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COMMENT

Comment on the letter of the Society of Vertebrate Paleontology (SVP) dated April 21, 2020 regarding "Fossils from conflict zones and reproducibility of fossil-based scientific data": the importance of private collections

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Motivation for this comment

The Society of Vertebrate Paleontology (SVP) has recently circulated a letter, dated 21st April, 2020, to more than 300 palaeontological journals, signed by the President, Vice President and a former President of the society (Rayfield et al. 2020). In this letter, significant changes to the common practices in palaeontology are requested. In our present, multi-authored comment, we aim to demonstrate why these suggestions will not lead to improvement of both practice and ethics of palaeontological research, but conversely, will hamper its development. Despite our disagreement with the contents of the SVP letter, we appreciate the initiative and the opportunity to discuss scientific practices and the underlying ethics. Here, we consider different aspects of the suggestions of the SVP in which we see weaknesses and dangers. Our aim was to collect views from many different fields. The scientific world is, and should be, a pluralistic endeavour. This contribution deals with the aspects concerning amateur palaeontologists/citizen scientists/private collectors. Reference is made to Haug et al. (2020a) for another comment on aspects concerning Myanmar amber.

First of all, we reject the notion implied by the SVP letter that studying and describing specimens from private collections represent an unethical behaviour. The question whether privately owned specimens should be considered in scientific studies is a purely scientific question (as long as the specimens were legally obtained by their owner), and thus should be answered on the basis of the scientific problems and merits of such actions.

Amateur palaeontologists/citizen scientists/private collectors

The statements in the letter of the Society of Vertebrate Paleontology (SVP) in our view shed a rather negative light on amateur palaeontologists/private collectors/citizen scientists, especially by noting that "fossils outside of the public domain, such as those in private collections and privately-operated for-profit museums that are not managed within the public trust as permanent institutions, do not meet […] essential standards" (Rayfield et al. 2020: p. 2).

In our opinion, this statement is highly problematic. Amateur palaeontologists, or more generally, amateur scientists, contribute to science in an essential way augmenting

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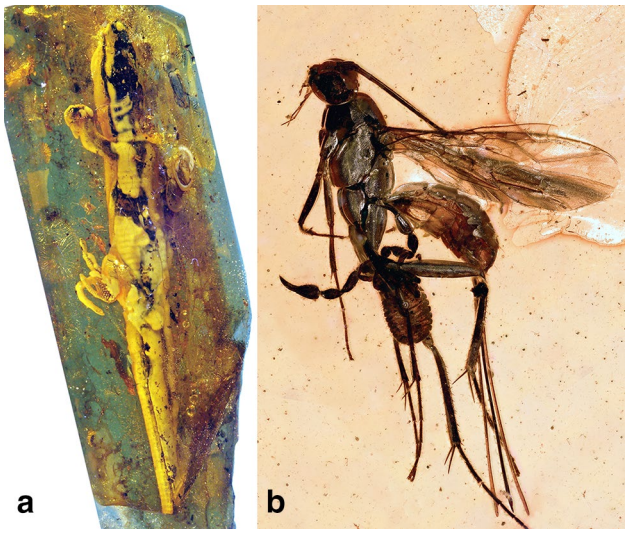

Fig. 1 Numerous unique fossil specimens and type material were at the time of the first scientific description in private ownership and came only into public collections after the death of the private collectors. **a** The iconic 'Königsberg amber lizard' *Succinilacerta succinea* (Boulenger, 1917) [specimen length ~ 4.2 cm] from the private amber collection of Richard Klebs (1850–1911). First described by George Albert Boulenger in 1917 and purchased by the Prussian State and the former Königsberg Albertus University in Königsberg in 1926; today, the holotype is deposited in the Göttingen Geoscience collections (GZG.BST.15000; see Reich 2008b). **b** This intriguing piece of Baltic amber with a male pseudoscorpion (*Oligochernes bachofeni* Beier, 1937) latched onto an ichneumonid wasp [specimens length ~ 9.3 mm] comes from the private collection of Adolf Freiherr Bachofen von Echt (1864–1946). It shows one of the first fossil examples of a phoretic relationship between pseudoscorpions and insects and was figured in numerous textbooks and other works. A large part of the Bachofen-Echt amber collection was purchased by the State of Bavaria in 1958, and the specimen is today part of the Munich Palaeontology collections (SNSB-BSPG 1958 VIII 195; see Reich and Wörheide 2018)

professionals. In palaeontology, they provide material (Fig. 1) and crucial information on many different groups, for example:

- *Sharks:* René Kindlimann, in Klug and Bolliger 2012; Mollen et al. 2012; Kriwet et al. 2015; Pollerspöck et al. 2018; Jambura et al. 2018, 2019; Bracher et al. 2019; Stumpf et al. 2019; Slater et al. 2020;
- *Ray-finned fishes:* Menzel et al. 1982 (see Lehmann 2003); Tischlinger and Arratia 2013; Ebert 2019;
- *Plesiosaurs:* Sachs et al. 2013;
- *Mosasaurs:* Mulder et al. 2013;
- *Turtles, dinosaurs and dinosaur tracks:* Ballerstedt 1921, 1922; Wiffen 1991; Lindgren et al. 2008 (see Hornung and Reich 2007); Rauhut et al. 2012; Field et al. 2020;
- *Mammals:* Micklich 2001; Martin et al. 2005; Mol et al. 2006; Reumer et al. 2018;
- *Carboniferous vertebrates:* Stan Wood, in Fraser et al. 2018; Smithson and Rolfe 2018;
- *Echinoderms:* Rievers 1961 (see Dehm 1961); Hess 1975; Kutscher 1978; Jagt 1999, 2000a, 2000b, 2000c, 2000d; Kutscher and Villier 2003 (see Reich 2001); Hess and Messing 2011 (see Etter 2018); Thuy et al. 2012, 2018; Jagt et al. 2014, 2018; Gale et al. 2018;
- *Cephalopods:* Mundlos 1973 (see Hagdorn 1988); Kaplan et al. 1987; Hewitt and Jagt 1999; Dietze and Hostettler 2016; Jagt and Jagt-Yazykova 2019; Jenny et al. 2019; Košťák et al. 2019;
- *Molluscs in general:* Van Eldijk et al. 2019;
- *Arachnids and myriapods:* Bachofen-Echt 1934, 1942 (see Reich et al. 2019); Selden and Shear 1996; Bartel et al. 2015;
- *Trilobites:* Krueger 1972, 2004;
- *Crustaceans:* Bachmayer and Mundlos 1968; Hyžný and Hudáčková 2012; Van Bakel et al. 2012; Hyžný et al. 2014a, b; Audo et al. 2014, 2017; Haug et al. 2015; Fraaije et al. 2015, 2019; Nagler et al. 2016; Haug and Haug 2016a, 2017; Charbonnier et al. 2017; Keupp and Mahlow 2017; Charbonnier and Audo 2020; Joe Collins, in Donovan and Mellish 2020; Jakobsen et al. 2020; Pazinato et al. 2020;
- *Insects:* Kutscher 1999; Kutscher and Koteja 2000 (see Bechly and Wichard 2008; Reich 2008a; Dlussky and Rasnitsyn 2010); Hoffeins 2001; Hoffeins and Hoffeins 2003; Hörnig et al. 2014; Gröhn 2015; Van Eldijk et al. 2017; Haug et al. 2018, 2020b; Fowler 2019; Kirejtshuk 2020; Makarkin and Gröhn 2020;
- *Sponges:* Rhebergen and von Hacht 2000; Rhebergen and Botting 2014;
- *General faunal assemblages:* Ade 1989; Shabica and Hay 1997;
- *Ferns:* Reumer et al. 2020;
- *Plants in general:* Robert Noll, in Lausberg et al. 2003; Uhl et al. 2004; Rößler and Noll 2006, 2010; Kerp et al. 2007a, b; Knoll 2010; Rößler et al. 2012, 2014; Tavares et al. 2014; Neregato et al. 2015; Gröhn and Kobbert 2017; Van der Ham et al. 2017; Feng et al. 2019; Kelber 2019;
- *Foraminiferans:* Franke 1912, 1925, 1928 (see Schroeder 1991);
- *Ichnofossils:* Donovan et al. 2019.

The support of amateur or citizen scientists is particularly relevant in research fields in which there are either not sufficient numbers of professional scientists due to the decreasing number of palaeontologists in official institutions (museums, universities, geological surveys, etc.) in many countries or insufficient resources for conducting fieldwork or for obtaining scientifically important specimens. Different palaeontological societies even recognise outstanding achievements in palaeontology by amateurs with awards, e.g. the 'Harrell L. Strimple Award' of the *Paleontological Society*, the 'Mary Anning Award' of *The Palaeontological Association*, the 'Prix Saporta' of the *Association Paléontologique*

Française, the 'Karl-Alfred-von-Zittel-Medaille' of the *Paläontologische Gesellschaft*, or the 'Amanz Gressly-Preis' of the *Schweizerische Paläontologische Gesellschaft*, just to name a few. An example from a field with important impact of amateur palaeontologists is palaeoentomology. Amateur palaeontologists and palaeoentomologists have always played an important role in the field of palaeoentomology; the discipline was largely founded by enthusiasts and collectors (Zherikhin et al. 2008; Szwedo and Sontag 2015; Beck and Joger 2018). The same is true for the study of fossil decapod crustaceans or fishes, which very often relies on the material collected by amateurs or are even described by them.

