; Hrynaszkiewicz *et al.* 2020), taking into account that editorial boards of scientific journals cannot always be expected to be experts on 3D data. The impulse for defining standardized 3D datasets needs to come from those researchers working with the datasets. Furthermore, it is encouraged that researchers understand their digital datasets, especially in the early stages of their digitization projects, to avoid their posterior misuse or producing inaccurate results (see Modesto-Mata *et al.* 2025).

An increasing consciousness of the importance of transparent data sharing has led to an improvement of the described situation over the last decade (Alsheikh-Ali *et al.* 2011; Vines *et al.* 2013; Hahnel *et al.* 2024); indeed, an increasing number of scientific journals, publishers, funding agencies and institutions have been introducing research data policies (Jones *et al.* 2019; Hrynaszkiewicz *et al.* 2020). Nevertheless, even with a data policy at hand, authors are not always making their supporting data available, and when they do, the data do not necessarily meet the minimum standards of quality that allow for verification of results or enable the data to be re-used for new studies (Davies *et al.* 2017; Hardwicke *et al.* 2018; Stodden *et al.* 2018; Blackburn *et al.* 2024; Modesto-Mata *et al.* 2025). Researchers' willingness to share data can be greatly influenced by the data policy of the journals (Meadows 2014; Schmidt *et al.* 2016). Journal data policies can be improved by regularly evaluating how well they present and articulate transparency requirements, and how well they support the authors' efforts to make supporting data accessible to others (Christian *et al.* 2020). The prominence and comprehensiveness of the data policy will have an impact on its effectiveness.

SHARING OF 3D DATA

The above mentioned points also apply to 3D datasets. Sharing palaeontological (and other) 3D data becomes particularly important when the data to be shared is based on historical collection material with a colonial background and/or one of injustice (see Díez Díaz *et al.* 2020 for an example of such 3D data). Whereas negotiations about restitution of such materials, and even collaboration attempts, research and travel grants for the scientists of the country of origin of the material can be challenging, lengthy and not necessarily successful, giving access to full 3D data- and metadata-sets provides a possibility to make the data available with immediate effect. In turn, these scientists would become better equipped to develop their own research projects based on this data, and enhance student and public education programmes, thereby strengthening their own visibility within the global scientific community (Díez Díaz *et al.* 2025a).

However, in studies involving 3D digital datasets (i.e. 3D models and associated data and metadata) of biological and palaeontological specimens, authors often do not publish their supporting data (Davies *et al.* 2017; Falkingham *et al.* 2018). Indeed, sharing or publishing 3D supporting data are often not a top priority among authors and has effectively been considered optional when not enforced by a scientific journal. While the sharing of 3D datasets has increased since these publications, the general points of these papers are still valid. As these authors highlight: 'As digital morphology has evolved, most of us in the research community have failed to achieve what might now be considered best practice of open data. 3D digital datasets associated with published studies should be verifiable and fully traceable from production to publication, and later republication'. In palaeontological research papers, 3D models are generally included in the supporting information in different forms (e.g. embedded in a PDF file, videos, different 3D formats) or a specific online repository (e.g. MorphoSource, MorphoMuseuM, Figshare). Often, only the 3D file itself is included, without metadata files or information on how the model was created in the main manuscript or the supporting information. Authors should be aware from the first steps of their digitization projects of the amount of data they are going to collect, create and submit to the journal and repository (Fig. 1) (see discussion on the preservation intervention points (PIPS) below; Golubiewski-Davis *et al.* 2022). Nonetheless, journals also can assist in this submission process by providing best practice recommendations, definitions of terms, types of file formats, etc. in the author guidelines (see Appendix S1). The cost of repository data storage is also an important point to take into account when sharing 3D models, as public repositories had limited free (or cheap) storage until recently, and 3D datasets can be large when compared to other types. Here, it is important to mention that Sketchfab, a platform widely used for sharing 3D models of fossils, cannot be considered as a genuine research repository, as it lacks data sharing standards. Instead, Sketchfab has its use as a platform to publish, view, and (sometimes commercially) share various 3D content. The use of 3D images embedded in PDF files is not recommended, as they limit the subsequent use of the data in later studies, becoming merely 3D visualizations of the specimen.

In this work, we discuss which 3D data and metadata needs to be shared in the scientific process to provide a comprehensive dataset compliant with the FAIR Data Principles (Wilkinson *et al.* 2016): Findability, Accessibility, Interoperability and Reusability of data. We also analyse the author guidelines of 137 scientific journals (comprising the subject area 'Earth and Planetary Sciences', journals with a palaeontological focus, and those with 3D models as supporting data published in 2023), with regard to their instructions for 3D data submission, access and archiving, to evaluate the current status of common policies of journals publishing palaeontological studies with 3D models. Our work expands on the publications of Davies *et al.* (2017) and Falkingham *et al.* (2018) to provide both researchers and scientific journals with a useful basis regarding good practices for sharing 3D datasets.

WHY SHOULD DATASETS BE ARCHIVED WITH A 3D MODEL?

This work takes into account the main techniques that allow the production of 3D models from a physical object, including computed tomography and surface digitization techniques (i.e. photogrammetry, laser scanning and structured light 3D scanning). Even though a 3D model can be defined as the digital representation of a physical specimen, the choice of the digitization device, technique, methodology and even the users themselves can produce different results and qualities (Katz & Friess 2014; Evin *et al.* 2016; Fau *et al.* 2016; Díez Díaz *et al.* 2021; Modesto-Mata *et al.* 2025). For example, it has been confirmed that mixing meshes created by different techniques could affect the results of works that rely on the detailed anatomy of the specimens, such as landmark placement and geometric morphometrics (Katz & Friess 2014), or the taking of measurements (Modesto-Mata *et al.* 2025). That is one of the reasons why it is so important to include the associated data and metadata of the 3D model, especially if we want our dataset to be properly reused in the future. Including this information is also useful in the peer-review process, particularly if the 3D model has undergone subsequent modifications (e.g. simplification, decimation, deletion of errors, retrodeformation, modelling of non-preserved parts), to improve transparency in the process, and for the reviewer to know objectively what they are reviewing. The inclusion of image and scan stacks within the data set is helpful when re-doing the 3D model in the future, especially when the software has undergone a major upgrade or update (or when it has become obsolete and can no longer be used), or if the 3D file type has become obsolete.

An important task for scientific journals and public repositories (especially for those focused on specific data file formats and types) is to clearly define what data and metadata is, and which files are essential to clarify how the research was carried out and the 3D model was created, and which ones are recommended for upload as best practices (Davies *et al.* 2017). As of today, there is no clear distinction between the concepts of data and metadata, and these definitions can vary depending on the field (Karr 2010). Nonetheless, this data exists and must be collected to enable the use, accessibility, management, distribution, archiving, interoperability and reproducibility of the created 3D objects (Depraetere *et al.* 2025). See Table 1 for definitions of terms relevant to 3D datasets in palaeontological research.

