Journal of Natural Science Collections

ISSN 2053-1133 Volume 8 | 2021

NatSCA
Natural Sciences Collections Association

The Natural Sciences Collections Association

The Natural Sciences Collections Association (NatSCA) is a UK based membership organisation and charity (No. 1186918) which is run by volunteers elected from the membership.

NatSCA's mission is to promote and support natural science collections, the institutions that house them and the people that work with them, in order to improve collections care, understanding, accessibility and enjoyment for all.

More information about NatSCA can be found online at: **natsca.org**

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Journal of Natural Science Collections

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The *Journal of Natural Science Collections* is a place for those working with these collections to share projects and ways of working that will benefit the museum community. The Journal represents all areas of work with natural science collections, and includes articles about best practice and latest research across disciplines, including conservation, curatorial methods, learning, exhibitions, and outreach. Articles in the Journal should be relevant and accessible to all of our diverse membership. Submissions are peer reviewed, resulting in high quality articles.

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Editorial Board

Front cover image: A springhare, *Pedetes capensis* Forster, 1778, from the collections at University Museum of Zoology, Cambridge (UMZC E.1441). © *University of Cambridge.*

Editorial

Jan Freedman

Welcome to Volume 8 of the *Journal of Natural Science Collections*. It has been an extremely difficult year for many of us. I am extremely grateful to all the authors in this Volume firstly for their patience with the review process, and secondly to have spent time producing such high quality work, despite being in the middle of a global pandemic. I also have to thank the Editorial Board for all their work ensuring the articles are expertly peer reviewed: Rob Huxley, Paolo Viscardi, Bethany Palumbo, Lucie Mascord, Donna Young, and Matthew Parkes. A special thank you to Lucie, who spend an enormous amount of time supporting and organised peer reviewers and checks for all the articles in the Conservation Conference section of this Volume. Thank you to the many reviewers for their valuable time and constructive comments on all the articles, despite the difficulties of furlough and in some instances, illness.

Sadly Matthew Parkes passed away unexpectedly late last year. He was an invaluable member of the Editorial Board, working on the review process for many articles over the last several years, including one paper in this Volume. His kindness, knowledge, good humour, and support will be missed dearly.

This volume can be divided into two sections: papers from the highly successful Conservation Conference held at the Oxford University Museum of Natural History in 2018, and collections papers. sections. The first section focuses on several articles from the Conservation Conference . First, **Larkin, Dey and Hutchinson** describe the intricate work involved in mounting the almost complete specimen of a fragile pliosaur for display. **van Gaver** outlines the intricate process involved in the conservation of an Aldabra giant tortoise specimen, and the positive public engagement outcomes as a result of the work. An interesting paper by **Ferreira** looks at the key issues involved with conserving bound books. Finally, **Royce and Baars** examine the several varying conservation issues that minerals have in our collections, and identify a method for assessing these types of collections.

The next section focuses on a wide range of collections topics, including conservation, colonialism, and collections in general. **Holloway and Bakaloudis** look at the damage caused by another species of Anthrenus, *A. flavipes* LeConte, 1854, with useful images comparing it to the more familiar *A. verbasci*. The next paper by **Ashby and Machin** examine in detail the shocking colonial violence that is linked to natural history collections, focusing on two specimens that have been popular with the general public. **Jackson and Sellers** provide a detailed overview and history of the Edenhall Collection at the Tullie House Museum and Art Gallery, focusing on a sporting family's collection of bird and mammal taxidermy. Finally, **Freedman and Gelsthorpe** introduce a recently 'rediscovered' collection of an island Pleistocene mammal from the collections at the Manchester Museum, with a brief overview of the species.

This Volume is full of practical articles, as well as collections related articles that may challenge how you look at your own specimens.

View from the Chair

I was honoured to be elected Chair for NatSCA at our virtual AGM in May 2020. It's been a challenging but important first nine months to be serving in this role, as we navigate a global pandemic. NatSCA's trustees have faced a spectrum of difficulties during this time that will have been shared by many of our members, from furlough to illness to increased caring responsibilities. Despite this we have pulled together, adapted how we work and continued to deliver. A lot of what we have learned we hope to take forward to the benefit of our organisation and community in the future – from virtual committee meetings which save travel costs, time and emissions, to virtual events with increased accessibility and reach.

Of course the pandemic is not the only global challenge we face. NatSCA are committed to working with our community to explore how natural science collections can help address urgent issues such as climate and ecological crisis, and the need for decolonising practice. As part of this work we were very grateful to all of our speakers at our 'Decolonising natural science collections' virtual conference in November 2020, which pulled in content from our cancelled May event. The conference had our highest ever attendance figures, with many new members joining us. Miranda Lowe and Subhadra Das delivered an important keynote speech, updating their landmark paper 'Nature Read in Black and White' published by NatSCA in 2018 and accessed over 5,000 times. We are now preparing for our May 2021 conference which will focus on environmental breakdown. A special thanks to Donna Young, Glenn Roadley, Jack Ashby and David Gelsthorpe for all their work on these conferences, supported by many of our wider team.

In addition to our annual conference Lucie Mascord, our Conservation Representative, with the support of NatSCA's much valued Conservation Sub-committee delivered our first ever Twitter conference in January 2021. This was a fantastic opportunity to learn from natural science conservation experts in the UK, Ireland, Switzerland, Estonia and Argentina.

It has been wonderful to see the regular digital content provided by our blog lead Jen Gallichan, with thanks also to Lily Nadine Wilks for her help as part of the Digital Digest team. Thanks also to our Journal Editor Jan Freedman for all his hard working pulling together this volume, and to our Editorial Board including external member Rob Huxley. We are extremely sad to have lost much valued Editorial Board member Matthew Parkes who passed away in October, and would like to recognise his enormous contribution to the collections community.

'Behind the scenes' the NatSCA trustees have been working to complete our transition to Charitable Incorporated Organisation status – Treasurer Holly Morgenroth has recently found a solution to difficulties obtaining a suitable new bank account during the pandemic. Our 'Bill Pettit Memorial Award' of up to £3,000 to support natural science collection projects closed 26th February 2021 and we're looking forward to reviewing the applications. David Gelsthorpe who leads delivery of this grant stream has published a list of previously funded projects on our website to help future applicants. Our membership secretary Clare Brown has been streamlining our membership processes. We have also continued to represent natural science collections on the steering group of the Subject Specialist Network Consortium, and with national sector bodies.

Finally, we had a range of insightful and helpful responses to our 'User Survey 2020'. Thank you to everyone who contributed to this. The committee have been analysing the results to inform our 2020-23 strategic plan which we hope to share over the next few months.

On behalf of NatSCA I would like to recognise my predecessor as Chair, Paolo Viscardi, for his leadership and dedication over an impressive seven years serving in this role. Paolo will be remaining on committee to continue to lend his experience. A special recognition also for our previous Membership Secretary, Maggie Reilly, who stepped down at our May AGM after many years' incredible work for NatSCA. I would also like to thank our Secretary Yvette Harvey who has dealt admirably with the increased workload brought about by monthly instead of three-monthly trustee meetings, and to welcome Bethany Palumbo who joined as a trustee in 2020 and Kirsty Lloyd who returned from maternity leave in February. Justine Aw has been a fantastic support for our technical operations.

Finally and most importantly, thank you to all of our members and wider community for your fantastic contributions, interest and support for NatSCA over the past year. We look forward to seeing you, virtually at least, in the year ahead.

Mounting the type specimen of *Pliosaurus carpenteri* Benson *et al.*, 2013, an 8m-long fossil pliosaur skeleton, including the 3D-printed 1.8m-long replica of the skull for Bristol Museum & Art Gallery

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Received: 28th Jan 2020

Accepted: 18th June 2020

Citation: Larkin, N. R., Dey, S., and Hutchinson, D. 2021. Mounting the type specimen of *Pliosaurus carpenteri* Benson *et al.,* 2013, an 8m-long fossil pliosaur skeleton, including the 3D-printed 1.8m-long replica of the skull for Bristol Museum & Art Gallery. *Journal of Natural Science Collections.* **8.** pp.3-12.