Citizen science programmes engaging the public in authentic research is widely championed for its potential to strengthen the understanding of the participants of science, environmental learning and critical thinking skills (Carlson and Fox 2012; Lynch et al. 2018). Amateur and citizen scientists are able to perform both long-term studies (at the same site, or a number of localities) and fossil rescue excavations (e.g. at construction sites or road works or when colliery tips are removed, e.g. see Austen 2001) as well as time-consuming fossil-picking or fossil concentrations for which official institutions are often not able to provide time or financial resources. Thanks to amateur work under rules of the Portable Antiquities Scheme, nearly 1.5 million archaeological objects from UK were found, identified and data-based (House of Lords 2006, https://finds.org.uk/). A recent, widely recognised example (e.g. by the BBC, Science, The Washington Post) comes from the field of insect ecology in which a massive decline of flying insect biomass over the last 27 years was documented with the aid of a team of amateur scientists (Hallmann et al. 2017, 2020). Another important example is the international "MECO Project" (Mediterranean Elasmobranch Citizen Observations), for which variable numbers of citizen scientists provide information for scientific studies (e.g. Jambura et al. in review). Since many years, a team of enthusiastic citizen scientists, guided by Angelika Leipner from the natural history department of the Museum am Schölerberg in Osnabrück (Germany), collects material in the well-known Piesberg quarry. A few years ago, they found a new lake deposit that has yielded several meso- and xerophyllous plants and an accompanying fauna that are normally not preserved in Pennsylvanian basinal coal-bearing strata. Important specimens have been deposited in the museum collection in Osnabrück, where palaeontologists have full access to the material. There is a steady exchange between collectors, museum curators and palaeontologists.

These are just a few of many examples in which amateur and citizen scientists contribute important work to scientific studies (see i.a. "Fossilfinder—Österreich forscht", "Citizen Science—myFossil", "Fossil Atmospheres Project"; Fossilfinder 2020, myFossil 2020; FAP 2020). Joint knowledge, specimens and collections, efforts and activities of amateurs and institution-based professionals are more than the sum of their parts. Answers to diverse biological, environmental, and societal questions at the global scale, across eons of time, and spanning vast diversity across the Tree of Life is the main goal of the global community of museums (the 'Global Museum') joined together through emerging digital resources (Bakker et al. 2020). In many countries (e.g. Austria, Belgium, Czech Republic, Denmark, France, Germany, Italy, Lebanon, The Netherlands, Poland, Russia, Slovenia, Spain, Switzerland, UK; see Haug and Haug 2016b; Ouden and Pouwer 2018; Rauhut 2018; Furrer 2019; Fossiel.net Team 2020; ÖPG 2020; PalGes 2020), including the USA (MacFadden et al. 2016), the role of amateur palaeontologists in science has historically grown over many decades, to the point that it has proven crucial for advancing scientific knowledge, not least due to the declining number of professional palaeontologists employed by universities or public museums. In addition, it should not be forgotten that numerous former private collections form the basis of important palaeontological museums in Germany (Fig. 2), such as in Berlin (collection of Ernst Friedrich von Schlotheim; see Dietrich 1960, Hoppe 2001), Frankfurt/M. (collections of Johann Christian Senckenberg and Eduard Rüppell; see Struve 1967), and Munich (collection of Count Georg zu Münster; see Reich and Wörheide 2018).

We have to acknowledge the following realities:

1. It will always be impossible for professional palaeontologists to regularly survey all outcrops to secure all potentially important specimens.
2. It will never be possible to save all fossils and store them securely. This applies to plants, vertebrates, non-vertebrates and other organismic remains.
3. Potentially scientifically important specimens are lost every day, be it by erosion, by construction or quarry works.
4. The number of employed palaeontologists will never reach a level where all fossil groups can be described appropriately.

This being said, amateur or citizen palaeontologists do fill some of these gaps and it is beneficial for palaeontology to let them continue doing so:

1. They regularly survey fossiliferous outcrops.
2. They provide storage space for fossils (temporary or permanent).
3. They rescue many fossils from erosion or other destruction.

4. Upon tolerant and open-minded behaviour of professional palaeontologists, they often happily inform about their discoveries and in many cases make them available to science.

The cases where the material gets destroyed, is stored without important information, or where the citizen palaeontologists keep their discoveries secret are likely almost negligible compared to those where our science actually profits from their activities. Mary Anning is possibly one of the most shining examples supporting this point. By contrast, the SVP letter will most likely have a negative impact on collaborations with amateur or citizen palaeontologists, as they might feel offended by its statements and be disinclined to cooperate in the future; additionally, it might put off young people just discovering palaeontology via amateur collecting (see also Liston 2016 on the symposium "Fossillegal" on ethics in palaeontology at the annual meeting of the European Association of Vertebrate Palaeontologists (EAVP) in 2016). We also would like to note that many (or most) professional palaeontologists have started as amateur palaeontologists, usually during their childhood; hence, the SVP letter potentially reduces the number of future professional palaeontologists. It actually unintentionally patronises this peer group, which is important for our field.

