THE SOCIETY OF VERTEBRATE PALEONTOLOGY'S PUBLICATION POLICY IS INCONSISTENT WITH SCIENTIFIC EPISTEMOLOGY

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Abstract

The Society of Vertebrate Paleontology has urged scientific journals to reject studies that use data from privately owned fossil collections. Here, I argue that the Society's perspective on reproducibility in science is overly simplistic. Their suggested publication policy, at best, slows the progress of science and, at worst, permits scientific misconduct through a form of data falsification and provides a potential mechanism to bully and censor researchers. The best way to ensure the long-term survival of fossil data is to collect and publish the data while the specimens are available.

Introduction

The Society of Vertebrate Paleontology (SVP) is undoubtedly one of the largest and most influential professional paleontology societies, having been founded in 1940 and possessing more than 2,300 members according to their official website¹. On April 21, 2020, the executive committee of the SVP, consisting of the President, Vice President, and Past President, published an open letter to the editors of approximately several hundred scientific journals urging them to reject studies that use privately owned specimens in the name of reproducibility². They specifically suggested the following as a template for editorial policies:

“Any fossil specimen that is described or illustrated in a manuscript intended for publication must be formally accessioned into a permanent, accessible repository, where the specimen will be available for study by the scientific community. Long-term loans from private individuals or private organizations to repositories generally are not sufficient to ensure longterm access to fossils or reproducibility of results” (pg. 2)².

Such a position is not a particularly novel one for the SVP³. However, not all paleontologists agree with the policy as drafted by the three executive committee members. In response to their letter, an international team (including members from the USA, where the SVP is based) of 46 academic paleontologists published in the scientific journal *PalZ*, criticizing the letter and defending the importance of private collections⁴. As a scientist who is presenting my research at the 2020 SVP annual meeting for the fifth consecutive year, I had independently hoped to raise my own criticisms of the policy at the 2020 virtual meeting, but the submitted abstract was ultimately not accepted since it did not closely match the available themes of the sessions (i.e., Education and Outreach).

In this article, I present my concerns about the policy, hopefully without excessive overlap with arguments previously made by my colleagues. I am of the opinion that the policy is inconsistent with scientific epistemology (i.e., the way by which scientific knowledge is obtained). Additionally, the ambiguity inherent in the stated conditions of permanence and accessibility of repositories opens the possibility of inconsistent application and abuse of the policy against specific institutions or individuals.

Discussion

Epistemology, not ethics

The first part of the SVP letter discusses major ethical concerns regarding human suffering associated with the collection and sale of Burmese amber². While other scientists have questioned whether their call for a ban on publishing data from Burmese amber is the most appropriate course of action in light of these concerns^{5,6}, I do not intend to address these sorts of ethical questions here. Instead, I will discuss the second part of the SVP letter², which relates to publishing on privately owned specimens, under the assumption that no serious ethical concerns, such as human suffering, are at play in such cases. The epistemic question of how best to forward scientific progress can therefore be soberly addressed, without inappropriate conflation with genuine and serious ethical problems. One can then examine the fundamental argument behind the SVP policy – that fossils at risk of being lost, either literally or otherwise made inaccessible, should not be

studied in the name of reproducibility. The stringent position of the SVP regarding this argument is inconsistent with scientific epistemology.

Reproducibility – a worthy goal, not an absolute

It should first be stated that proper, long-term conservation of fossils in accessible repositories, such that all researchers can freely access the primary data inherent in the fossils in order to gain new insight or to evaluate the veracity of previously published claims, is inarguably the ideal scenario for scientific progress. I cannot see how any researcher who sincerely cares about the scientific method and holds an inherent appreciation for fossils as remnants of Earth's deep history would prefer scenarios in which fossils are poorly cared for, inaccessible to researchers, or at risk of being lost or destroyed. However, the question at hand is not what characteristics an ideal fossil repository should possess, but under what circumstances should fossils be studied and published on in order to best benefit science. I argue that publication of fossil data while it is currently available is always the best option in the long-term.