Abstract

The type specimen of *Pliosaurus carpenteri* Benson *et al*., 2013 from Westbury in Wiltshire, UK, is the most complete skeleton known of this extinct species, with an estimated body length of 8m. The skeleton was mounted for a temporary display at Bristol Museum & Art Gallery in 2017 for the first time since it was excavated in 1994. The fossilised skull is 1.8 m long, very heavy and consists of many very fragile pieces. Mounting the real skull in position would have required a large amount of unsightly supporting metalwork that also would have obscured some very interesting pathology on the palate inside the mouth. One option was to CT scan the individual pieces of the skull and use the subsequent digital models to 3D-print replicas. This method of making a lighter replica skull would present less risk to the specimen than traditional moulding and casting and would be quicker, cheaper and safer for the duration of the exhibition. Importantly, the process would also provide detailed 3D morphological data of the skull's internal anatomy for the first time, which would be invaluable to ongoing research. The pieces of the 3D-printed skull were mounted with internal steel armature and painted to match the real specimen. However, there are many ethical and practical issues to consider when replacing missing bones with replicas, including: making clear to the public what is real and what is not; and using appropriately stable and tested materials where possible.

Keywords: pliosaur, skeleton, display, mounting, CT scanning, 3D printing.

Introduction

The work described below was undertaken for an 8-month temporary family-orientated exhibition 'Pliosaurus! face to face with a Jurassic beast' displayed at Bristol Museum & Art Gallery (BMAG) from 17th June 2017 to the extended date of 18th February 2018. The skeleton (BRSMG Cd6172) that formed a centrepiece of the exhibition is the 'type specimen' of *Pliosaurus carpenteri* Benson *et al.,* 2013, a large pliosaur (marine reptile) skeleton that was found in Lower Kimmeridge Clay sediments at Westbury in Wiltshire in 1994 by Simon Carpenter who donated the material to Bristol Museum (Sassoon *et al*., 2010; Sassoon *et* *al*., 2012). The specimen is significant not just because it represents a new species, but because it is one of the most complete specimens of its kind known. It is also huge, about 8 m long (Figure 1) with a skull that is nearly 2 m long. Elements preserved include approximately half of the vertebrae, part of the gastralia, fewer than half of the ribs, a selection of phalanges and one shoulder girdle. The taxonomically important areas - the skull and mandible - are complete and many large teeth were found with the skeleton. Other more fragmentary elements of Cd6172 remained in store and did not go on display.

Accompanying the mounted skeleton on display were other fossils including marine reptiles and invertebrate fossils from the Southwest of the UK, showing visitors how fossils are preserved, collected, curated and interpreted. The exhibition included skulls of modern animals (a crocodile, a gharial, a false killer whale and a tiger shark), highlighting how diet affects the shape of teeth, and there was also information about the discovery of the pliosaur skeleton and its excavation.

A life sized, fleshed-out reconstruction of *P. carpenteri* was commissioned for the exhibition from model maker Tony Hitchcock (Figure 2). The model incorporated features and pathologies (based on evidence from the fossil) that were designed to show the specimen as a living individual. The model had moving eyes that tracked visitors as they walked close to her head; a reptilian heartbeat; halitosis; a flipper pathology (complete with pus); and a low rumble when visitors got too close. To generate interest in the project and to give a sense of ownership to the people of Bristol (as the specimen was found less than 30 miles from the museum), members of the public were asked to help choose a name for the specimen. A shortlist of names was drawn up by museum staff for the public to vote on: Brizo (a Greek goddess that was a protector of mariners, sailors and fishermen); Doris (a sea nymph from Greek mythology); Chompy; and Pip. Doris was chosen by the public and the specimen was often referred to as '#DeadlyDoris' on social media and in museum displays, and advertising literature.

The exhibition was divided into three main sections: 'Back to the Jurassic' where visitors were invited to step back in time to Jurassic Bristol; 'Meet the Beast' where visitors came face to face with the life sized reconstruction of Doris and

Figure 1. The fossil skeleton (BRSMG Cd6172) of Pliosaurus carpenteri *Benson* et al.*, 2013 laid out next to Roger Vaughan (1948-2015), the conservator (later curator) who prepared the fossil at BMAG in the back hall at BMAG. Note: only elements composing one limb are preserved - although this is fairly complete – and about half of the vertebrae and fewer than half of the ribs. The taxonomically important areas - the skull and mandible - are complete. Image © Bristol Museum & Art Gallery.*

Figure 2. Visitors appreciating the ability to get up close and personal with the life size fleshed-out model of Pliosaurus carpenteri *Benson* et al.*, 2013 (also known as 'Doris') by model maker Tony Hitchcock. Image credit: NRL.*

were encouraged to investigate her story hands-on; and 'Scintillating Science' where visitors could see the real skeleton on display and learn about Doris and the science behind her story through a series of interactive stations. This included learning about her many pathologies, investigating colour in the fossil record, what was on the menu for Doris and who she was sharing her Jurassic marine world with. Visitors were finally signposted to other areas of the museum and further afield where they could see more fossil material and develop skills and interest. The exhibition attracted over 76,000 visitors.

Materials and methods

Designing the pose and the fossil mount

At the start of the project the conservator and museum staff studied all the bones and teeth of the skeleton in the museum stores to work out the various ways they might be mounted and how the whole skeleton might be displayed in terms of its pose. A structured light scanner was used to record the three dimensional morphology of every bone. From this data a low resolution 3D digital model of each bone was created, and an anatomically accurate virtual skeleton assembled with the support of museum designer Simon Fenn and the palaeontologist Dr Judyth Sassoon, who had originally described the fossil material. This enabled all involved in the project to visualise how the bones of the specimen articulated together, what the different poses would look like on display and, crucially, how much space it would take up (Figure 3). The skeleton is only partially complete and it would have been possible to take more detailed scans of some bones (through CT scanning or photogrammetry) and mirror the data to 3D print missing elements, such as making a complete right forelimb based on the data captured from the complete left forelimb and/or mirroring ribs to make up replicas of some of the missing ones. However, it was decided to keep the specimen as original as possible. This work would have also added substantially to the cost of the project.

Mounting the postcranial material

BMAG created various detailed CAD plans of the skeleton and a method of safely mounting the skeleton was devised by the project's conservator. The steel armature would have to support over 100 kg of fossil bones to millimetre precision, constructed in a fashion that would allow easy assembly and dis-assembly as the mounting work would be undertaken in an offsite conservation studio in Shropshire and the mount and the fossil would need to be transported back to Bristol in sections.

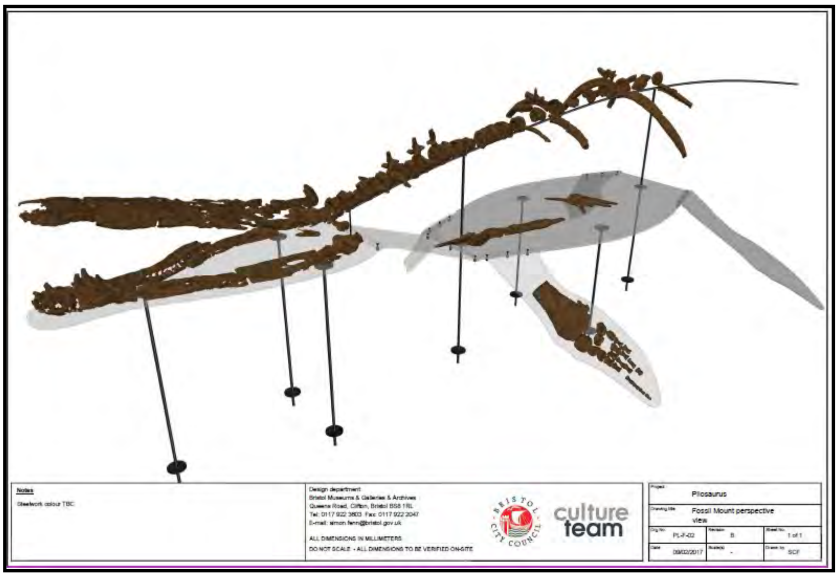

Figure 3. The detailed design using the 3D digital models made from data captured by the structured light scanner scans of the bones, articulated in discussion with the palaeontologist Dr Judyth Sassoon. Image © Bristol Museum & Art Gallery.