Availability of specimens

The SVP letter recommends that editors should add the following to their 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 organisations to repositories

Fig. 2 Historically, numerous private collections form the basis of the palaeontology collections of our larger natural history museums—for example, in Berlin and Munich: **a** The holotype (MB.E 85) of the German 'Muschelkalk' crinoid *Chelocrinus schlotheimi* (Quenstedt, 1835) [specimen length ~ 5.5 cm] from the former private collection of Ernst Friedrich von Schlotheim (1764–1832) at the Berlin Naturkundemuseum was first part of other older private collections (Michael Reinhold Rosinus in Hann. Münden, 1687–1725; Johann Heinrich Grätzel in Göttingen 1691–1770), but is one of the oldest specimens in the Berlin collections. **b** Echinoid spines from the classic Triassic Cassian beds of the Dolomites [paperboard width ~ 12 cm] were part of the former famous private collection of Count Georg zu Münster (1776–1844), which provided the historical basis for the foundation of the Munich Palaeontology museum (SNSB-BSPG AS o. Nr.; see Reich and Wörheide 2018)

generally are not sufficient to ensure long-term access to fossils or reproducibility of results" (Rayfield et al. 2020: p. 2). This shows general concerns over the availability of specimens held in private collections and is indeed an important issue on which all authors agree. The deposition of a specimen in a publicly accessible collection is, of course, seen as the ideal scenario, but it should be noted that private collectors are in most cases willing either to donate their specimens to such institutions or sell them to institutions at a price often far below the market level. In Denmark, the national government has introduced a special scheme, by the name of 'Danekræ', which urges amateur collectors (even foreigners, see Hald 1993), to submit their palaeontological finds to a special committee to be evaluated (see Jakobsen 1991; Bonde et al. 2008). If deemed important as national heritage, the specimens are then bought from the collectors and placed in a public collection. In the Netherlands, museums that hold the so-called ANBI status, can buy (parts of) properly registered collections from private collectors, after obtaining assessment reports by external experts, by offering these collectors tax deductions for a period of 5 or 10 years.

Other solutions are also possible, for example, official recognition (via registration) of a scientifically very important specimen. The specimen itself can then stay in a private collection but still remains available to science. An example of such a registered find is the Altmühl (11th) specimen of the famous fossil bird *Archaeopteryx* (Foth et al. 2014), which is registered as no. 07901 in the "Datenbank geschützter Kulturgüter" after § 6 Absatz 1 Nr. 2–4 KGSG (Kulturgutschutzgesetz). The same procedure was performed with the Schamhaupten (12th) specimen of *Archaeopteryx* (DNWK 02924; Rauhut et al. 2018) and the single specimen of the theropod dinosaur *Sciurumimus albersdoerferi* (DNWK 02922; Rauhut et al. 2012) (Fig. 3).

Even if none of the above options can be implemented, we consider it to be more problematic for science to ignore fossils deliberately just because they are not stored in a publicly accessible collection managed within the public trust than to include them in analyses, despite the fact that their final repository cannot be secured at that particular moment (e.g. Rauhut et al. 2014; Rauhut 2018). Not everything can be stored in a publicly accessible collection, e.g. many ichnofossils of larger vertebrates (tracks and trackways) of which normally casts are made or photogrammetry (structure from motion) is undertaken; the fossils themselves are left to erosion or mining (see also recent discussion in Lucas and Harris 2020). Additionally, there are several types of data in different fields of the natural sciences related to palaeontology that can generally not be deposited in museum collections:

Behavioural data: data acquired in behavioural studies are generally recorded as ethograms. Neither the observed specimens nor parts thereof are usually deposited.

Biomonitoring data: organisms captured for biomonitoring studies are in many cases not stored long-term. Specimens killed, for example, in traps or by fogging are counted and studied systematically, but afterwards disposed of. Organisms captured and measured alive are released again. It is a moot point whether deadly viruses should be retained following eradication in the population.

Destructive/invasive methods: for several types of analyses, the specimen analysed is destroyed or transformed during the analysis. A prominent example of such analyses is the serial sectioning of fossils (e.g. studies of Erik Jarvik on the sarcopterygian *Eusthenopteron foordi*; e.g. Jarvik 1942, 1954) or serial grinding to reconstruct their three-dimensional appearance if no other imaging methods are possible (e.g. fossils from the Herefordshire Lagerstätte: Siveter et al. 2020; rudist bivalves or cephalopods to see internal structures: Pascual-Cebrian et al. 2013; Tajika et al. 2020). Such a destruction or highly invasive treatment of fossils is widely accepted in the community, the only remaining data being images. This leads to the paradoxical situation: we accept that, following photography, a fossil could be systematically destroyed and still be published, but could not be stored in a private collection according to the requirement in the SVP letter.