The term “accessible” carries ambiguity, given that public fossil collections are not like public libraries – only an extremely small number of qualified researchers are allowed to work on often fragile specimens, for very understandable reasons. However, even for credentialed researchers with higher degrees, curation in a public repository is no guarantee of access in cases where other researchers claim precedence to publish on certain fossils or make access contingent upon co-authorship with researchers working at the curating institution, compromising freedom of academic enquiry.

Although often called for by the SVP, extreme language like ‘permanent’ or ‘perpetuity’⁷ invoke an obviously impossible standard for repositories. Specimens in any repository can be damaged, lost, stolen, or even deaccessioned and subsequently sold, auctioned, or disposed of. Just a few inadvertent cases include the longest known *Stegosaurus* tail spikes destroyed by a burst water pipe at the University of Wyoming in the 1920's^{8,9} as well as the vast collections lost from the National Museum of Brazil in 2018 due to a fire¹⁰. Specimens also risk being lost through economic setbacks. The American Alliance of Museums warned that as many as one third of US museums could be permanently closed due to loss of funding because of the COVID-19 pandemic¹¹.

Furthermore, governments historically rise and fall. Since modern math and science trace their roots to many extinct civilizations, it is most likely that scientific progress made at the present will be relevant even after the collapse of our current institutions and governments, meaning that we should work to advance human understanding with the full recognition of our institutions' impermanence. When stating any official policy, the SVP must be precise with its language. Permanence and perpetuity are absurd standards to put forth by a scientific society that often considers the evolution of the biosphere over millions of years. Unless the SVP intends official standards for repositories to be that public museums must assuredly survive any foreseeable war or natural disaster, the downfall of civilizations, the extinction of our species, the death of our sun, and the ‘heat death’ of the universe, it should start to carefully consider the wording of drafted policies so as not to make them immediately dismissible, open to interpretation, or arbitrary.

Is paleontology an outlier among the sciences?

The SVP's position on reproducibility is overly simplistic and often not matched by other sciences, even for observational or exploratory research in addition to structured experimentation. Biologists do not refrain from studying the behavior or ecology of critically endangered species¹²,

even though the high probability of their extinction would prevent subsequent researchers from reproducing the work. This is because it is self-evidently best to collect such data while it is available. I would be curious to see if the SVP would support an argument that data on recently extinct species, such as the thylacine or passenger pigeon, should not have been published or disseminated prior to their extinction or currently be analyzed in scientific studies, since such observations cannot be reproduced. In fact, my presentation here of a public domain photograph of thylacines demonstrating *in vivo* posture/behavior (Fig. 1) could presumably be in violation of the SVP position on not publishing non-replicable data from extinct organisms.

Figure 1. Photograph of living thylacines prior to their extinction in 1936. Such photographs now represent non-replicable data that would presumably fail to meet the standards set forth by the SVP (Smithsonian Institution Archives, 1906, Public Domain).

Furthermore, space exploration is often non-replicable in practice. If researchers studying organic compounds on Mars were to publish a paper that taphonomists within paleontology objected to, the likelihood that the group outside of a well-funded space agency could obtain the resources required to send their own probe to Mars in an attempt to reproduce the work would be near zero, the story of SpaceX notwithstanding. The question for the SVP would then be: does the National Aeronautics and Space Administration do science?

Generally, historical sciences deal with issues of irreproducibility on a regular basis. Paleontologists that study events in Earth history, such as mass extinctions, cannot witness many of the relevant phenomena, such as meteorite impacts, in a repeated manner. It is easy to brush this limitation off as irrelevant when the events occurred millions of years in the past. However, far more recent historical sciences may very well call into question the SVP's myopic view of reproducibility. In 2005, Hurricane Katrina was measured to have maximum wind speeds over 170 miles per hour, according to the National Hurricane Center of the National Oceanic and

Atmospheric Administration¹³. However, this measurement can never be reproduced. Presumably, according to the position of the SVP, their published report would fail to meet the standard of professional science.