A sturdy base (488cm x 122cm) was made for the armature using four sheets of 30 mm thick MDF. These were arranged in two pairs, with several 45mm batons separating the sheets in each pair, screwed together after all the MDF had been sealed with two coats of clear Dacrylate® varnish. Adjustable feet were added to the underside of the base, as the gallery floor of the temporary exhibition space in Bristol was known to be slightly uneven.

The main metal armature (8m long and 2.5m high) required to support all the bones in articulation was made from steel tubes and flat steel strips that were heated and bent to shape according to the CAD drawings and the morphology of the bones. The armature was MIG welded together (Figure 4). The armature had to be made in sections not only so that it could be dismantled and transported to Bristol within a Luton van but so that it could be carried into the exhibition space through the various doors and corridors. The vertebrae of the spine and the various small ribs, gastralia and limb bones were held in place with rods and/or strips of brass shaped to the outline of the bones (Figure 5) and brazed to one another (brazing joins two metals by soldering with an alloy of copper and zinc at a high temperature). Where required, the metalwork was lined with black inert Plastazote® foam (thickness 2mm and 5mm, depending on the weight of the bone) to protect the bones from the metal. The armature for the postcranial material was supported by two upright steel tubes cut to the appropriate height. A floor plate was welded near one end of each which would sit on top of the wooden base but the end of the pole would insert through a hole drilled right through the base, under which it would be secured with nuts and large spring washers (threaded bar had been inserted into the lower end of the tube and welded in place).

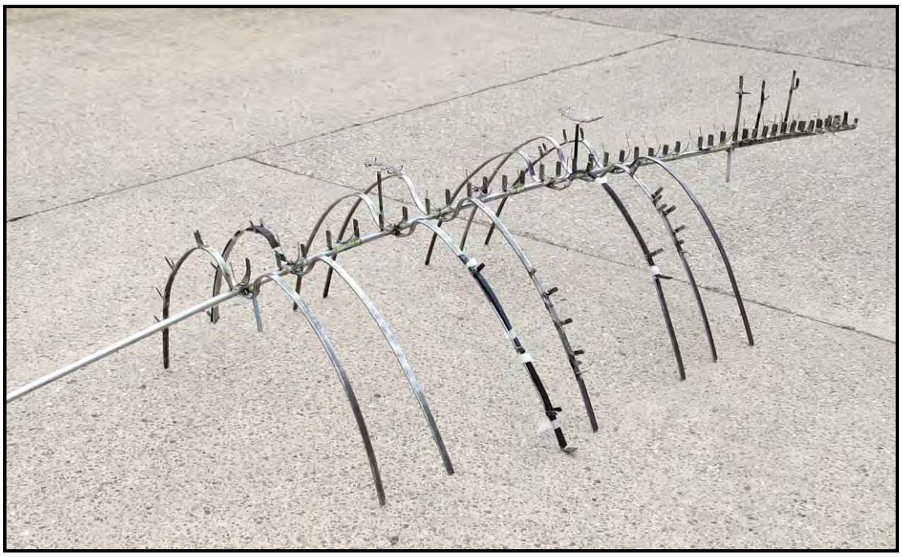

Figure 4. The steel frame made to hold the larger ribs and vertebrae in place, not yet positioned on the upright supports.
Image credit: NRL.

Figure 5. Brass strips and rods brazed together to hold smaller ribs in place. Image credit: NRL.

The main sheet of Perspex that had been cut in the outline of the fleshed-out body was held in place in a horizontal aspect by more floor plates that were welded to each of the main uprights at the appropriate height. As the four sheets of Perspex indicating the size and shape of the fleshed-out limbs (Figure 3) were to be securely attached to this main sheet of Perspex that represented the body (using nuts and bolts through pre-drilled holes), further upright supports were needed to hold the horizontal Perspex in place so that it did not sag with the extra weight. These supports and the Perspex sheets themselves added extra rigidity to the whole structure. The gastralia bones were simply laid on the Perspex of the body outline. The composite limb bones were located on a steep slope so brass rods brazed to the brass armature that held the bones in association were inserted through the Perspex through small holes drilled in place (Figure 6). All the metalwork was painted a dark grey colour to the specification of the designer before the black Plastazote® foam was adhered in place as required with double-sided tape.

Mounting the skull and mandible

The skull and mandible of any skeleton are always important. Not only are they usually the most significant part of the animal in terms of identifying the species, but they are the elements people most want to see on display, especially when it is a large predator with large teeth (Figure 7). The skull and mandible of this pliosaur skeleton are particularly well preserved. Both are almost totally complete although dorso-ventrally compressed. There is interesting pathology on the palate of the skull and in the jaw where elements were fractured in life

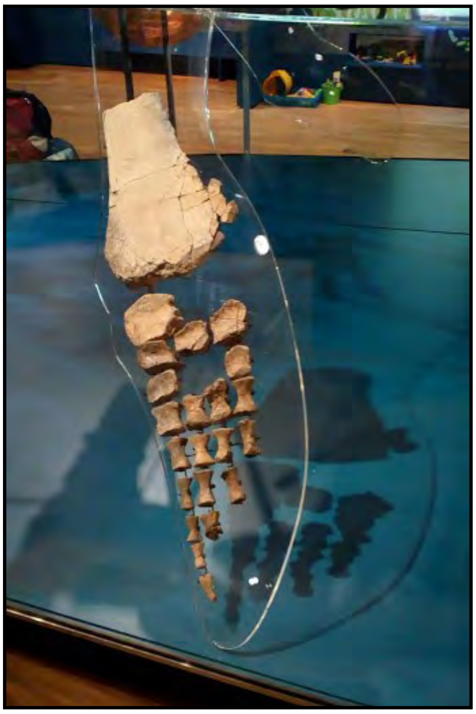

Figure 6. The bones of the composite forelimb held in place with the brass armature on Perspex shaped to the size of the fleshed-out limb. Image credit: NRL.

then healed, plus evidence of overbite tooth depressions from misalignment of the jaw (Sassoon *et al.*, 2010) and a flipper pathology. However, the skull was excavated in about 20 pieces, is about 1.8m long and weighs over 25kg. To have mounted this original material would have required a large amount of intrusive supporting metalwork which would have obscured the interesting pathology, and also have been a risk to the specimen while on display for a significant length of time. Therefore, suitable methods of replicating the skull were explored so that a replica skull with replica teeth could be mounted and articulated with the real mandible and the rest of the skeleton, with the interesting pathology visible for visitors to examine more easily.

A replica skull could have been made by carefully moulding the individual pieces of the original skull to make resin casts but this would not have been without risk. Many of the original skull fragments are quite thin and fragile. They could have been broken during the moulding process. Also, making moulds of a specimen can be invasive due to the consolidants, rubber, water soluble putty and other products that have to be used in the process, so the material can end up adulterated (Goodwin and Chaney, 1994). An alternative solution was to

Figure 7. Three of the large teeth of BRSMG Cd6172 with a (large male) hand for scale. Image credit: NRL

either 3D scan the bones using photogrammetry or to CT scan the bones, then build detailed 3D digital models from either set of data and 3D print the bones in a suitable medium. CT scanning would require the bones to be taken to a suitable facility, involving road transport and therefore some risk to the material. Photogrammetry could have been undertaken on site with less risk involved. However, the bones had to undergo road transport anyway to get to the conservation facility in Shropshire where the mounting was to take place, so suitable sturdy protective bespoke packaging had already been manufactured by the conservator. Despite being such an important specimen, the skull had not yet been CT scanned and therefore CT scanning the skull for this project would provide current and future researchers with an accurate morphological model and data about the internal structure of the specimen for the first time: a lasting legacy for science from the project. For similar reasons, although the mandible did not need to be scanned for replication purposes it was decided that this would be CT scanned at the same time as the skull as there would be no extra cost for scanning this in the same session.