If a specimen cannot be secured for further research, at least proper documentation through 2D/3D photographs, X-ray computed tomography scans or other imaging methods will rescue data that can be used by scientists, regardless of the fact that the specimen involved is kept in a private collection with limited or no access or is destroyed. This is very similar to the increasing attitude of museums not providing real specimens on loan anymore, but instead providing virtual specimens for study, which can then be investigated by researchers worldwide without visiting the collections physically. As a consequence, the database involves not just the fossil specimens themselves, but also all images or other forms of data recorded from them, in contrast to the statement in the SVP letter (Rayfield et al. 2020: p. 2).

The International Code of Zoological Nomenclature (which also applies to fossils) does not require that the type specimen is deposited for the formal erection of species (ICZN 1999, Article 72.5.6; 73.1.4). This rule has specifically been added for not endangering rare extant species, but may well be expanded to include also rare fossils. The International Code of Nomenclature for algae, fungi, and plants strongly *recommends* that holotypes are deposited in a public collection; however, this is no formal requirement for a species erection (Turland et al. 2018, Recommendation 7A.1). The SVP letter does not cite the ICZN, which states that types "are to be held in trust for science by the persons

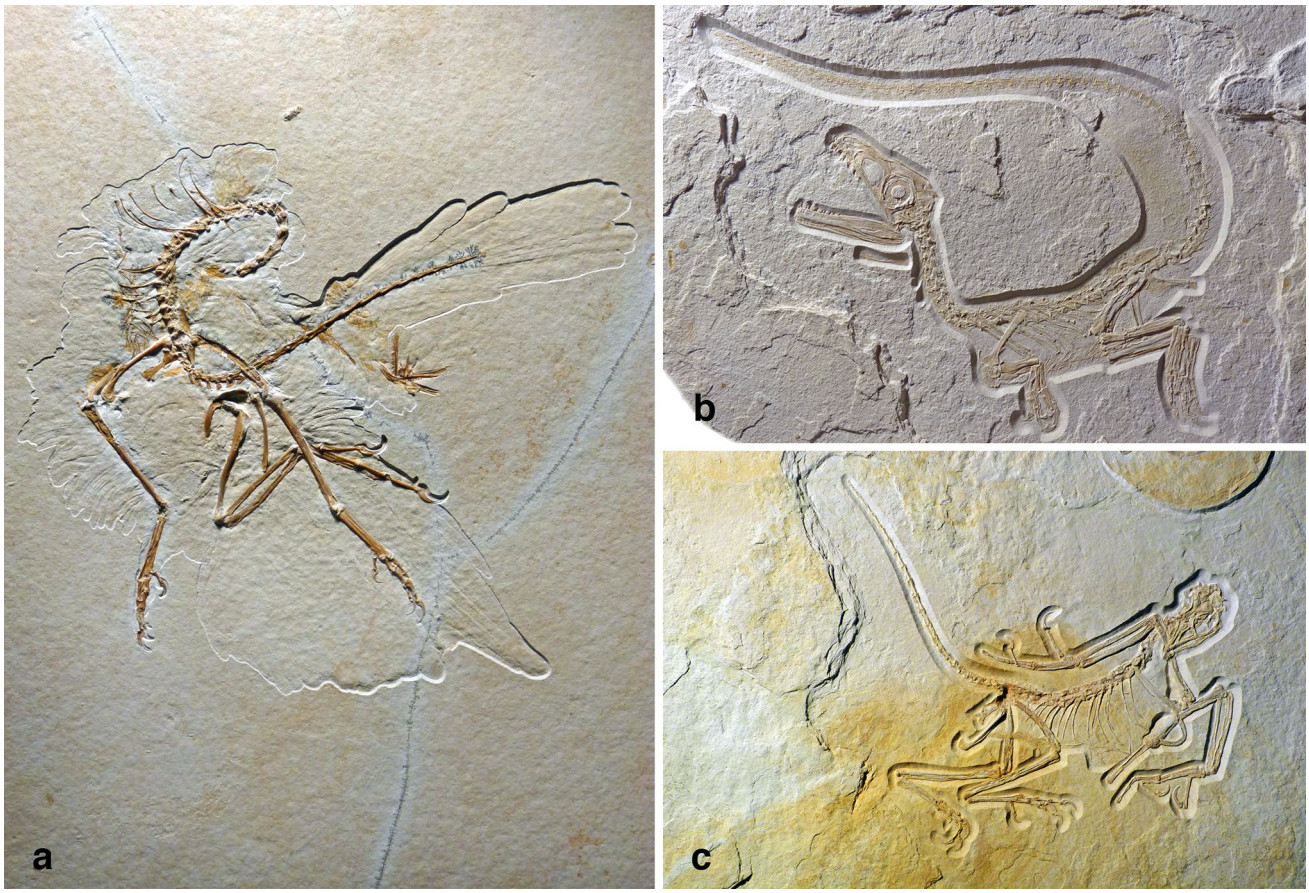

Fig. 3 Several unique and scientifically very important fossils still remain in private collections, but were officially registered in the 'Datenbank geschützter Kulturgüter' (*database of protected cultural property*) in Germany—for example, several iconic vertebrate fossils from the Upper Jurassic Plattenkalk deposits of Bavaria: **a, c** The 11th (a) and 12th (c) skeletal specimens of the 'Urvogel' *Archaeopteryx* (from Eichstätt and Schamhaupten, respectively) [slab widths ~ 37 and ~ 40 cm]. **b** The juvenile specimen of the theropod dinosaur *Sciurumimus albersdoerferi* from Painten [slab width ~ 40 cm]