Davies *et al.* (2017, table 1) summarized the essential data (for verification) and recommended (as best practice) data and metadata that should accompany the created 3D model, especially to comply with the FAIR Data Principles. Regarding 3D datasets from collections involving indigenous communities, especially those containing cultural, biological, territorial, or traditional knowledge data, they should also follow the CARE Principles for Indigenous Data Governance (Collective benefit, Authority to control, Responsibility and Ethics) (Carroll *et al.* 2021). Journals and repositories should indicate common

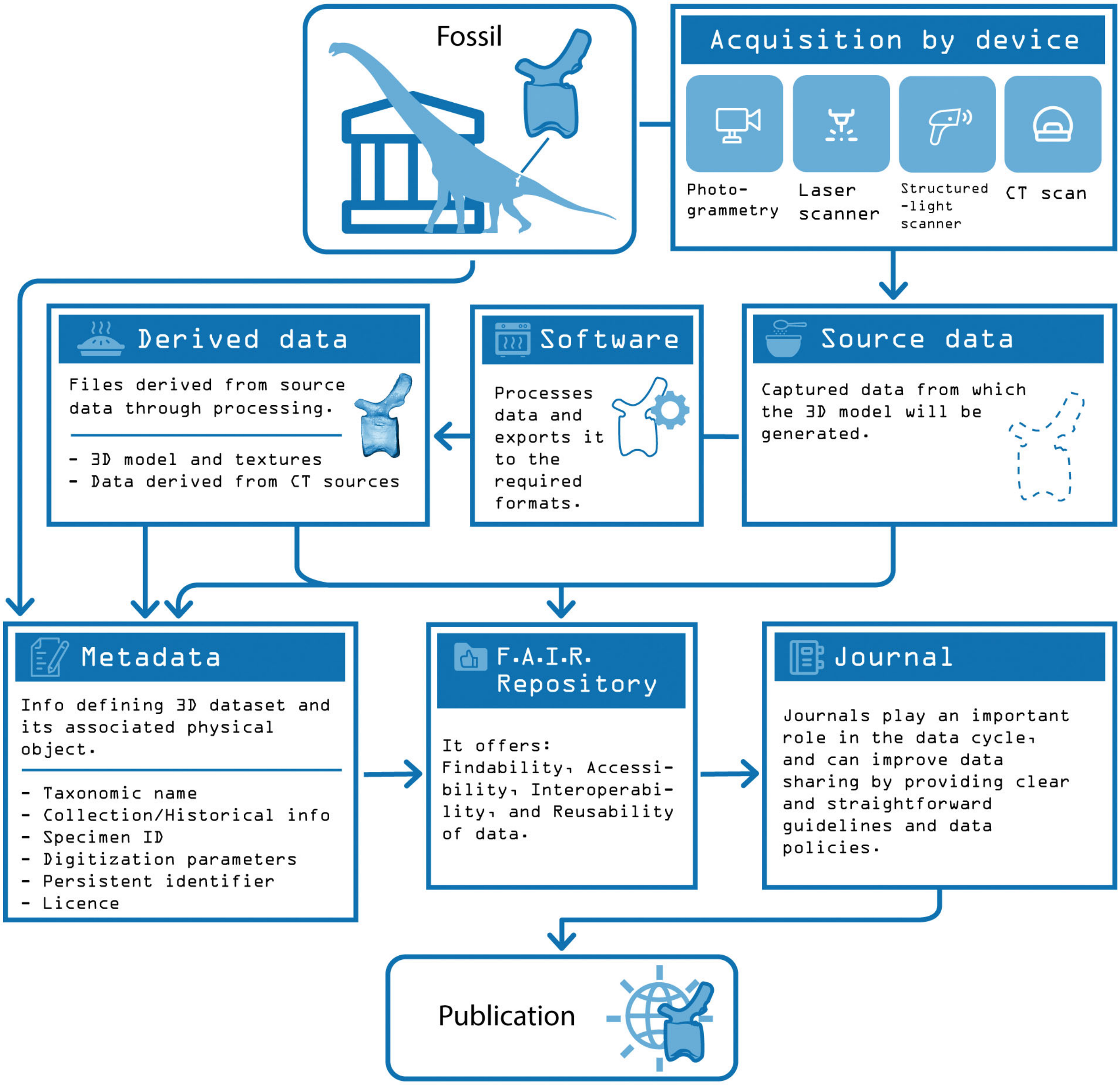

FIG. 1. Infographic showing the main steps in the preparation and publication of 3D datasets.

and interoperable file formats (see e.g. Davies *et al.* (2017) for a list of these formats) for those data and metadata obtained in the process of creating a 3D model, which have to be submitted together with the manuscript and final 3D file. As Golubiewski-Davis *et al.* (2022) indicated, sufficient documentation of the 3D data collection, creation and processing should also be stored alongside the 3D models for others to understand and use these data (this can be a README text file describing all this information and the project report file created by the software). Díez Díaz *et al.* (2021) indicated some mesh features which could help define the quality of the surface 3D model and how it was created (e.g. digitization technique and device, number of photographs/scans, resolution/number of faces or vertices, accuracy/scaling error, file size). In terms of the processing workflow, it is also important to indicate whether any photographs were edited or enhanced (e.g. masked, colour correction) before processing, as well as whether any algorithms, scripts, or inputs were applied, particularly if they were created by the author. All this information can be included in the README text file or as a CSV/Excel file, being part of the metadata of the 3D model. Persistent identifiers (McMurry *et al.* 2017), such as unique resource identifiers (URIs) or digital object identifiers (DOIs) have proven to be very useful to include metadata, and to link it to both the 3D model and the physical specimen.

TABLE 1. Terms defined for 3D datasets in palaeontological research.

Term	Definition
3D digital dataset	All data and metadata that are related to the generation of a 3D model. Within this dataset we find:
Data	3D digital objects themselves, together with all associated files
Source (RAW) data (**or** 'Parent data')	Source or captured data (e.g. photographs, scans, image stacks) from which the 3D model will be generated
Derived/processed data (**or** 'Child data')	Files derived from source data through processing (i.e. the 3D model in this work).
Metadata	Information that defines and contextualizes each 3D dataset and its associated physical object, such as its taxonomic name, collection and historical information, the identifier of the physical specimen of which it is the digital model, data collection, scan parameters, 3D file format, size, resolution, etc. For those natural history collections or objects with a controversial past (e.g. colonial collections or specimens brought irregularly to the current institution) metadata exist that could be relevant for an objective contextualization of the specimen. These should be collected (e.g. historical documentation, field notes) in order to make the digitization and sharing processes as transparent and open as possible (see also Kaiser *et al.* 2023; Díez Díaz *et al.* 2025a, 2025b, and references therein).