Therefore, both the skull and the mandible were taken to the Royal Veterinary College, London. To minimise any risks involved in the process a risk assessment was undertaken and as a result the project conservator packed and unpacked the bones, transported them carefully and handled them throughout the CT scanning session. It is possible that CT scanning may damage some DNA in museum specimens (Grieshaber *et al*., 2008), especially if a specimen is scanned multiple times, although some studies have found this is not the case (Hall *et al*., 2015) and specimens as old as the pliosaur are unlikely to have any DNA within them to damage. Nonetheless, specimen exposure to CT scanning should be minimized - such as scanning it just the once in this case - and all such procedures should be recorded in the museum's specimen database.

A GE LightSpeedPro 16 CT scanner was used to scan the bones at 100 kV and 10 mA in 1.25mm slices (Figure 8). The scan resolution could have been finer but because the material was so dense and there was so much of it, had it been scanned at a higher resolution the scanner would apparently have overheated. However, this resolution still gave superb results partly because there is no matrix on the bones at all and the resolution of the eventual 3D print was more than adequate for display and research purposes.

The output of the CT scans were TIFF image files of large sets of x-ray cross-sectional images through the various skull fragments and mandible. 3D printers require digital 3D mesh surface models as input so the first digital preparation job was

Figure 8. CT scanning the anteriormost tip of the pliosaur skull (BRSMG Cd6172) at the Royal Veterinary College London. Image credit: NRL.

to extract the outer surface from these 2D CT images and convert them into appropriate digital models (Figure 9). The software used to do this conversion was 3DSlicer (version 4). 3DSlicer is an open source CT application designed for human clinical uses but also suitable for animal bone and fossil specimen scans.

Once the 3D surface models were extracted, they were converted into 3D print ready closed hull digital models. The software used in this process was Blender version 2.6, which is a multi-purpose 3D mesh modelling and animation application. The skull fragments were to be reconstructed into a whole skull so to assist in this process some holes were digitally created through the sides of many of the fragments for the insertion of steel supports later. This was done using a Boolean operation to remove cylinders of material from the internal structure. Doing this digitally allowed for accurate placement of these internal structures ensuring they went through the thickest parts of the skull walls and avoiding thinner structures and holes like the teeth sockets. This was not possible on every fragment, however, as some parts were very thin. The 3D printer being used to recreate the bones was an industrial colour jet gypsum 3D printer. Although the replica skull bones could have been 3D printed in full colour it was decided to 3D print them in a base colour and paint the replica skull by hand after it had been assembled on its armature to ensure a good and consistent match with the real material. The 3D print volume in this printer was limited to 38cm x 25cm x 20cm but fortunately all the fragments except one fitted into this volume. The only exception needed to be partially split on a corner and reconnected once 3D printed.

The 20-plus 3D printed pieces of skull (Figure 10) were articulated by adhering the smaller pieces together with Jesmonite acrylic resin which bonds well to the gypsum, and using the lengthwise holes through the thicker pieces for two long thin steel rods that held them all in articulation together. The thinner pieces had channels cut into them with a mixture of angle grinders, chisels and scalpels, in which the steel rods could sit. Any gaps left from this process were filled with Jesmonite acrylic resin bulked out with hollow plastic microspheres to lessen the weight and to make the filler more easily carved and worked. The 3D-printed gypsum was then painted to match the real bone of the skull with artists' acrylic paints (Figures 11, 12 and 13).

The skull itself was quite dorso-ventrally flattened but some of the teeth (preserved separately from the skull during burial) were robust and were not

Figure 9. The high-resolution 3D digital model of the skull and mandible of BRSMG Cd6172 generated from the CT scans. Image credit: SD.

Figure 10. All the pieces of the pliosaur skull freshly 3D printed in gypsum at ThinkSee3D (with a single replica tooth placed temporarily in a socket). Image credit: SD.

significantly crushed. These had to be replicated and then the roots of the replicas trimmed so that they could be inserted into the empty tooth sockets of the flattened skull to recreate tooth placement as in life. Because of the way different aspects of the project were funded, and because of timing issues, the teeth were replicated by moulding them and making casts. They are very robust so were unlikely to be damaged during the process, unlike some pieces of the skull, and they were first protected by a reversible layer of consolidant (Paraloid B72 in acetone at 5%). The silicone rubber used for moulding the teeth was Silastic 3481 base cured with 81F catalyst and the replicas were cast in Jesmonite AC100 acrylic resin with woven glass fibre matting then painted to match the original material with artists' acrylic paints. They were adhered in the sockets of the skull with Jesmonite acrylic resin. Extra copies of the teeth, without the rods trimmed off, were made for display purposes and handling sessions.

The heavy, real, sections of the robust mandible were held together with Plastazote®-lined bespoke metal brackets. These were made by heating and bending strips of steel to the shape of the mandible when it was positioned in articulation upside-down, cooling-down the metal first each time before offering it up to the bone to check the shape. The pieces of the mount were welded together away from the fossil material and then the fit was checked. The mandible in its bracket was positioned on the horizontal piece of Perspex shaped to the size of the fleshed-out skull. The painted 3D skull model was mounted above this, with a large enough gap so that all the teeth could be appreciated and the palate seen, but stability of the structure was not compromised. It was held in place with a single upright steel tube within the mouth and two small-steel rods at the rear.

Discussion and conclusions

Aimed at families with children aged 3 to11 years old, the exhibition focused on Bristol Museum's spectacular 8-metre-long holotype fossil *Pliosaurus carpenteri*. Using an imaginative family focused approach, the exhibition took visitors on a journey that brought Doris the pliosaur 'back to life' and engaged them with the history and science behind her story.

CT scanning has been used for decades to image human anatomy. More recently, the technology has aided anatomical descriptions in zoology and palaeontology (Porro *et al.,* 2015) by enabling the digital preparation of small or fragile specimens (Butler *et al.*, 2010), the visualization of internal anatomy (Lautenschlager *et al.*, 2012), and the capture of morphology for shape and biomechanical analysis (Porro *et al.*, 2013). Only recently have the benefits of CT scanning for conservation, exhibitions and education begun to be explored. CT scanning combined with 3D printing, although expensive on a large scale, can be a powerful tool for museums and educators in natural history (Tembe and Siddiqui, 2014). CT data may be used to produce 3D models and animations, such as cut

Figure 11. The 1m long painted 3D printed skull positioned above the real fossil mandible, lying on a Perspex sheet, on display. Image © Bristol Museum & Art Gallery.

Figure 12. The mounted partial skeleton of the 8m-long fossil pliosaur skeleton (BRSMG Cd6172) with the Perspex sheets indicating the 'flesh outline' of the animal. The specimen was displayed behind Perspex panels. Image © Bristol Museum & Art Gallery.

-away sequences, which may be incorporated into museum exhibits and educational settings and provides increased access to rare or delicate material without increasing risk to these specimens (Kuzminsky and Gardiner, 2012; Tembe and Siddiqui, 2014).