responsible for their safe keeping" (ICZN 2000, Article 72.10). The demand of the SVP letter to deposit fossils in a "stable repository within the public trust" begs the question what requirements such repositories should have. Many private collections or museums are well curated, well sorted and accessible to researchers (some prominent examples: the collection of Dr. Gordon Hubbell, Florida, one of the largest collections of fossil sharks and rays in the world, see Perez et al. 2020; the enormous collection of Baltic amber inclusions of Christel and Hans-Werner Hoffeins, Hamburg, which has been a major engine for our improved understanding of the Eocene fauna and climate, see von Tschirnhaus and Hoffeins 2009; the Sauriermuseum Aathal in Switzerland founded by Hans-Jakob Siber, see Siber and Möckli 2009; the Oertijdmuseum Boxtel in the Netherlands founded by the Fraaije family; the Urweltmuseum Hauff in Holzmaden, Germany, founded in 1936, see Lindgren et al. 2018, Jenny et al. 2019). This is not necessarily true of many public repositories, which are indeed "managed within the public trust". In Germany, Austria and probably in many other countries, university collections, which also hold type material, are uncurated, endangered or already lost because resources (curators, space) were reallocated in the course of current abandonment of specimen-based research in academia. Due to severe shortage of staff (and sometimes adequate storage facilities), appropriate curation is often not guaranteed. Many specimens are, in fact, lost to research, either because they cannot be found anymore, are inaccessible in an overcrowded store, were lost/destroyed (e.g. in different European museums in WWII, or during or in the aftermath of many modern wars such as those in Iraq, Afghanistan or Syria; in the worst case, almost the entire collection is lost as during the fire in the Museu Nacional da Universidade Federal do Rio de Janeiro in 2018), have degraded from neglect, or are contained in displays inaccessible for scientific investigation.

In some cases, the deposition of specimens in public collections was detrimental as the specimens were sold off

subsequently at fossil fairs by the institution concerned. In the case of the San Diego Natural History Museum, which wanted to sell several historical specimens of the Sternberg collection in an auction in 2013, the protests of many colleagues led the museum to withdraw the specimens from the auction (Switek 2013). Another example is the large collection of the well-known French palaeobotanist Charles René Zeiller (1847–1915), former president of the *Societé botanique de France* and the *Societé géologique de France*, which was originally kept in the *École Nationale Supérieure des Mines de Paris*. This collection contained many type specimens, but in the 1980s, the host institute was no longer interested and it was moved to the University of Lyon-Villeurbanne. However, it soon appeared that important type specimens were missing. Rumour has it that they were sold at a fair soon after Zeiller passed away. Unfortunately, the situation in the new host institute was not ideal. In the mid-1990s, several specimens appeared to be broken and parts of the same specimens were kept in different cabinets, partly even under different locality designations. The material was not labelled properly and holotypes were not marked. The new host institute did not have the humanpower and expertise to maintain this collection; it even did not have copies of the monographs in which the material was described. Without the material then kept in private collections, it would not have been possible to correlate a common type of Early Permian foliage with a specific fructification and to assign the reconstructed plant to the group Peltaspermales (Kerp 1982, 1988). Meanwhile, it is generally accepted that this group, which was traditionally regarded as typically Mesozoic, was much more common in the upper Palaeozoic. An inventory of the Rotliegend floras from the Saar-Nahe Basin (Kerp and Fichter 1985) would have been impossible without the help of many private collectors, e.g. Arnulf and Harald Stapf from Nierstein (Germany). Therefore, we vehemently disagree that the deposition of a specimen in a public collection automatically secures its availability for future research and that specimens in private collections are generally deemed inaccessible.