MAIN ACTORS OF THE DATA CYCLE

Besides researchers and journals (main actors discussed within this work), funders and institutions also play a key role in the data cycle. An important point in data sharing is economical sustainability, which is mandatory for the long-term preservation of research data (Vision 2010). For that, funding bodies, infrastructure providers and publishers have pivoting roles in providing a consistent and easy-to-use environment for FAIR data sharing (Hübner 2020; Hahnel *et al.* 2024). To confirm that the data generated in a study will be shared openly, science funders, publishers and governmental agencies already mandate data management and stewardship plans for data generated in publicly funded research projects (e.g. the Dutch Research Council (NWO), the European Commission, the European Organization for Nuclear Research (CERN), the German Research Foundation (DFG), the National Science Foundation (NSF), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Wellcome Trust) (Vines *et al.* 2013; McKiernan *et al.* 2016; Wilkinson *et al.* 2016; Stieglitz *et al.* 2020; Hahnel *et al.* 2024).

Academic institutions, such as universities and museums, also play a pivotal role in the data sharing ecosystem. Indeed, they can support open data practices by providing the resources, infrastructures and professional recognition (Hahnel *et al.* 2024). Moreover, if the institution is afraid of misuse or commercial (e.g. by 3D printing them) use of 3D objects created from its collections, it can limit access by enforcing more restrictive licences, thus creating a conflict with funders 'requests and researchers' decisions. But as mentioned below, openness can be considered as a continuum of practices, and can be discussed among all parties in search of consensus.

As indicated above, money spent on data archiving is extremely cost-effective, as it avoids re-collecting the same data and duplicating the digitization effort, and allows assessment of previous analyses and the development of new project ideas. Considering these arguments, we agree with Vines *et al.* (2013) that journal based mandatory data archiving policies and data accessibility statements should be more widely adopted (see also Hahnel *et al.* 2024), also in the common efforts of the entire community.

Attribution to the original contributor improves 3D data sharing

In response to the increasing need for transparent display and accessibility of data in science, several journals have introduced data archiving and availability policies into their author guidelines (Vines *et al.* 2013; Hahnel *et al.* 2024). However, not all authors necessarily make the 3D data associated with their works publicly available (Christian *et al.* 2020). One factor could be the lack of incentives or requirements in the academic system for researchers to do so (Nosek *et al.* 2012; Rousi & Laakso 2020). But also technical, economic, and individual/non-technical barriers play a significant role in these decisions. The balance between career benefit and risk, together with perceived effort, is strongly linked to data sharing attitudes (Piwowar & Vision 2013; Kim & Zhang 2015; Kim & Nah 2018). It is widely recognized that one of the reasons authors are hesitant to publicly share their datasets is the worry about how this may affect their careers (McKiernan *et al.* 2016). For example, Savage & Vickers (2009) found that only one in ten researchers would share their data with unknown scientists, despite data being requested from open access journals. Indeed, the exchange of data and intellectual resources in the academic system is built through trusted relationships (Wallis *et al.* 2013). Piwowar & Vision (2013) indicated that a reason for lack of transparency in data sharing could be the fear of other researchers finding errors in their results. However, young researchers present a greater intention of sharing data, probably because the future of their careers depends on publications and their own visibility (Milia *et al.* 2012).

Another important factor affecting data sharing is the fear of data reuse and misuse. Some researchers fear that they are losing their own value by making their research data publicly available, also thinking that they are sacrificing the opportunity to get more works published, as others could develop similar projects using these data as a source (Piwowar & Vision 2013; Wallis *et al.* 2013; Stieglitz *et al.* 2020). However, it must be highlighted that open research is associated with a higher citation ratio, more media coverage, an increase in potential collaborations, and funding opportunities (Hitchcock 2024; Piwowar & Chapman 2008; Piwowar & Vision 2013; McKiernan *et al.* 2016; Hahnel *et al.* 2024). Open practices are already being recognized in promotion and tenure evaluations in several institutions and stated in faculty job advertisements (McKiernan *et al.* 2016). This confirms that open research practices bring more benefits and prestige to a researcher's career than more traditional closed practices; indeed, they also help to increase the discoverability and visibility of the researcher's work (McKiernan *et al.* 2016). This also makes sense the other way round: recognition and improvement of one's status or reputation can be motivators for sharing data (McKiernan *et al.* 2016; Stieglitz *et al.* 2020). To accomplish this, the academic system needs to ensure that data will always be correctly cited using persistent identifiers, and so attributed to the original contributor when it is reused (Piwowar & Vision 2013; Blackburn *et al.* 2024; Hahnel *et al.* 2024). Scientific journals can support open data sharing by including specific instructions about data citation in their guidelines and practices (Hrynaszkiewicz *et al.* 2020) (see Journals' Author Guidelines and Data Policies Assessment, below). A new way to achieve safeguarding of data is preregistration of data, which both increases the transparency of research data and research projects, and registers it to the author's name, therefore guarding it from plagiarism (Nosek *et al.* 2018). This practice creates and posts to a public repository a time-stamped, read-only research plan before data collection begins, helping researchers to address and avoid methodological risks (Ladyzhensky *et al.* 2025).

Finally, the availability and ease of using public repositories have an important impact on the willingness of researchers to share their 3D data (Kim & Zhang 2015).

It is important to acknowledge that not all researchers, or institutions, are comfortable with the same level of data sharing (Hrynaszkiewicz *et al.* 2017), or that risks and shortcomings may exist, such as discrepancies between institutional data policies or data management of colonial collections, where consent to share the 3D datasets should be sought from the administration of the country of origin of the specimens (Díez Díaz *et al.* 2025a). However, there are several ways to make the research data publicly available. Indeed, openness can be considered as a continuum of practices (McKiernan *et al.* 2016). One of them is the publication under Creative Commons (CC) licenses, which function within the legal framework of copyright law (Creative Commons 2024). Under these licenses, authors retain copyright and grant specific (non-exclusive) reuse rights to publishers, as well as other users. CC licenses require attribution, which allows authors to receive credit for their work and increase citations. Through open licensing, researchers can retain control over how their work is read, shared, and used by others (McKiernan *et al.* 2016). Numerous scientific journals ask authors to sign contracts granting these copyrights and reuse rights of the researcher's data to the publisher. It is important that the author carefully reads these policies while deciding which journal they are going to submit their work to, to see if they conform to their beliefs and needs. Moreover, the intellectual property of digital surrogates is a topic still being discussed (Wallace & Farmer 2024), and copyright of 3D data should not be granted to journals without keeping this information in mind. Generally, authors publishing in OA journals retain nearly all rights to their manuscripts and data (McKiernan *et al.* 2016).

The scientific community needs to find a consensus towards data sharing, so researchers can feel more confident and improve their data sharing behaviours (Zimmerman 2007; Hahnel *et al.* 2024). After all, data sharing implies that the authors value transparency and have confidence in their own research (McKiernan *et al.* 2016).