Within paleontology, destructive analysis is inherently not reproducible, for example, when sampling a fossil with heterogeneous chemistry. While a fossil bone can have its dimensions repeatedly measured, barring any wear or damage from repeated handling, the very act of destructive analysis excludes the precise reproduction of a result. Once a sample is destructively analyzed it cannot be analyzed again, even in some cases where the same method is to be used. For example, the same sample cannot be run through pyrolysis-gas chromatography twice due to irreversible pyrolytic decomposition of molecules during analysis¹⁴.

Replication in paleontology occurs at a slow rate

While other sciences can often attempt to replicate a published study within logistically feasible timeframes, paleontological data collection occurs very slowly. A chemist may be able to quickly repeat a published experimental protocol in a laboratory, a biologist might be able to observe the behavior of animal populations during a field excursion or in captivity with high confidence of encountering an abundant species, and psychologists can easily offer undergraduates extra credit for participation in much-needed experimental replication attempts.

However, if a fossil exhibiting novel characteristics is lost for one reason or another, it may take many years before a similar specimen is uncovered during fieldwork. This reality is understandably frustrating to paleontologists. Ultimately, though, this process is not significantly different from other forms of scientific replication, just over far longer periods of time. Distress arising from this hindrance can be mitigated through humility on our part. Science is an interpersonal and intergenerational pursuit. While it might be vexing for an individual researcher to never encounter additional specimens of interest, science impersonally marches on. Regardless of whether paleontological conclusions take one year or one century to replicate with additional specimens, the process is no different to that of other sciences in any fundamental way. The slow pace at which fossil data is collected actually encourages, rather than dissuades, prolific publication such that observations made in the lifetime of one researcher can be recorded and easily passed on to future researchers. Any paleontologist who has cited the work of early scientists such as Darwin, Huxley, Cope, Marsh, Owen, Cuvier, or Agassiz, rather than going through the effort of reexamining all surviving specimens described in those early publications, understands the benefit of having a written record on hand when performing science in the present.

Triangulation is better than mere replication

Ultimately, replication alone is not the goal if one wishes to reach conclusions that are highly supported. Independent validation or ‘triangulation’ of conclusions using multiple methods is often more powerful than simply replicating a single method. Repeating the same analysis or using the same methods can help us judge whether the previous execution of those methods was successful and can help us assess variability in the sampled population of data or the precision of the method. However, replication alone does not ensure the accuracy of the conclusion if the method used is inappropriate for the question at hand – a point I have previously made with respect to conclusions about molecular preservation in fossils¹⁵. Munafò and Smith¹⁶ of the University of Bristol Medical Research Council’s Integrative Epidemiology Unit state:

“These efforts [to replicate results] are laudable, but insufficient. If a study is skewed and replications recapitulate that approach, findings will be consistently incorrect or biased... replication alone will get us only so far. In some cases, routine replication might actually make matters worse. Consistent findings could take on the status of confirmed truths, when they actually reflect failings in study design, methods or analytical tools. We believe that an essential protection against flawed ideas is triangulation. This is the strategic use of multiple approaches to address one question. Each approach has its own unrelated assumptions, strengths and weaknesses. Results that agree across different methodologies are less likely to be artefacts” (p. 399-401)¹⁶.

In paleontology, triangulation of conclusions without necessarily requiring reexamination of a particular fossil specimen can take different forms beyond examining similar fossil specimens: previously published data can be subjected to different statistical analyses, mathematical modelling/simulation can be performed, modern analogues can be studied, etc. When independent lines of evidence are consistent with a single conclusion, the conclusion is far better supported than if a single methodology were simply to be repeated.

The ‘black or white’ fallacy

In addition to the consideration of replication versus triangulation, other epistemological considerations exist in relation to the SVP policy. The SVP publication policy actively excludes certain datapoints (i.e., specimens) from formal discussion in the scientific literature. Prohibiting certain forms of data encourages dichotomous thinking (i.e., evidence either does or does not exist), when scientific models (i.e., our current best understanding of the universe) are better described with degrees of evidence (e.g., weak evidence is by definition different than no evidence). Deductive Popperian falsification is an extremely powerful tool, particularly in an experimental context. Still, observational studies, such as fossil collecting, often invoke inductive reasoning with degrees of uncertainty (e.g., calculating biodiversity trends through time based on the sampled fossil record) in line with the ultimate aim of science – to induce universal laws from our observations and experiments¹⁷.