Another query concerning these issues comes to mind: What are the requirements for a "stable repository within the public trust" as requested in the SVP letter? Does it have to be funded by governmental institutions (in full, or partially), or may it also be privately financed? Can it be a regional/municipal museum funded by a province, a city or a smaller community? In general, the ICOM Code of Ethics for Museums (ICOM 2017) and the ICOM Code of Ethics for Natural History Museums (ICOM 2013) do not distinguish between museums in public/governmental and private properties. As long as a museum accepts and complies with the ICOM Code of Ethics, any private museum including private collections is de facto regarded as a stable, permanent and accessible repository for published fossil material. To provide some numbers: in Bavaria, there are more than 1300 museums and officially recognised collections (also including art-historical, ethnological and other collections with some palaeontological specimens) in total. More than 1200 of these institutions are entirely not or not exclusively owned by the state (so-called "nichtstaatliche Museen"; Landesstelle für die nichtstaatlichen Museen in Bayern 2020). Hence, the vast majority of the collections are not (or not exclusively) under the control of the Bavarian state. This also applies to a larger part of all museums and institutions with palaeontological collections (> 200) in Germany (cf. Jansen and Steininger 2002). Furthermore, several large museums like the American Museum of Natural History in New York or the Field Museum in Chicago are not in state hands, but are owned by private trusts. Another example is the Museo Paleontológico Egidio Feruglio in Trelew, Argentina. The museum was founded by a private foundation in collaboration with the city of Trelew, and has now become a research institution recognised by CONICET (Consejo Nacional de Investigaciones Científicas y Tecnícas) and the official fossil repository of the province of Chubut. In the USA and UK, an increasing number of art galleries are completely privately run (see Ellis 2008; Brown 2017), as are also several palaeontological museums (e.g. Wyoming Dinosaur Museum). There is an administrative continuum between fully state-owned and -managed institutions and entirely private institutions, with a large "grey area" with many intermediate states including growing mixed funding, in which private donors are playing significant roles.

Also, is it necessary to have an accreditation for such repositories? If yes, which organisation should take care of that? It becomes clear that it is not trivial to decide which types of repositories fall into the category "stable repository within the public trust". It depends on local circumstances and procedures, if any. It will remain impossible in many respects to store all the materials of these—in the broadest sense—private museums in state-controlled institutions. By contrast, the diversity of ownerships and funding bodies actually increases the likelihood that, in the long run, at least some of these collections survive, taking the volatility of politics and economies into account.

Fewer restrictions may lead to better collaboration between professional and amateur palaeontologists: the Netherlands as an example

Unlike archaeological remains that are protected by the Valletta Treaty (also known as the Malta Convention), and living biota (fauna, flora and habitats), which is protected by national and European legislation, fossil remains are not legally protected in the Netherlands. It is not forbidden to

collect them or to possess them as a private person. The result of this situation is a relatively large number of private collectors. The vast majority of them is happily collaborating with scientists at universities and natural history museums. Quite a few 'amateurs' are engaged as voluntary curators. When new taxa are being described, the type specimens that they collected and kept in their possession are transferred to public collections, but most of the other material remains in their care. Often the collectors have made testaments regulating the eventual transfer of their collection to a museum after their death. Museums can make various legal arrangements to facilitate such bequests in advance.

Four major sources of fossil material attract special interest from private collectors: (1) glacial erratics ('geschiebe') originating from the Scandinavian/Baltic region (material dating from the Ordovician to the Cretaceous); (2) the Middle Triassic of the Winterswijk quarry (Muschelkalk, Anisian, c. 247 Ma); (3) the Late Cretaceous of the type Maastrichtian near Maastricht (c. 70–66 Ma); and (4) Cenozoic vertebrates from the North Sea Basin (some Miocene, and mostly Pleistocene; Fig. 4). Some examples are here given:

Ad (1). The find in a sand quarry near the German border of a small enigmatic fossil by an amateur collector that was donated to the museum Natura Docet/Wonderryck Twente (NDWT, Denekamp) led to the discovery of about a dozen similar fossils from a discrete area spanning the Dutch–German border in several private collections. The fossils were identified as leaf imprints of an Early Jurassic fern (*Clathropteris meniscioides*) originating from source sediments in southern Sweden, and transported to the Netherlands by the Eridanos river system (Reumer et al. 2020). Some, but not all, of the specimens will be donated to NDWT or to the University Museum in Bremen, Germany. These specimens of *Clathropteris* were the first ever discovered in the Netherlands, and the help of amateur collectors was indispensable in tracking them.

Ad (2). A micritic limestone of Anisian age has been commercially quarried in an open pit mine near Winterswijk, eastern Netherlands, since the 1930s. An amateur discovered fossil bones of marine reptiles and ichnofossils (foot prints) during the 1960s, and ever since a flourishing group of amateur collectors has been actively searching for fossils. Many of them have amassed important collections. So far, three ichnofossil taxa, five marine reptile species, three crustaceans and one fish species have been discovered that were new to science, and subsequently described. The type specimens of these were donated to public repositories. Some recent examples are the skull of *Nothosaurus winkelhorsti* (named after the amateur collector Herman Winkelhorst; Klein and Albers 2009), *Palatodonta bleekeri* (named after the amateur collector Remco Bleeker; Neenan et al. 2013), *Pararcus diepenbroeki* (named after the amateur collector Gerben Diepenbroek; Klein and Scheyer 2014), and the cyclid crustacean *Halicyne oosterinkorum* (named after the late collector Henk Oosterink and his family; Schweitzer et al. 2019). Recently, a new marine isopod species was found by Mr. Winkelhorst, donated from his collection to the Naturalis Biodiversity Center, and described as the new taxon *Gelrincola winterswijkensis* (Schädel et al. 2020). It can be stated without exaggeration that most of our knowledge about the Middle Triassic of the western Germanic Basin is based on material collected by amateurs. They wholeheartedly made and make their collections available for study to scientists from the universities in Bonn (Germany) and Utrecht (The Netherlands), and Naturalis Biodiversity Center (Leiden, The Netherlands).