3D DATA ARCHIVING & SHARING THROUGH THE SCIENTIFIC PROCESS

Data archiving & reuse

As McKiernan *et al.* (2016, and references therein) mentioned, open access policies are generally motivated by ethical, moral or utilitarian arguments, like the right of taxpayers to access the results and publications from publicly-funded research projects or the importance of reproducibility. Moreover, unarchived data are often misplaced, corrupted, or the software in which they were produced becomes obsolete (Vision 2010). The long-term preservation of data is best achieved by archiving them in an independent/public repository (McKiernan *et al.* 2016; Golubiewski-Davis *et al.* 2022), if possible specific to the data type. This choice is in line with the FAIR Data Principles, as researchers will ensure the discoverability and reuse of their data (Wilkinson *et al.* 2016). Indeed, these public repositories should have priority over institutional ones as, for example, research institutions can suffer cyberattacks (Kwon 2024), but also renovations, institutional neglect of the IT-infrastructure, moves of collections and roadwork can contribute to failures in the system. Most of these public repositories assign digital object identifiers (DOIs) to the data uploaded (McKiernan *et al.* 2016), safeguarding the correct attribution and citation to the original author.

As mentioned above, open access publications are associated with higher citation rates, regardless of whether archiving is decided by the author or mandated by an institution or funder (Gargouri *et al.* 2010; Xia & Nakanishi 2012). Journals can help by promoting the practice of data archiving upon publication (Vision 2010), also suggesting some (data type specific) independent and public repositories, or search tools. Indeed, journals which mandate data archiving policies and also require the inclusion of an explicit Data Availability Statement (DAS) in the manuscript, improve the possibility of finding the data online almost 1000-fold compared to having no data archiving policy at all (Vines *et al.* 2013; see also Hahnel *et al.* 2024). Moreover, while authors use their own datasets in the two years following the first publication, data reuse papers published by third-party researchers continued to accumulate for at least six years (Piwowar & Vision 2013). Indeed, this number grew rapidly after data archiving rates started to grow. The development of long-term archiving practices increases the reproducibility of the published results and the ease with which other researchers can use, extend, and cite the work (McKiernan *et al.* 2016).

Although it may help when dealing with institutions that are not completely willing to share their digital specimen, a practice that should be progressively reduced and eventually abandoned is the 'data available upon request' one. Vines *et al.* (2013) stated that requested datasets took a mean of 7.7 days to be received, while online data can be obtained within minutes. This value decreases with time (e.g. 25% of data received after 6 months of repeated requests; Wicherts *et al.* 2006), even receiving replies from authors who are not able to find their data anymore. The possibility of not recovering data that is not deposited in a repository increases over time, as researchers could leave academia, or because computers, external drives or websites get misplaced or servers fail (Michener *et al.* 1997; Wren *et al.* 2006). It is easier to prepare research data for sharing during the active phase of the project than reconstructing them after several years have passed (McKiernan *et al.* 2016). Nevertheless, the positive news is that this type of practice, although still dominant, is on the decline (Hahnel *et al.* 2024). A good example of a data storage service that also provides training on how to best prepare and store various research data is Yoda (https://www.uu.nl/en/research/yoda/guide-to-yoda), provided by the Research Data Management Department at Utrecht University Library, as well as the Data Archiving and Networked Services (DANS) of the Royal Netherlands Academy of Arts and Sciences (KNAW) (https://dans.knaw.nl/en/training/). Both institutions provide workshops on how to create a data management plan, how to use FAIR Data Principles, and how to manage various types of data, even sensitive information, thus aiding in data literacy of students and professionals. There is no EU wide training network yet, to our knowledge.

On the other hand, repositories such as MorphoSource offer the possibility of restricting downloads of digital datasets. This practice can effectively function as a 'data available on request' model. This can be a legitimate mechanism to manage access, for instance, when linked to the institution holding the physical specimen or due to ethical concerns (e.g. cultural heritage, lack of consent from the country of origin, risks of commercial monetization by third parties via 3D printing). Therefore, while immediate open access is preferable to fully align with the FAIR Data Principles, it is not always feasible. Encouraging direct collaboration between the institution and the repository (e.g. MorphoSource) can help establish clear, permanent access protocols. Authors should indicate in the DAS the reason behind restricted downloads (e.g. 'institutional policy', 'ethical embargo', 'ongoing study').

As seen, journal data archiving policies are positively correlated with data sharing practices, and can be very effective in ensuring the availability of the data (Vines *et al.* 2013; Naughton & Kernohan 2016; Hahnel *et al.* 2024). We agree with Vines *et al.* (2013) that, given the long-term benefits of data accessibility for the academic community, mandatory journal data archiving policies and mandatory DASs should be more widely adopted. Nonetheless, data archiving can also be a long task, and the workflow should be built in the first steps of the PIPs within the digital project (Fig. 1) (see also Golubiewski-Davis *et al.* 2022), not leaving it until the manuscript submission.

Public online repositories for 3D morphological data

Davies *et al.* (2017, suppl. table 1) and Boyer *et al.* (2022) provided a thorough analysis and discussion on how to choose the best repository for the created 3D models and associated data and metadata, and how to prepare these data for deposition. A high-quality public repository for 3D models should:

1. Be cost-free (at least for non-funded research projects or small to medium datasets, e.g. MorphoSource may request an economic contribution starting at 100 GB uploaded per project)
2. Accept several common and interoperable 3D data and metadata types
3. Allow the visualization of the 3D model (at least with vertex colour) in an embedded viewport
4. Allow the upload of associated data and metadata, if possible with an application programming interface (API)
5. Permit annotations in the 3D model
6. Let the author choose the access rights/copyright of the 3D model and its data and metadata, and ask for their permission to download the data
7. Create a DOI for the correct citation of the 3D model and its data and metadata
8. Offer an embargo facility
9. Provide curatorial services (e.g. file checks and migration, administrate metadata)
10. Be research-academic oriented.

Currently, no public online repository for 3D morphological data covers all these points, but MorphoSource (www.morphosource.org), MorphoMuseuM (https://morphomuseum.com), and more recently Kompakkt (https://kompakkt.de), cover a certain number of them, which makes each one a good option to deposit 3D models even if improvements are still to be hoped for to perfect the process. In any case, we recommend that authors read in detail the information documents for each of them, so that they can see which one most closely matches their preferences and objectives. If further help is needed to make a choice, we recommend that they ask the following questions (taken from Boyer *et al.* 2022) of the repositories (if these are not already included on their website):

1. What is the cost, if any, for depositing data?
2. What is the technical process for the user of depositing their data in the repository?
3. Does the repository offer additional curation services? What are the fees?
4. Is there appropriate metadata that meets the needs of the data?
5. Is the repository sustainable?
6. How is the material accessed?
7. What steps does the repository take to keep files secure?
8. What, if any, certification has the repository undergone?