However, there are many ethical and practical issues to consider when mixing 3D printed models or other replicas with real specimens. Firstly, the public should be aware of what is replicated and what is real either immediately and obviously as in the case of the Quagga skeleton recently remounted at the Grant Museum of Zoology (Figure 13) whose missing bones were replicated in a matt black colour to differentiate them from the real bones (Larkin and Porro, 2016), or by noting it within the display text or labels as was the case with the display of Cd6172 discussed in this paper. Also, freshly 3D printed materials and resins used for casting can 'off-gas' which could affect nearby specimens. Ideally, the stability and likely longevity of all the materials used would be known but very few 3D printing materials have been tested and the results published. White nylon 3D printed models may "yellow" over time due to oxidation (Martyn Carter and Richard Beckett, University College London, pers. comm.) but most have been in use for such a short time that little is known about their stability. Therefore, the authors are actively testing the stability and longevity of the most commonly used 3D printing materials with colleagues including Gabrielle Flexer in Wiltshire through undertaking Oddy tests (Robinet and Thickett, 2003). In the meantime, when 3D printing replicas for use in museum displays our preferred material is gypsum using water based inks. This is surely the least problematic 3D printing material for long term use in museums as there is a long history of gypsum being used in museums in the form of plaster of paris. Replicas made out of plaster (gypsum) have been used in museums for hundreds of years. Therefore gypsum is a known entity for long term use in museums unlike all other materials currently used in 3D printing. SLA 3D printing (the most commonly used replication process in industry) is entirely different and produces replicas in cynoacrylic, a relatively modern material known to be far less stable and which will off-gas.

This pliosaur display in Bristol was only temporary and the skeleton was not sealed in a display case with the gypsum 3D prints. Also, there were

Figure 13. The UCL Grant Museum of Zoology quagga skeleton LDUCZ-Z581 on display after cleaning, conservation, remounting and installing the 3D printed models of the left hind limb and right scapula. Image courtesy of UCL Grant Museum of Zoology. Image credit: NRL.

several months between 3D printing the skull elements and putting them on display with the real material, allowing off-gassing to take place. However, in other exhibitions real specimens may be mounted with elements that are 3D printed from less benign and placed in display cases with no precise knowledge of how the material will age over time nor how it may affect the specimens around them. Until these materials are proven to be safe, the use 3D printed objects in direct association with real specimens should be minimal, ideally temporary and such products should not be in direct contact with original material nor be enclosed in sealed cabinets with them. All 3D printed materials used for long term projects in museums should be checked regularly (i.e. once a year) for signs of ageing such as change of colour and embrittlement.

Although this exhibition was only temporary, the project required several months of scanning, digital model making, designing, blacksmithing, welding, grinding, brazing, 3D-printing and painting. The steel, brass and Perspex® armature has been kept by BCMAG, as well as the 3D printed skull enabling the specimen to be put on display again relatively easily in the future. The temporary exhibition therefore has a fourfold permanent legacy: many thousands of people will have been inspired by the exhibition containing the massive skeleton and model; funds were raised during the exhibition for the life size model of Doris to be suspended permanently in the rear hall of BCMAG after the temporary display was over where she is mounted today; the 8m-long skeleton could be displayed again in the future with relative ease; and the data from the CT scans of the massive skull and mandible will allow researchers to investigate the internal anatomy of this unique material for the first time.

Acknowledgements

Thanks are due to: Simon Carpenter, Isla Gladstone, Vicky Purewal and Simon Fenn at Bristol Museum & Art Gallery for collaboration on the project; Gemma Larkin for assisting with the skull model; and staff of the Royal Veterinary College, London, for the CT scanning of the massive skull and mandible. The following helped to fund the exhibition: Bristol Museums Development Trust; The Geologists' Association Curry Fund; The Palaeontological Association Engagement Grant; and The Royal College of Pathologists Public Engagement Innovation Grant Scheme.

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Bringing taxidermy back to life: the conservation of an Aldabra giant tortoise *Aldabrachelys gigantea* Schweigger, 1812

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Received: 7th March 2019

Accepted: 5th Jan 2021

Citation: van Gaver, A. 2021. Bringing taxidermy back to life: the conservation of an Aldabra giant tortoise *Aldavrachelys gigantea*, Schweigger, 1812. *Journal of Natural Science Collections.* **8.** pp.13-20.

Abstract

The University Museum of Zoology Cambridge (UMZC) reopened in June 2018 after a major Heritage Lottery funded redevelopment. As part of this redevelopment the opportunity to display a 19th century mounted giant tortoise presented itself. The specimen had been kept in storage for decades and was chosen to head up the turtles' section in the tree of life display. Badly damaged, both structurally and superficially, the specimen was one of the biggest conservation projects undertaken. The large areas of skin loss was an opportunity to test out a variety of structural fills to find the most sympathetic, stable and visually pleasing result. I will present the results of these tests, and also discuss the stabilisation of the deteriorating internal structure and explain the aesthetic challenge of imitating reptile skin. Affectionately named Susan Mildred by a visiting school group, the tortoise soon became a firm favourite with the public and outreach team. Talks on the conservation project were held in the museum and highlighted during the 'Meet the experts' outreach project. This article will examine both the conservation challenges experienced during the lengthy treatment, and the collaboration with the museum's outreach team that developed.

Keywords: conservation, taxidermy, tortoise, structural fills, colour-matching, outreach, engagement, collaboration

Introduction

Taxidermy is often described as making a dead animal look alive again (OED, 1989 "taxidermy"), which, when skilfully done, provides an engaging and anatomically correct example of that species. Unfortunately, when a specimen suffers damage, the effect can be completely lost. This was the case for a mounted Aldabra giant tortoise (UMZC-R.3812) from the University Museum of Zoology, Cambridge (Figure 1).

In poor condition, this specimen was kept in storage for decades before the museum closed in June 2013. This was to change as part of the redevelopment, when it was decided that a tree of life display to highlight the diversity of the animal kingdom with a selection of impressive animals, including this tortoise, would be created.

The Aldabra giant tortoise *Aldabrachelys gigantea* Schweigger, 1812 is a threatened species, indigenous to small islands in the Seychelles. Being

Figure 1. Taxidermy of an Aldabra giant tortoise before treatment at the University Museum of Zoology, Cambridge (UMZC-R.3812). © Anastasia van Gaver, 2017.

some of the largest tortoises in the world, this female was a great example to head up the turtle's section in the tree of life case. Her male partner, mounted as a skeleton, was also put on display in another part of the gallery. According to the museum's archives, the pair were originally shipped from the Seychelles alive by Admiral W. Kennedy in October 1894 before becoming part of the museum's collections in 1896.

Since then, the female tortoise had become so damaged that it was questionable whether this specimen could be redeemed. Nevertheless, in August 2017, a long conservation treatment was started to improve its condition. This was followed by several education and outreach activities, which really brought the tortoise 'back to life'.

Condition

Mounted at the end of the 19th century, the tortoise was badly damaged after decades in storage. While there is no written data to confirm what happened, this damage was likely due to poor storage conditions and a fluctuating environment. Indeed, all the materials used to mount this tortoise are especially sensitive to changes in temperature and relative humidity (RH). As an organic material, the tortoise's skin is susceptible to drying and shrinking in a low RH (Graham, 2018). On the contrary, the internal plaster is particularly prone to damage in a high RH environment due to its support structure of wood and metal which expand and corrode respectively, causing the plaster to crack (Chapman, Smith-McNally and Byrne, 1997). Another potential explanation of the tortoise's condition would be bad handling of this plaster-based object, which is very vulnerable to impact.

As a result, the main issue was the structural instability of several areas, especially the neck and legs, where the original plaster had failed (Figures 2 and 3). The damage was so extensive that the plaster would crack or crumble on contact. The tail had also fallen off and been retained in a separate sample bag, along with many bits of skin. Much of the tortoise skin was splitting and flaking off, with some parts completely missing, resulting in a disfigured specimen.

The shell had also suffered damages, mostly on the carapace where the nuchal scute (directly above the head and neck) was missing and several other scutes were lifting off, creating large, unnatural gaps. Additionally, the plastron (ventral surface of the shell) had become loose. Overall, the tortoise appeared extremely unstable and dirty, and absolutely not in a state to be displayed without appropriate conservation. These material issues also meant that the value of the tortoise as a scientific specimen was overlooked and considered insignificant.