Ad (3). A private collector discovered a large mosasaur at the huge ENCI quarry near Maastricht, where Cretaceous limestone was excavated until two years ago. The specimen was taken to the Natural History Museum Maastricht, and turned out to be a new species of mosasaur. It was formally described as *Prognathodon saturator* in 2002 in an article with the finder as first author (Dortangs et al. 2002). Much of the material from the Maastrichtian is discovered, collected, prepared and studied by amateur collectors, without whom our knowledge of the type Maastrichtian would be much less detailed.

Ad (4). In the Netherlands, being situated on the edge of the North Sea Basin, many fossil vertebrates are being found in its mostly sandy sediments. Famous sources were traditionally the sand and gravel pits along the major rivers (Rhine and Meuse), the large estuaries in the southwestern province of Zeeland, and the bottom of the North Sea. Large sand supplements to the (eroding) coast and for constructing extensions of the Rotterdam Port (the so-called Maasvlakte 1 and Maasvlakte 2) are more recent sources of an abundance of fossil vertebrates, mostly (but not necessarily) originating from the Late Pleistocene fauna of the Mammoth Steppe. Nearly all fossils from the Maasvlakte and other localities were collected by amateurs and kept in their collections. Here again, most of these collections are made available for scientific research (e.g. the specimens of the Barbary monkey *Macaca sylvanus*, see Reumer et al. 2018; Fig. 4). A by now famous fossil, found on board a fishing vessel by a private collector and donated to the Natural History Museum in Rotterdam, is the (so far) only Late Pleistocene sabretooth cat *Homotherium latidens* (Reumer et al. 2003). Here again, our knowledge of the northwest European late Cenozoic largely depends on the effort and collections of citizen scientists.

To sum up, it can be noted that palaeontology in the Netherlands owes a great debt to the effort of amateur collectors and citizen scientists. Their collections are an indispensable source of material. The absence of legal protection for fossils makes it easy for them to collect,

Fig. 4 The Netherlands is one example of a country with a strong tradition of fruitful collaborations between private collectors and professional palaeontologists, leading to important scientific discoveries such as specimens of the Barbary monkey *Macaca sylvanus* (Linnaeus, 1758) from Maasvlakte 2, Rotterdam, The Netherlands (Pleistocene; see Reumer et al. 2018). **a–d** Left upper canine tooth (C sup. sin.) found by and in the collection of Mr. Henk Houtgraaf, Papendrecht (The Netherlands), inv. nr. HHO-0420. **a** Buccal view. **b** Anterior (mesial) view. **c** Lingual view. **d** Posterior (distal) view. **e–h** Right mandibular fragment with the lower third molar (M3 dex.) preserved, found by Mr. Cock van den Berg, collection of the Natural History Museum Rotterdam, inv. nr. 999100010537. **e** Anterior (mesial) view. **f** Occlusal view. **g** Buccal view. **h** Lingual view. Photographs were taken by Susann Döring and arranged by Evelin Haase (Senckenberg Research Station of Quaternary Palaeontology Weimar, Germany)

prepare, share, and publish their material. We should also keep in mind that amateurs often have more time and sometimes even more money to pursue their avocation than do professional palaeontologists who are tied to responsibilities and budgets and ever decreasing storage capacity.

Conclusions

All in all, the situation is far more complex than presented in the SVP letter. Therefore, we recommend that the editors of palaeontological journals should postpone the implementation of the requested changes formulated in that particular letter because we believe that the issues raised in the letter should first lead to a discussion in the whole palaeontological community, including all its subdisciplines, with a worldwide participation before appropriate ethical standards

for scientific journals are verbalized. Such a discussion is essential, because requests formulated by only one part of the palaeontological community, in a seemingly rushed manner, will have serious consequences for research far beyond their own particular subfield or their regional scientific community; indeed, it seems as if these consequences have apparently not been evaluated thoroughly by the authors of the SVP letter. If palaeontological practice is to be reformed, such reforms should be broadly supported and not unilaterally imposed. Moreover, the recommendations of the SVP would doubtlessly drive a valuable community of active amateur researchers/citizen scientists into isolation and eventually obliteration. Thereby, our research field would lose parts of its most important peer group, rich sources of material and data, as well as sources of young academics. Instead, we recommend fostering the diversity in our science on all levels, i.e. from gender via ethnical groups to modes of repository, material sources, and educational background of non-professional collaborators.

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