For example, if the question of interest is what the maximum length of *Stegosaurus* tail spikes was, the measurements and photographs of *Stegosaurus longispinus* spikes destroyed from a burst pipe in the 1920’s^{8,9} do not now represent a complete absence of evidence. However, this surviving evidence is clearly not as strong or reliable as it would be if the fossils had survived. The criticism of ‘black or white’ fallacious thinking is analogous to recent criticisms of *p*-values¹⁸, which often fool researchers into declaring that a given effect is either present or absent, and I have previously explored this topic in relation to evidence for sexual dimorphism in the fossil record¹⁹.

Conclusions less easily replicated are weaker than those that can easily be. Stronger conclusions are often expected to be more frequently cited and built upon with ensuing research. This predicted advantage of stronger conclusions over weaker ones means that selection mechanisms already exist in professional science in favor of replicable conclusions, rendering SVP policy unnecessary. External goods that derive from high quality science (i.e., benefits beyond the ability to successfully uncover truths about the universe) include job offers, tenure, funding, and prestige¹⁷. Why should a professional scientific society add red tape to the publication process that can only hinder scientific progress, when positive incentives already exist to encourage well-supported scientific conclusions, which in part depend on openness, accessibility, and reproducibility?

There is a simple, non-bureaucratic solution for dealing with scientific conclusions that cannot be reproduced or data that cannot be accessed – one can simply place less confidence in those conclusions. The history of science is predominantly one of abandoned hypotheses and continually outdated models of our universe (e.g., cold-blooded, tail-dragging dinosaurs), so the SVP cannot effectively argue a case for keeping the scientific literature pure from muddled conclusions. Hypothesis testing involves trial and error, and the SVP publication policy appears to halt the process at the former, possibly out of fear of the latter. I would urge the SVP to let science evolve naturally and select against weaker hypotheses without introducing top-down institutional bias.

When ‘open secrets’ exist in our community of specimens with the potential to inform on active and lively scientific debates that have been examined firsthand by multiple established researchers, have prolific images available online, or even have entire documentaries produced on them, banning data and descriptions of such specimens from the literature based on technicalities of ownership status does more than simply slow the progress of an already sluggish scientific discipline. Science ultimately attempts to uncover truths about the universe through objective examination, and treating known specimens as if they do not exist is undoubtedly incompatible with this goal. Therefore, a policy that encourages what amounts to a denial or willful ignorance of reality in the academic literature is diametrically opposed to the mission of science.

Scientific misconduct in the name of reproducibility?

While I focus here on scientific epistemology, it is worth noting a potentially significant ethical issue brought about by the SVP publication policy. This ethical issue, however, is one that directly affects the production of reliable and objective scientific work, and is therefore relevant to my epistemological discussion. The ethical consideration in question is scientific misconduct, specifically data falsification.

When a researcher does not report certain results, either under the attempted justification that they are outliers or, more egregiously, if those results run counter to a preferred hypothesis, a form of scientific misconduct known as data falsification has occurred²⁰. If a researcher for a pharmaceutical company were to selectively publish results on the efficacy of a new drug such that results showing side effects were unreported, we would universally condemn this behavior. Scientific misconduct in academia is a severe and potentially career-ending offense. Why would circumstances in which paleontologists selectively report fossil data on public specimens, while completely ignoring data on known private specimens, not fall under the category of data falsification, particularly in cases where doing so helps to bolster ‘pet hypotheses’?

Beyond the professional ramifications of scientific misconduct, data falsification is, in my opinion, far more damaging to the scientific pursuit than publishing conclusions that are difficult to reproduce and therefore of lower confidence. There is no shame in being wrong in science, and acknowledging uncertainty is a sign of maturity, but purposefully biasing results is unacceptable.

Paleontology is evolving

Technological advances further render the SVP policy anachronistic. There are continuously developing means by which to record and curate high resolution primary data from fossils. For example, modern imaging methods alongside computational advances and a growing culture of ‘open science’ can drastically mitigate the loss of data if the fossil itself is lost. Ignoring this potential with outdated perspectives on publication represents a tremendous missed opportunity to advance paleontology.