Data storage energy cost

Environmental sustainability is an issue that must be taken into account when creating and storing digital data. The preservation of such data relies on an infrastructure known as information and communication technology (ICT), which includes items such as computers, network-connected devices, satellites, data centres and all the networking infrastructure required to connect them all (Pendergrass *et al.* 2019). And these components, and therefore digital preservation practices, have a negative impact on the environment; we are still far from a sustainable transition from physical to digital formats (Hecker 2003). We need to find a consensus between economic and environmental sustainability when carrying out digitization projects and identifying and storing data and metadata. Pendergrass *et al.* (2019) proposed two suggestions that could help in reducing the environmental impact of digital preservations practices: (1) reduce the amount of digital content that will be preserved; and (2) reduce the resource-intensity of its storage and delivery. Repositories are the primary recipients of the second proposal, but researchers can greatly contribute to the first. To do this, a clear preservation and action plan must be developed from the beginning of the digitization project. Golubiewski-Davies *et al.* (2022) proposed some minimum PIPs to take into account when carrying out a digitization project, whether mass digitization or isolated elements. These points cover preservation, data collection, creation and processing, curation and archiving plans. By having a clear action plan from the beginning, the key points of the project will be identified, as well as the data and metadata to be created, stored and shared. Moreover, the environmental impact of their creation and preservation will also be managed in a more objective way, having more flexibility to adapt the project in consequent steps if needed. That is why we consider it crucial to plan these PIPs from the beginning of the project, not only for the optimal conservation of the data, but also for that of the environment. Pendergrass *et al.* (2019, tables 1–3) offered additional questions that can be useful for the preparation of these PIPs.

As Rodríguez Reséndiz (2025) mentioned, while in the last century sustainability consisted of the search for economic resources to develop mass digitization strategies in the shortest possible time, the current and future challenge is digital preservation based on principles of environmental sustainability.

3D data accessibility in the peer review process

Even though the academic community acknowledges the importance of data in the scientific process, it is not often included in the manuscripts' peer review stage, compromising the transparency and integrity of the research work undertaken. Data needs to be evaluated efficiently during peer review, in a timely and constructive manner; moreover, manuscripts should not be sent out for evaluation until the underlying data can be accessed easily and securely (Scientific Data 2016). Editors should be aware of the journal's data policies in advance, so that they can check all files submitted by authors, request missing files necessary for an objective review of the paper, and advise authors about possible repositories for such data. As previously said, open access is a continuum, and accessibility settings can be defined in the repository, so only journal editors and reviewers have access to the data during the submission and revision steps. At the time of writing (February 2025), both MorphoSource and MorphoMuseum offer the option of making the 3D database accessible in the review process by creating a specific DOI for it, and several journals ask for it in their author guidelines (e.g. *Journal of Systematic Palaeontology*, MorphoMuseum, *Palaeontology*).

By reviewing the associated data, the integrity of the methodology is assured and the conclusions can be more objectively reviewed and discussed (Rousi & Laakso 2020). Moreover, the inclusion of the data in the peer review process helps to ensure that they are as FAIR as possible (Scientific Data 2016).

STUDY OF 3D DATA POLICIES OF JOURNALS FOCUSED ON PALAEONTOLOGICAL RESEARCH

As part of the analysis and discussion of data cycle practices, we have carried out a study to assess the current situation regarding 3D data policies of scientific journals focusing on research in palaeontology. By comparing their policies and guidelines, we aim to highlight common shortcomings and propose recommendations to improve the overall process of publishing 3D datasets. Nonetheless, it ultimately remains the author's responsibility to ensure that any published 3D dataset is complete, meaningful and accessible, regardless of the specific requirements of the journal.

Scientific journals sample

The SCImago Journal & Country Rank for the subject area 'Earth and Planetary Sciences' and the subject category 'Paleontology' was downloaded, in order to have a starting point for the journal search (https://www.scimagojr.com/journalrank.php?category=1911&area=1900&year=2022). The ranking for 2022 was the most recent one available when this research began (November 2023). 112 scientific journals were recovered after this search (Table S1). Palaeontological research is also often published in journals falling under other subject areas, depending on the methodology employed and research focus. In order to find recent journals which published palaeontological research studies using 3D models a search was carried out in Google Scholar with the key words '3D (model)', 'fossil' and/or 'pal(a)eontology'; focus was laid on papers published from 2023 onwards. A thorough examination of all the results was carried out to confirm that the papers did indeed fall within the palaeontology field and included 3D models. A further 25 journals were added to the sample; however, this list was reduced to 18 as several belong to the same publisher, and therefore share similar guidelines and policies (i.e. American Association for the Advancement of Science, Nature Research and Royal Society Publishing publishers; Table S1).

The Transparency & Openness Promotion (TOP) guidelines

In November 2014, the Transparency and Openness Promotion (TOP) Committee met at the Center for Open Science in Charlottesville (Virginia, USA) to address journals' procedures and policies for publication. They defined eight standards with the aim of moving scientific communication toward greater openness (Nosek *et al.* 2015). The objective was to translate scientific norms and values into concrete actions and change the current incentive structures to drive researchers' behaviour toward more openness (https://www.cos.io/initiatives/top-guidelines). Indeed, transparency, openness, and reproducibility are readily recognized as vital features of science (McNutt 2014; Miguel *et al.* 2014). Currently, more than 5000 scientific journals have signed the TOP Guidelines.

We have indicated those journals which have already embraced these guidelines, and their scores (Table S1). From the complete list of 137 journals, only 14 have signed the TOP Guidelines (2 from the subject area 'Earth and Planetary Sciences' and 12 from the list after the secondary search in Google Scholar – 7 of them belonging to the American Association for the Advancement of Science and Nature Research publishers). Scores range from 0 to 12 in our sample.

Journals' author guidelines & data policies assessment

In order to objectively evaluate the journal guidelines and policies regarding 3D data and metadata preparation, submission, availability and archiving, a set of questions was developed. This was created after the works of Vines *et al.* (2013), Davies *et al.* (2017), Hrynaszkiewicz *et al.* (2017, 2020), Falkingham *et al.* (2018), Rousi & Laakso (2020), Moore *et al.* (2022) and the guidelines provided by MorphoSource (Table S2).

Definitions. Do the author guidelines provide a definition of research 3D data and accompanying metadata?