Figure 2. Condition before treatment: detail of the detached neck and missing nuchal scute (UMZC-R.3812).
© Anastasia van Gaver, 2017.

Figure 3. Condition before treatment: detail of the damaged right back leg (UMZC-R.3812).
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Treatment goals

The conservation treatment aimed to fulfil four main requirements:

- Firstly, the specimen needed to be stabilised to ensure it could be displayed safely and stay preserved in the long term. In its current state, it was barely stable enough to begin treatment without plaster and skin crumbling apart.

- Secondly, the specimen's appearance had to be improved for visitors to see the animal with its original beauty and personality. The museum wanted the public to be able to imagine the tortoise alive, rather than seeing it as a broken object.

- Thirdly, any treatment undertaken on the specimen had to be checked not only against general conservation ethics but also against scientific accuracy. As a renowned university museum, UMZC is frequently used by students and visiting zoologists, which meant respecting the true anatomy of the tortoise was especially important. This was even more of a factor considering the vulnerable status of this species: should they become extinct, a specimen like this would be a rare chance to engage with these tortoises.

- Finally, the support on which the specimen was originally mounted needed to be removed. The tortoise was mounted by a metal structure that ran through its body and feet, to a wooden platform which was too wide to fit into the intended display case. This had to be removed without damaging the specimen before the rest of the work could begin.

Ethics

Considering the treatment goals, it was clear from the start that this conservation project was going to be highly interventive: an object as badly deteriorated as this tortoise would require irreversible restoration. As conservation students, we are taught to always think about minimal intervention and reversibility during our decision-making. However, these principles are rarely appropriate and the belief in reversibility is now considered a "dubious principle" (Muñoz Viñas, 2002) and a "fashionable naivety" (Schinzel, 1999) by many professionals. The treatment progressively grew more and more interventive because the long-term stability of the specimen and the wider benefits for the public were considered more important than the potential reversibility or re-treatability.

In order to achieve an accurate representation of this animal, I needed to conduct thorough research into the tortoise species and its appearance in life. Thankfully, I could consult with departmental specialists and museum curators as well as take advantage of the many literary sources at my disposal. After much testing and experimentation, a representative approach was implemented.

Given the extent of the damage, it was decided, in agreement with the senior conservator and the curator, to fill and paint large areas of loss. Fills were needed to improve the stability of the specimen as well as to make it more accessible for the public. While interventive, this treatment would be documented during each step with written and photographic records to ensure all information is preserved for future conservators, curators or researchers.

Treatment

After a thorough documentation process, including a detailed condition report, the first step was to remove the tortoise from the large wood and metal mount it was standing on. The museum's mount maker was there to give her input regarding the tortoise's stability and to supervise the removal of excess metal wires. With her help, the tortoise was then placed on Plastazote® and soft bean bags to better support it during conservation. While doing this, it became clear one of the legs was more unstable than the others and would require extra stabilisation to help bear the weight. Dry cleaning was then performed with a museum vacuum and a soft brush initially, followed by smoke sponges. Most of the loose, unstable materials such as broken plaster and straw were removed, as they had failed and were no longer serving their purpose. Flakes of skin that had fallen and could not be put back were collected in sample bags.

Stabilisation

The internal structure of the tortoise was consolidated by pipetting and injecting 10% Paraloid B72 in acetone. This was successful on the majority of the plasterwork with the exception of two load-bearing areas that kept breaking. For these, stronger solutions of Paraloid B72 were tried but this was still not enough, and it broke again. It was then agreed with the senior conservator to use something stronger: a two parts Araldite®. This epoxy adhesive cannot be removed but long-term stability of the specimen was, in this case, considered more important. Epoxy resins, including Araldite®, are often used in conservation, mostly for glass and ceramics. Their main issue is a tendency to yellow and lose strength over time, due to photodegradation (Coutinho, *et al.*, 2008). However, this was not a problem for the tortoise, as the Araldite® was only used internally: the resin was less likely to degrade as it would not be exposed to light. Finally, to stabilise the skin, Jade R was chosen as it is an acid free, pH neutral, reversible EVA adhesive, which dries clear.

Fills

Several materials were researched and tested for fills. They were mostly chosen based on my previous experience and on advice from the senior conservator, as well as on their availability in the lab. The three main requirements for the materials were 1) to be suitable to stabilise the whole structure of the specimen; 2) to be strong enough to hold the tortoise's weight; 3) to be easy to shape, sculpt and paint to mimic reptile's skin.

Tested materials included:
- plaster in water;
- papier mâché in water;
- 50:50 plaster:papier mâché in water;
- glass balls GB03 (micro balloons) with 10% Mowilith 50, in 50:50 IMS:acetone;
- glass balls GB03 (micro balloons) with 35% Paraloid B72 in acetone.

Based on the easiness of application, working time, drying time, strength and aesthetic match for the skin, it was decided to use the 50:50 mix of plaster and papier mâché in water (Figure 4). It was easy to mix to the desired consistency, it applied well and held itself without dripping, and was ideal to 'sculpt' while drying to give a reptile skin effect. It was also compatible with the original plaster and did not emit fumes, as opposed to acetone and other volatile solvents.

Following consolidation, the plaster and papier mâché mix was applied to fill the missing areas, in several layers due to the depth of the losses. Once the fill got closer to the level of the skin, powdered pigments were also added to tint the mix, and moulds of the skin were pressed onto the wet mix to give the right texture of tortoise scales. These moulds were made of Steramould, a silicone based moulding compound which produces fine, flexible moulds which can easily be re-used. Finally, after several tests on practice pieces, the fills were colour-matched with acrylic paints. This was a long process as there were large areas to be painted and they had to replicate the look of the tortoise's skin, with a variety of colours and patterns to imitate real scales (Figures 5-8).

For the carapace, the large gaps between the scutes were filled with papier mâché in water and

Figure 4. During the fill process: detail of the right back leg with final layers of plaster and papier mâché mix (with pigments), pressed with Steramould moulds (UMZC-R.3812). © Anastasia van Gaver, 2017.

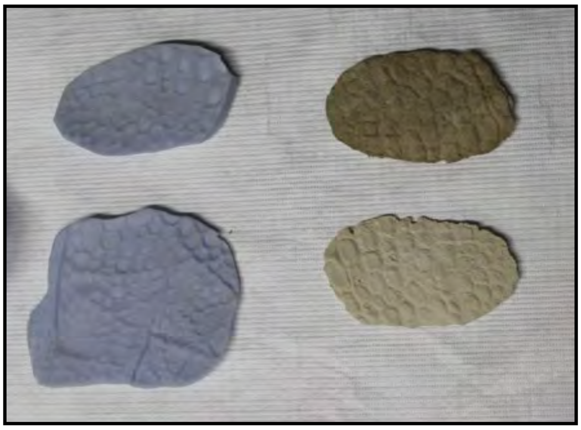

Figure 5. Steramould moulds of skin (left) with moulded test pieces in plaster and papier mâché (right).
© Anastasia van Gaver, 2017.

Figure 6. After treatment: detail of the neck with painted fills and the replacement scute (UMZC-R.3812).
© Anastasia van Gaver, 2018.

painted with acrylics. The missing nuchal scute was replaced with some Apoxie® Sculpt. This durable epoxy putty cannot be readily removed but was chosen for its other properties: it is stable and self-adhering, it does not shrink, it can easily be sculpted and painted. Like the rest of the tortoise's treatment, this decision was taken with display in mind, but detailed documentation would allow potential researchers to know the exact positions and materials used if necessary.

In the end, after nearly 150 hours of work, and despite initial doubts as to whether the tortoise was even salvageable, it was ready to go on display. However, more could be done to extend the impact of the specimen and the conservation work it had undergone.

Education and outreach

Conservation is not only material-based, it also has a social value and can widen the engagement with museums and heritage (Koutromanou, 2015). Rather than simply viewing a dead tortoise in a display case, the museum wanted visitors to have a richer experience, to get more out of the specimens and the conservation work, to celebrate and showcase the feats accomplished during the museum's redevelopment. This was achieved through outreach and education.