Digital representations of fossils, such as from photogrammetry, white light scanning, or computed tomography, can preserve high resolution surficial and internal structural data that can then be manipulated digitally through software or reproduced physically through 3D printing. Online databases, such as Dryad or Morphobank, greatly extend long-term curation of a variety of data types and file formats. Cultural shifts in academia towards ‘open science’²¹ help to ensure free accessibility of raw data. Even the SVP president on the policy letter² recognizes the importance of open, digitally curated morphological data²². Why would digitally curated data be any less valuable coming from a private specimen?

If a fossil specimen is lost (e.g., through a museum fire), but has high resolution, securely curated, freely accessible digital data available alongside a prior publication record in the academic literature, would the SVP prohibit further publication on that data? If not, then the SVP publication policy is deeply contradictory and unjustifiable.

Do you practice what you preach?

If a specimen in a public repository is known to have been destroyed, would the SVP allow data on that specimen to be published? If so, the implication is that the SVP believes that a specimen known to have been destroyed is more accessible and capable of reproducible results than a specimen in a private repository that, crucially, still exists. Such a position is clearly false.

The alternative to publishing fossil data while it is currently available is illogical and clearly undesirable. Above, I discussed some examples of specimens in public collections that were destroyed through accidental occurrences. Perhaps one of the most famous instances of the destruction of publicly curated specimens occurred during the bombings of World War II. Scientifically important collections in Europe, such as the Bristol City Museum in the UK, were bombed and many fossils, including marine reptile material found by Mary Anning, were destroyed²³. Allied bombing of Munich led to the destruction of many fossils as well, including the famous holotype material of *Spinosaurus*²⁴. These specimens are now only survived by their recorded and published descriptions, photographs, and data, which are heavily cited and discussed by both professional scientists and the public to this day. Stromer’s 1915 publication on the holotype of *Spinosaurus*²⁵ has already been cited multiple times in 2020 alone, along with renewed interest in the destroyed material and *Spinosaurus* generally.

One cannot simultaneously hold the belief that publication on fossils later destroyed in World War II or other events was ultimately beneficial, while supporting the SVP policy; the two positions are irreconcilable. The fact that researchers continue to reference such studies empirically supports the position that publication is the best way to ensure long-term survival of fossil data. I would be shocked by and, frankly, highly skeptical of any researcher who claims to be of the opinion that modern paleontology would have been better off if such lost specimens were never published on in the first place.

Weak policies have human costs

I will end my discussion with a brief point about ethical implications of the policy more distant to the topic of scientific epistemology than the case of scientific misconduct mentioned above. Typically in this debate, these sorts of ethical topics are framed around the act of publishing on specimens unapproved by the SVP based on poorly defined criteria. However, I think far more serious ethical concerns arise when the policy is in place and invoked. Publishing data on fossil specimens does not harm people, but a mechanism for censorship and intimidation can.

I described in the previous section how there is a contradiction between the SVP as an institution and the actual behavior of its members in how they interact with publications on now inaccessible fossils (i.e., scientists engaging in the process of academic writing routinely cite papers that cannot be reproduced, and therefore are not acceptable scholarship according to the SVP policy). However, there is also a hypocrisy at the individual level. Ambiguity in poorly written policy allows for some researchers to support the SVP position and, by extension, censorship of science^{26–30}, while simultaneously assisting in the excavation of private specimens³¹ or publishing data from specimens within private institutions^{28–29,32–33} (e.g., SMA and VFSMA), even private specimens that were for sale at the time^{32–33} (e.g., a specimen previously referred to as either NHMUK R36730, NHMUK PV R36730, SMA S01, SMA RCR0603, or SMA DS0RCR-2003-02).

Ambiguity inherent in a policy makes it amenable to selective and subjective application against certain researchers or institutions. The SVP, based in the USA, should consider whether more recent paleontological collections in developing countries might lack the public funds or resources required to meet whatever their criteria happens to be. Combined with the fact that private collections have historically helped to birth long-term public collections (e.g., what is now the Denver Museum of Nature & Science³⁴), this publication policy might increase the difficulty in establishing new, responsible fossil collections around the world if their specimens are barred from the academic literature. When the development of international paleontology collections is stifled, the ability for new researchers to join an international academic community is repressed alongside a cost to scientific output itself.