The research work and its underlying data are strongly linked, and these data are directly involved in the preparation of manuscripts (Hrynaszkiewicz *et al.* 2020; Rousi & Laakso 2020). Every policy must define research data as being the data that support the findings or claims made in the published article. Definition of data (3D data and metadata here) helps researchers to identify those files the journal asks for and which help improve open science:

1. **Do they suggest common 3D file types?** Here it is important to indicate non-proprietary, community-endorsed, standard file formats, with the aim of long-term archival, access, interoperability and reusability of the data.
2. **Do they indicate which metadata should be submitted together with the 3D model?** As previously indicated, metadata include important methodological information about the 3D model and the object the model is based on, and must be always uploaded and downloaded together.
3. **Do they define types of metadata?** Examples of essential (for verification) and recommended (as best practice) digitization metadata files can be found in Davies *et al.* (2017).

Repositories. Do the author guidelines and journal data policies include (a list of) recommended, trusted or supported 3D data repository(ies)?

Journals must support data preservation by providing a list of recommended, trusted or supported data repositories, which require deposition of data and metadata in standard, common formats, enable more efficient discovery and reuse of data and provide professional data curation (Hrynaszkiewicz *et al.* 2020).

Data availability policy. Has the journal a data archiving/availability policy?

The journal data policy must include a definition of a Data Availability Statement (DAS) and where it should be placed in the manuscript (Hrynaszkiewicz *et al.* 2020). This is especially important, as less than the 70% of journals don't mention data sharing in the author guidelines (Malički *et al.* 2019; Hübner 2020). The policy must specify the data sharing mandate(s) that must be followed as a condition of submission and/or publication and the mechanisms for demonstrating compliance, such as deposition in specific repositories. A DAS stating 'Available on reasonable request' should not be acceptable (Hrynaszkiewicz *et al.* 2020). We have evaluated five situations in our sample: (1) no data availability policy; (2) data availability policy recommends share of data without a DAS in the manuscript; and (3) with a DAS; (4) data availability policy mandates sharing of data without a DAS in the manuscript; and (5) with a DAS. To assess the policies in these situations, we considered them against the following four criteria (presented here as questions):

1. **Does the journal data archiving/availability policy indicate how data should be shared and point out the citation style?**
2. **Does it require the data for the peer-review process?**
3. **Does it mention FAIR Data Principles and benefits of data sharing to open science?**
4. **Does it suggest 3D data licensing options?** The data policy must specify if the copyright in research data is transferred or not to the publisher. The policy must express a preference for Open Data conformant licenses (such as Creative Commons Attribution License, CC BY, Creative Commons Public Domain Waiver, CC0). Licensing can also be addressed in part with recommended repositories, as criteria for trusted repositories often include requirements for licensing (Hrynaszkiewicz *et al.* 2020).

Results

A thorough first study of the 137 journals' author guidelines and data policies was carried out between November 2023 and May 2024. Table S1 shows the dates on which each journal document was accessed, thus any subsequent changes to them are not considered in this study. In this first search, the main focus was finding policies specifically addressed to 3D data and metadata; after this screening, the list was reduced to 10 journals. A second reading was carried out on the guidelines and policies of the new journals list, focusing on the questions list indicated above (Table S2). One of the major difficulties encountered in the process was the heterogeneity of the guidelines, with important differences in their wording, which complicated objectivity when assessing some answers (e.g. 3D data citation and licensing policies). In other cases, the process could be lengthy as different web pages had to be accessed to find the right information (this was most notable in journals belonging to large

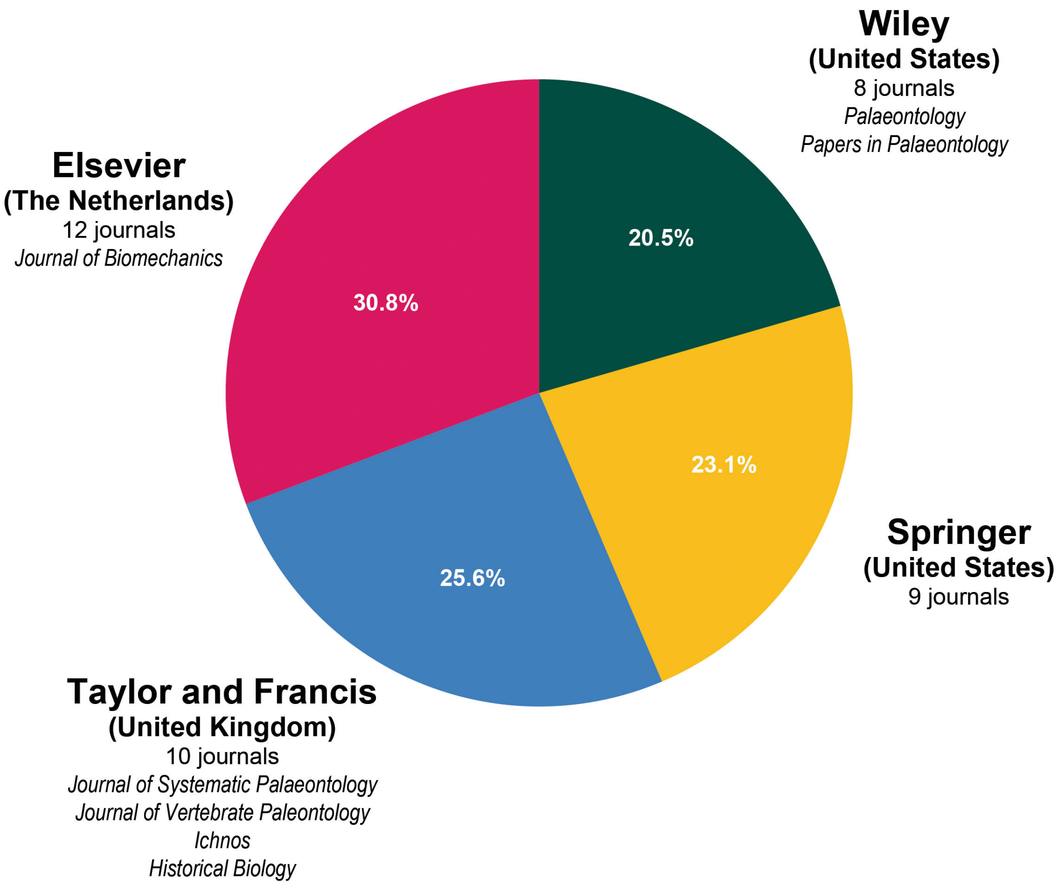

FIG. 2. Diagram showing the publishers with the most journals in our sample. The percentages refer to the number of journals from each publisher in relation to the total sample. The journals listed under each publisher are those with the best policies regarding the publication and access of 3D datasets.

publishers, which have their own guidelines, but redirect to the publisher's policies for specific ones).