Collaboration with the education team brought in an extra level of depth to the engagement that visitors and others can have with a specimen, in this case the giant tortoise. Sara Steele, Museum Learning Assistant at the Museum of Zoology, facilitated the tortoise's involvement in a number of outreach programmes.

Museum Take Over

Before the museum re-opened, the Museum of Zoology hosted a 'Museum Take Over', in which myself and another conservation colleague gave a talk to a group from a local secondary school. This University of Cambridge Museums (UCM) project

Figure 7. Detail of the head before treatment (UMZC-R.3812) © Anastasia van Gaver, 2017.

Figure 8. Detail of the head after treatment (UMZC-R.3812) © Anastasia van Gaver, 2018.

aims to engage with students from low socio-economic backgrounds, to open up museums as a resource and to share with them the range of career possibilities within the sector. To showcase the role of a conservator and share some behind-the-scenes work, we showed some on-going conservation projects, including the tortoise.

The students were all very enthusiastic and full of questions about the museum and conservation; one student even said that she would like to become a conservator. While discussing the on-going project of the half-conserved tortoise, one of the questions was "What's her name?". At which point they suggested "Susan" and "Mildred", so she became Susan Mildred Tortoise. The name got shortened to Susan and stuck with the whole museum team and for all later education programmes. Indeed, naming a specimen is not just fun, it can help to engage and involve visitors.

Meet the Experts

The second education activity Susan took part in was during the 'Meet the Experts' programme, held as part of an after-school science club for students between 11-15 years old. This was a pilot project, with three sessions. Just as with the previous project, students were unfamiliar with the role of a conservator and much of the behind-the-scenes work of a museum.

Susan featured as a case study in the final session. Students were provided with information about the specimen and its prior condition, then asked to match the condition problems with the appropriate conservation treatment with the help of images. The final activity was to practice colour-matching with acrylic paints on some white pieces of plaster and papier mâché to imitate Susan's skin, using practice pieces made during conservation as examples (Figure 9).

Figure 9. Practice pieces of plaster and papier mâché for colour-matching. © Anastasia van Gaver, 2018.

The feedback for the 'Meet the Experts' project was really positive and the teacher said these interactive sessions were "really accessible" and "helped them to engage with science in a different way". It was also possible to broaden their exposure to young scientists working in alternative jobs, such as conservation.

Curiosities & Conversations

Curiosities & Conversations was a collaborative project between UCM and Addenbrooke's Hospital. With a health and wellbeing focus, the goal was to provide a stimulating activity and distraction to patients undergoing dialysis using the museum collections as a tool in the hospital. Again, most participants were not aware of the role of a conservator or the work that they do, but Susan provided an engaging conversation topic.

Sara Steele ran the outreach session which included Susan. Photographs and easily transportable tactile skin samples produced as part of the conservation treatment could be shown to people outside the museum, despite not being able to take the whole tortoise. As a conservator, it was positive to see conservation documentation and samples used for engagement where it would usually be kept unseen.

Plant Patrol

The final programme Susan featured in was the 'Plant Patrol' summer trail at the Cambridge University Botanic Garden (Figure 10). The education team of the garden were looking for herbivorous animals to include in a trail exploring the plants they may feed on. As Susan and her partner used to live at the garden in the 19th century, they were enthusiastic to include her. Susan created a connection between the Museum of Zoology and the Botanic Garden: visitors would do the trail, learn about Susan, collect a badge of her, and then go to the Museum of Zoology to see the real specimen. This really brought her story to life.

Conclusion

From a conservation perspective, the treatment was successful as it fulfilled its four aims. The tortoise was stable enough to be displayed (Figure 11) and has since been enjoyed by many visitors to the museum. The value-based approach Appelbaum, 2007) to the conservation of the tortoise not only restored its physical stability but also its value as an important heritage and scientific specimen. Additionally, Susan proved that damaged or bad taxidermy has a lot of potential in museums, not

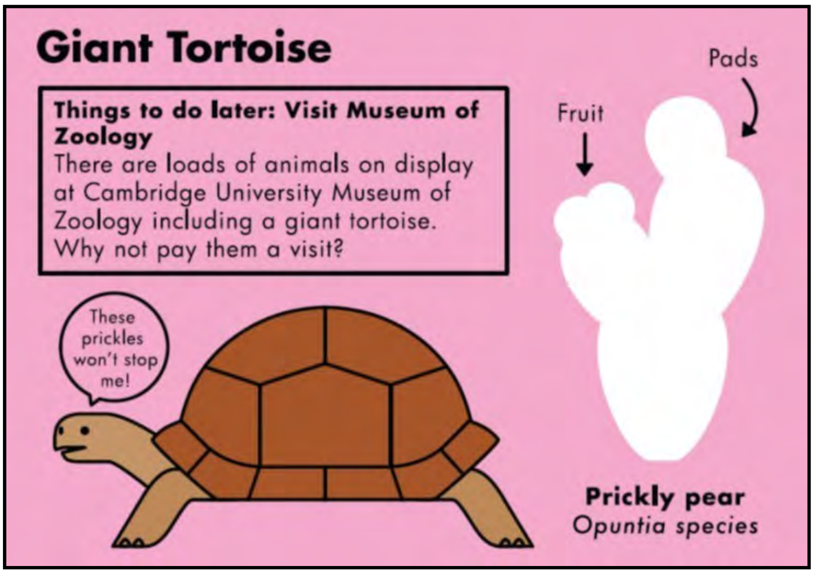

Figure 10. Detail of the 'Plant Patrol' booklet showing the giant tortoise with a prickly pear cactus. © Hannah and Holly for Cambridge University Botanic Garden, 2018.

only for interesting conservation treatment but also for public engagement.

Indeed, what was especially interesting as a conservator was to take part in education and outreach activities. This was a different experience than benchwork in the lab and I personally learned new skills with support from expert colleagues. This project was an example of the social value of conservation (Koutromanou, 2015), showing how conservation and education programmes can go hand in hand. Susan's journey in the education programmes revealed that the public are not always aware of the role that conservation plays in museums, but that given the opportunity there is often interest and relevance to be found, and as a result a greater depth of engagement. It also brings a level of awareness for the problems museums and museum professionals face which may open up opportunities for funding.

Acknowledgments

I would like to thank the Heritage Lottery Fund for their funding, Natalie Jones and Simon Moore for their conservation advice, curator Dr Jason Head for his trust, Rebecca Ash for her help with the mount, and Sara Steele for including me and Susan in several education and outreach programmes. Lastly, I would like to thank my two reviewers for their time and constructive comments.