Even well-intentioned policies can backfire and be used as a mechanism for bullying, especially within academia, which often suffers from a particularly malicious form known as academic mobbing³⁵. If the determination of what fossils can and cannot be studied is ultimately subjective, then there is no reason why selective application of the SVP publication policy cannot be used to intimidate, harass, or censor researchers that question fashionable hypotheses within the SVP or are personally disliked for any other reason. Has a researcher, particularly a younger, less established, and professionally vulnerable researcher, questioned a ‘pet hypothesis’ of yours? The SVP offers you a solution – simply find a referred specimen in their work and argue that the institution it is housed in fails to meet these undefined standards such that their work should be censored (i.e., rejected or retracted). This tactic is clearly not an admirable one for advancing scientific understanding. I am very worried that the poorly conceived SVP policy can be used to exacerbate a culture of cliquishness, bullying, and defamation in the paleontology community.

Conclusion

I fully understand that writing this criticism makes me vulnerable to targeting and retaliation by some of my colleagues. I would welcome reasoned arguments rather than personal attacks. Fortunately, I am not the only paleontologist calling for a policy of “publish before they perish”³⁶, although hopefully without so much overlap as to make my argument entirely unoriginal. I feel compelled to do so for the betterment of our science and our community’s culture. Furthermore, policies like these can further discourage amateurism and ‘citizen science’ that have historically been, and continue to be, vital for the progress of paleontology^{37–39}. The amateur fossil collecting community is large, and can assist academic paleontology by contributing to fossil discovery, curation, or study. In a time of global populist movements and broad skepticism of institutions, the SVP is not in a position of strength if scientists and the broader public alike begin to question the guidance and efficacy of large, established academic societies.

We should encourage openness and not further hinder an often data-starved science. Publication of fossil data while it is available is always the best option for the long-term functioning of science, since there is no harm from published claims that cannot be fully reproduced other than weakening the conclusions made by the original authors. In contrast, if a fossil is currently accessible but is ultimately lost before it can be studied, then an opportunity to add to collective human knowledge is missed and science is impeded. The history of my own alma mater, Princeton University, provides an important reminder of how even a nearly century-old museum that housed scientifically important specimens within a world-leading academic institution can be undone with the push of an administrative pen⁴⁰.

Recent events have brought the need for reform of the SVP to the forefront. After three decades of study, scientific publication (~50 papers by one estimate), and sharing of casts with museums across the world, the large, highly complete, and scientifically significant *Tyrannosaurus rex* specimen named ‘Stan’ was unfortunately sold at auction by the Black Hills Institute to an anonymous bidder⁴¹. ‘Stan’ has been privately owned since its discovery. If the specimen does indeed become inaccessible, the SVP’s position would presumably be that science would currently be better off had none of these studies or castings ever been carried out and shared with other researchers, since the study and publication on privately owned fossils is considered to be harmful to science. The term unscientific barely begins to describe such a preference. A commonly given excuse that scientific publications help drive up the price of specimens is one lacking evidence and, likely, totally out of touch with reality. I suspect it is highly unlikely that a non-scientist of extreme wealth was prompted to spend \$31.8 million dollars on a fossil because of numerous academic publications on the specimen. It is doubtful that the buyer judged the monetary value of the fossil after perusing “The paranasal air sinuses of predatory and armored dinosaurs (Archosauria: Theropoda and Ankylosauria) and their contribution to cephalic structure”⁴² and other studies of the specimen. It is far more likely that such a person is simply drawn to the idea of purchasing a giant, carnivorous dinosaur skeleton of the most famous species. Unsupported claims cannot continue to drive the SVP policy about dissemination of scientific data, and we must draft policies that actually promote science.

“Information about vertebrate fossils and their accompanying data should be disseminated expeditiously” – the SVP Member Bylaws⁴³, 2009, Article 12, Section 5.

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