None of the journals in this small sample present guidelines and policies regarding 3D data and metadata that are in total compliance with the requirements outlined above. *Palaeontology* and *Papers in Palaeontology* can be considered as the journals with the most comprehensive guidelines and policies for submitting 3D data and metadata in palaeontological research, only failing to highlight the FAIR Data Principles. The strength of these journals is indicating to the authors to follow best practice recommendations of Davies *et al.* (2017) and the repository Dryad (https://datadryad.org/stash/best_practices), where they will find all the information concerning their 3D data and metadata. However, it would also be helpful to summarize those best practices in their guidelines (see below). The other journals mainly fail to define 3D data and metadata and make the sharing of such data mandatory (and with a DAS included in the manuscript). Positive results are recovered for 3D data citation (all 10 journals have policies on this) and the sharing of 3D data and metadata in the peer review process (7 journals request it).

A more detailed analysis reveals that four publishers account for the majority of journals in the sample (Fig. 2): Elsevier (12 journals), Taylor and Francis (10 journals), Springer (9 journals) and Wiley (8 journals). However, Taylor and Francis is the publisher with the most journals in our sample that have the best guidelines regarding the publication of 3D datasets (4 journals). The policies of these four journals are generally quite similar, and if there were any points for improvement to highlight, it would be the inclusion of a mandatory DAS and the suggestion of a public research repository. It is also particularly striking that Springer does not have any journals from our sample with adequate author guidelines for 3D datasets.

However, it should be noted that not all of the journals included under these publishers have published research using 3D datasets in recent years, or their editorial line does not focus on this type of approach. Nevertheless, for those with a more general thematic focus, it would be

TABLE 2. Journals from our sample with a biological or multidisciplinary approach.

Journal	Summary of categories
Anatomical Record	Ecology, evolution, behaviour, systematics, anatomy
Communications Biology	Biology, genetics, molecular biology
Frontiers in Ecology and Evolution – Paleontology	Ecology, evolution, behaviour, systematics
Historical Biology	Biology
Journal of Anatomy	Ecology, evolution, behaviour, systematics, anatomy, biology, molecular and developmental biology
Nature Communications	Biology, genetics, molecular biology
Nature Ecology and Evolution	Ecology, evolution, behaviour, systematics
PeerJ – Life and Environment	Biology, genetics, molecular biology
PLoS One	Multidisciplinary
Proceedings of the Royal Society B	Biology, genetics, molecular biology
Royal Society Open Science	Multidisciplinary
Science Advances	Multidisciplinary
Scientific Reports	Multidisciplinary
Zoological Letters	Zoology

advisable to improve their 3D dataset policies, also in order to attract research papers that create and use them. This may provide a competitive advantage for journals with fewer submissions. This strategic approach would make them particularly attractive to researchers involved in the creation and use of 3D models, who value the proper preservation and dissemination of their data in accordance with the standards.

Although most of the sample studied here has a palaeontological focus, it is also important to note that many researchers who work with 3D models of fossils prefer to publish their research results in journals with a more biological (e.g. *Journal of Anatomy*, *Journal of Morphology*, *Historical Biology*) or multidisciplinary approach (e.g. journals published by the American Association for the Advancement of Science, *Nature*, *PeerJ*, *PLoS One*, or The Royal Society). Extending this work to a larger sample of biology journals would be a valuable future development, although this proposal is beyond the scope of the present study. Despite this, the analysis of our sample allows us to draw significant conclusions. By filtering the results and excluding journals categorized under 'palaeontology' or related disciplines, we observe a composite of ten biologically oriented and four multidisciplinary journals (Table 2).

From this list, only the journal *Historical Biology* presents adequate policies regarding 3D datasets. However, almost all of the journals on this list have published research papers that used 3D models. Although a more detailed study of journals with a more biological focus is needed, it can be concluded that, at the time of completion of our analysis, journals with a palaeontological focus provide better guidelines and policies regarding the use and publication of 3D datasets.

Limitations of the study

This is the first time that an extended study of the guidelines on how to submit 3D models in research articles focused on palaeontology has been carried out. However, due to the versatility of the projects carried out in palaeontology with 3D models, the results can be published in journals of other research areas as well (e.g. life sciences, biomechanics, ecology and environmental sciences, outreach and education, computer engineering). In order to try to homogenize the methodology and data obtained as much as possible, the sample has been chosen in the manner indicated above. Likewise, within the palaeontology journals of the SCImago Journal & Country Rank sample, there are numerous journals in which the focus appears far from the use of 3D models (e.g. stratigraphy, geochronology), making the final number of journals that include guidelines on 3D models look relatively low compared to the total sample. Although the data sharing policies had sentences similar to 'all data relevant to the study must be made publicly available', these journals were not taken into account in the sample, since we were looking to analyse those policies that dealt directly with 3D datasets. It has also not been analysed whether the following factors may have an influence:

1. Do publications that have made their 3D models and associated data and metadata openly accessible have more citations?
2. Do papers published in journals with clear guidelines on how to publish 3D models (e.g. *Palaeontology* or *Papers in Palaeontology*) receive more visits and get more citations?
3. Are those authors who indicated in the paper a DAS similar to '3D model under request' easy to contact and share such files within a reasonable time?
4. How do journals with printed issues address DASs and links to repositories? Do they have separate guidelines on how to reference the 3D data in printed and online issues?

These factors will be interesting to check in the coming years, especially if the open share of 3D models is normalized and standardized in the scientific community, and an increasing number of journals adopt the suggestions indicated in this work and the shared references on how to address 3D data guidelines and policies.

TOWARDS MORE STRAIGHTFORWARD 3D DATA POLICIES

As indicated above, journals should have comprehensive, clear and updated information describing the general approach to data sharing as well as the details of what is expected from authors in terms of provision of research data (Hübner 2020). This information needs to be indicated in research data policies that are related to the author guidelines. Complicated submission systems and extensive or unclear author guidelines make it difficult for all the files generated to be properly attached, and can lead to repeated re-submission of additional data and prolonged conversations about the submission process. In fact, in this study we encountered numerous difficulties in finding the specific sections on 3D datasets, having to search in the supporting information, click on various links, or even being referred to the publisher's guidelines, which in many cases did not include information about 3D datasets. We find the strategy followed by journals such as *Palaeontology* and *Papers in Palaeontology* (which attach links to Davies *et al.* 2017 and Dryad) and *Zookeys* (which refers the reader to the best practices of Penev *et al.* 2017) interesting and useful. Still, the inclusion in the author guidelines of, for example, a table summarizing the main points of such papers (e.g. Davies *et al.* 2017, table 1) may be even more efficient in the submission process. In fact, reading extensive papers on data sharing and archiving (without being topics in their field of research) could be more a barrier in the final decision and manner on how to share the generated 3D models and their data and metadata.

In this work, we have created a template for 3D data policies (Appendix S1), which journals can use to update and improve their own policies and author guidelines. Researchers can also use this template when discussing PIPs, to learn in advance about good practices for collecting, creating and sharing 3D data from their digitization projects, especially in anticipation of the publication of results.

CHECKLIST FOR RESEARCHERS, REVIEWERS & JOURNALS

The main recommendations that researchers, reviewers and journals should follow are summarized in this paragraph in the form of a checklist. These recommendations aim at researchers from the initial stages of their digitization projects to the publication of 3D datasets, reviewers for the review process, and journals for providing author guidelines and data policies that are comprehensive, accessible, standardized, and up to date. Any recommendation for reviewers and journals can be distributed also to technical editors or data managers of the journal, if that corresponds to the workflow of the respective journal. Reviewer-specific tasks in the process of data publishing would, however, be reviewing the validity and quality of the methodology used for creating the 3D model, checking if it corresponds to the results presented and the discussion thereof, and the like.

Checklist for researchers

1. Have you discussed the preservation intervention points (PIPs) before starting your digitization project?
2. Is your 3D dataset complete and comprehensive? Does it meet the minimum standards of quality? Have you performed a quality control check on all the files generated?
3. Have you included the main points of the digitization and post-processing protocols within the metadata? Have you included other information that could be relevant (e.g. systematic, historical) in relation to the digitized specimen in the metadata?
4. If you are going to provide or publish a simplified 3D dataset, have you stored the raw 3D dataset in a secure repository to prevent its loss or corruption?
5. Have you made sure that your 3D dataset meets the FAIR (and CARE if applicable) Data Principles?
6. Have you uploaded your 3D dataset to a public research repository?
7. Have you confirmed that your 3D dataset can be cited by a persistent identifier?
8. Have you included an (open) licensing option for your 3D dataset?
9. Have you submitted your 3D datasets to the review process of your manuscript?
10. Have you included a Data Availability Statement (DAS) in your manuscript? Will the complete 3D dataset be openly accessible?

Recommendations for reviewers/technical editors

1. Have you confirmed with the editor that you have received all supporting information and the complete 3D dataset for the review of this manuscript? Is the specimen and digitization metadata included and complete?

2. Do the files provided and their accessibility correspond to their description in the Data Availability Statement (DAS) and in the text?
3. Can the 3D dataset be downloadable in its entirety? If access is restricted (e.g. ‘available on request’ or via a ‘restricted download’ function), does the manuscript clearly state the reason (e.g. ‘institutional policy’, ‘ethical embargo’, ‘ongoing study’)? This step should be conducted by the journal’s technical editor/data manager.
4. Can all files included in the 3D dataset be opened and visualized correctly? This step could also be conducted by the journal’s technical editor/data manager.

Recommendations for journals

1. Do you have a technical or data editor specialist on the management of datasets?
2. Are the author guidelines and data policies updated?
3. Are the author guidelines and data policies clear and easy to understand? Are they easy to find on the website without having to navigate through multiple pages?
4. Do the author guidelines provide a clear definition of research 3D data and accompanying metadata? Do they suggest common 3D file types? Do they indicate which metadata should be submitted together with the 3D model? Do they define types of metadata?
5. Is the inclusion of a Data Availability Statement (DAS) mandatory for the publication of the manuscript?
6. Does the data archiving/availability policy indicate how data should be shared and point out the citation style?
7. Does the data policy suggest 3D data licensing options?
8. Do the author guidelines and journal data policies include a (list of) recommended, trusted or supported 3D data repository(ies)?
9. Do the editor, author guidelines, or data policies encourage authors and their institutions to work directly with repositories to ensure stable, long-term access conditions when restrictions apply?
10. Does the data policy require the data for the peer-review process?
11. Does the data policy mention FAIR Data Principles and benefits of data sharing to open science?

CONCLUSION

Science greatly benefits from data sharing, and 3D models and their associated data and metadata fall within this category. Besides, sharing data enhances transparency, availability of scientific data on a global scale, and confidence through all the steps of the scientific and publication processes, including peer-review (which is not always included in the data cycle). While four main actors (researchers, institutions, funders, and journals) can enforce the comprehensive submission of 3D datasets, researchers and scientific journals play the main roles in this data cycle. However, researchers are usually entrusted not only with the generation of these data, but also with decisions about their sharing and archiving (and even management on multiple occasions). Scientific journals and public repositories can clarify and facilitate this process by providing clear and easy-to-follow author guidelines and data policies. With a straightforward and easy standard 3D data policy, everybody from the scientific community (including journal editors) would benefit. The work of journal editors and repositories is essential, since they help authors in one of the most important steps of the scientific process: to ensure that these generated data are FAIR. Indeed, FAIRness is a prerequisite for proper data management and data stewardship, and this will benefit the entire academic community (Wilkinson *et al.* 2016).

The research and dissemination work carried out by networks and communities such as Community Standards for 3D Data Preservation (CS3DP), Europeana, the Non-Clinical Tomography Users Research Network (NoCTURN), or the open-access collection Ozbonebiz are of great help defining these standards related to the creation, processing, management and sharing of these 3D data (Moore *et al.* 2022; Borin & Donato 2023; Gignac *et al.* 2024; Weisbecker *et al.* 2025). Journals, institutions and funding organizations should also consult or engage in dialogues with these networks when developing or updating data sharing policies.

In the field of palaeontology specifically, the evidence confirms that researchers no longer limit the submission of papers with 3D datasets to strictly palaeontological journals. Indeed, there is a growing trend to submit these manuscripts to biology-oriented or multidisciplinary journals to reach larger audiences. The implementation of clear and sound policies on the publication and accessibility of 3D datasets could therefore constitute a competitive advantage for journals seeking to attract a research community that is increasingly committed to good scientific practice. This strategy could, in turn, have a positive effect on the impact of journals with a more modest reach. Consequently, journals in the biological and multidisciplinary fields are strongly encouraged to adopt these improvements in their 3D data policies. This adaptation is particularly compelling given the notable increase in the amount of research using these datasets, a trend that extends beyond the field of palaeontology. In order to objectively assess the current situation and suggest improvements, we encourage similar studies to be conducted with representative samples of journals in the field of organismic morphology.

3D models are not mere visual data accompanying the physical specimens. They constitute the digital representation of a physical object, and information on their creation and modification needs to be included to facilitate the best use of this thoroughly accumulated datasets.

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DATA ARCHIVING STATEMENT

The data examined in this research is available as supporting information.

Editor. Gabriel Ferreira

SUPPORTING INFORMATION

Additional Supporting Information can be found online (https://doi.org/10.1111/pala.70052):

Appendix S1. Optimal 3D data sharing policy template for journals.
Table S1. List of palaeontology, biology and multidisciplinary scientific journals, ranked according to SCImago Journal Rank (SJR). The 2022 Paleontology rank sample was retrieved in 2023 from: https://www.scimagojr.com/journalrank.php?category=1911&area=1900&year=2022. The 2023 list of biology and multidisciplinary journals in which 3D datasets have been published was retrieved in 2024. The Transparency & Openness Promotion (TOP) factors and justifications for each journal were checked in June 2024.
Table S2. Assessment of 3D data policies in the ten selected journals from the complete sample.

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