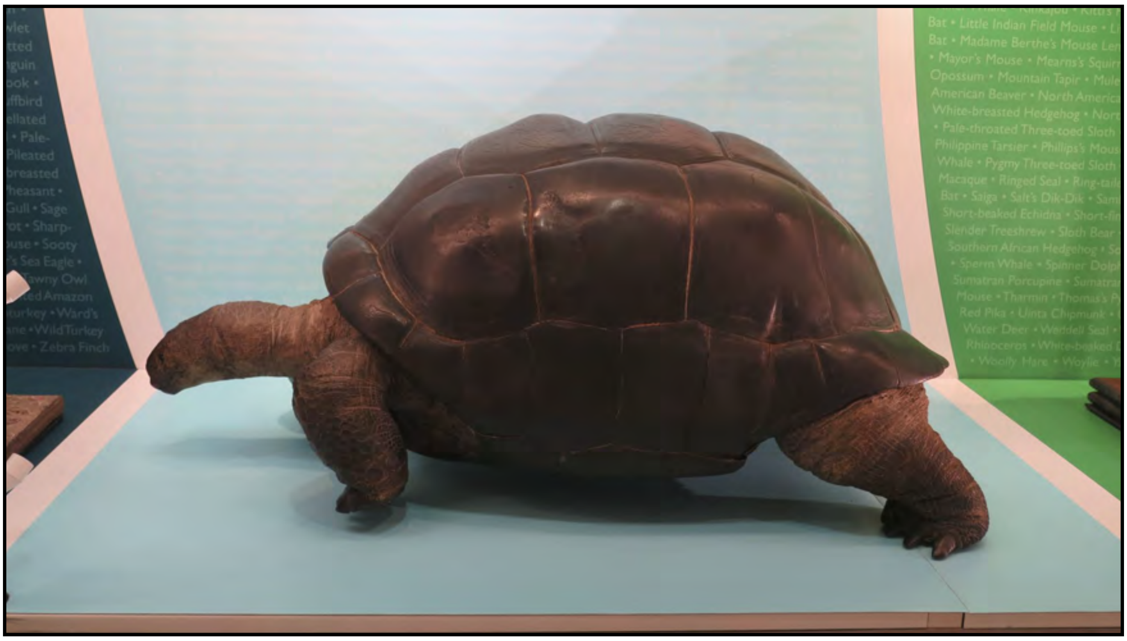

Figure 11. After treatment: the giant tortoise on display in the tree of life case (UMZC-R.3812) © Anastasia van Gaver, 2018.

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The reproduction of Leonard Jenyns Entomoligia Cantabragiensis: An insight into the preservation issues of bound books

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Received: 7th March 2019

Accepted: 7th Jan 2021

Citation: Ferreira, S. S. 2021. The reproduction of Leonard Jenyns Entomoligia Cantabragiensis: An insight into the preservation issues of bound books. *Journal of Natural Science Collections.* **8.** pp.21-27.

Abstract

Natural science museums often contain book and paper material that is inherently important to their collections. Although these materials can be as vital to the museums' narrative as the specimens themselves, natural science conservators are not necessarily familiar with this aspect of the collection and its conservation needs. During the recent redevelopment of the University of Cambridge Museum of Zoology, a project was undertaken to produce a facsimile of Leonard Jenyns' *Entomologia Cantabrigiensis,* Part One in order that it could be put on long term display. The notebook includes observations made by Jenyns regarding the Lepidoptera of Cambridgeshire, and as well as providing context to specimens as part of the display, it remains a significant source in evaluating wildlife conservation efforts occurring in the area today. The process of replicating the notebook gave unique access to the exploration of traditional bookbinding methods and offered an opportunity to gain new skills transferrable to one's needs. By outlining the various stages, and by introducing some general preservation issues regarding bound books, it is hoped that greater insight will be given as to their nature and the problems museum professionals may encounter in caring for books as part of their collections.

Keywords: conservation, Leonard Jenyns, *Entomologia Cantabrigiensis* book binding, facsimile

Introduction

As part of the ongoing redevelopment of the Museum of Zoology at Cambridge University, a dedicated part of the new displays will exhibit material collected by Leonard Jenyns, a 19th century naturalist with distinct connections to the museum. This offered the opportunity to display a rare body of work, the contents of which continue to influence wildlife conservation efforts today. However, due to conservation concerns, it was not deemed appropriate to put the original journal on long term display. Guidelines regarding library and archival material state that if highly sensitive material has a preservation target of 100 years, a limited display of 25 days per year at 50 lux should be aimed for (BS4971, 2017). It is also suggested that books displayed open have the pages changed as often as required to limit exposure to light and to limit strain on the binding structure in any one area. Both points severely restricted the scope of the new display and a viable solution was to exhibit a facsimile in place of the original notebook (NPO, 2000).

Leonard Jenyns and the significance of his work

Leonard Jenyns was one of two men offered the position of naturalist on board H.M.S. *Beagle*, before declining and suggesting a young Charles Darwin as a replacement. After declining this offer, Jenyns lived in Cambridgeshire for much of his life, collecting and observing wildlife in the local area. His work forms a rare, long-term list of species living in the area nearly 200 years ago and much of the material he collected is now stored or on display at the museum where it provides a glimpse of Cambridgeshire's recent past (Preece, 2012).

In 1868 Jenyns sent three handwritten notebooks to what is now the Museum of Zoology (Figure 1). These form what is known as *Entomologia Cantabrigiensis* and contain notes on all the insect and arthropod species he observed. Jenyns also recorded details on the timings of natural phenomena, such as the emergence dates of insects and flowers as well as a range of basic meteorological measurements which when taken together produce a valuable dataset to measure the effects of local climate change over time (Preece, 2012).

The significance of the journal extends well beyond the fabric of the museum and the examination of such records is one of the few ways we can view wildlife of the past and assess long term trends.

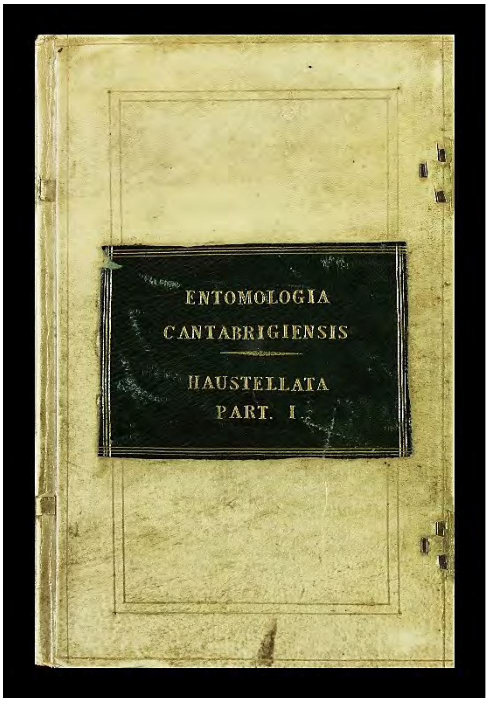

Figure 1. Rev. Leonard Jenyns' handwritten notebook, Entomologia Cantabrigiensis, Part 1. © University of Cambridge.

Examples taken from *Entomologia Cantabrigiensis* highlight how the preservation of historic records can help shape the future of certain species and their habitats. Jenyns' notebook entry for the Swallowtail Butterfly *Papilio machaon* Linnaeus, 1758, for example, reads that between 1820 – 1849 it was 'Found in the greatest plenty, thro'out the Fens between Ely & Cambridge'. In 2018 the species is locally extinct: most of their wetland habitats have been drained for agriculture. From the same period, Jenyns' notebook entry reads that the Large Copper Butterfly *Lycaena dispar* Haworth, 1803, was 'Not uncommon in Cambridgeshire'. In 2018 it is nationally extinct. It became extinct in the mid-1800s due to fenland drainage and could no longer survive without a large wetland habitat (Brian Eversham, 2018 pers. comm, 13th Oct). By comparing the records from these two time periods, we see that populations of some species have declined, others have increased, and some have remained much the same. What the Swallowtail and Large Copper Butterflies have in common is that they both live in wet fenland habitats. Using such information ensures that population decline can be better understood, furthering efforts to reverse specific trends.

As indicated by Jenyns records, the loss of the fens has been a large driver of species decline in the local area. It is clear, therefore, that re-expanding this habitat could help bring them back, something the Great Fen Project and Wicken Fen Vision are targeting by rewetting the landscape of Cambridgeshire.

The Museum is supplying these organisations with historical specimen data to provide them with a benchmark of a past 'natural' state. With time, Swallowtails may be able to recolonise these areas and if enough fenland can be reclaimed, it may even be possible to reintroduce the Large Copper Butterfly from populations abroad.

The original notebook

Jenyns' notebook is a case bound book on vellum with metal clasps (Figure 2). The text block, the pages which make up the book, has been constructed separately and then attached to a case which gives it protection. This is a common book type; most hard cover books we own at home have a similar construction. Pages of text were folded and collated into seventeen sections. These were sewn together incorporating what is termed a sewing support, in this case two vellum thongs sewn onto the spine and laced to the cover boards, helping to maintain its shape and provide attachment to the case. Decorative marbled

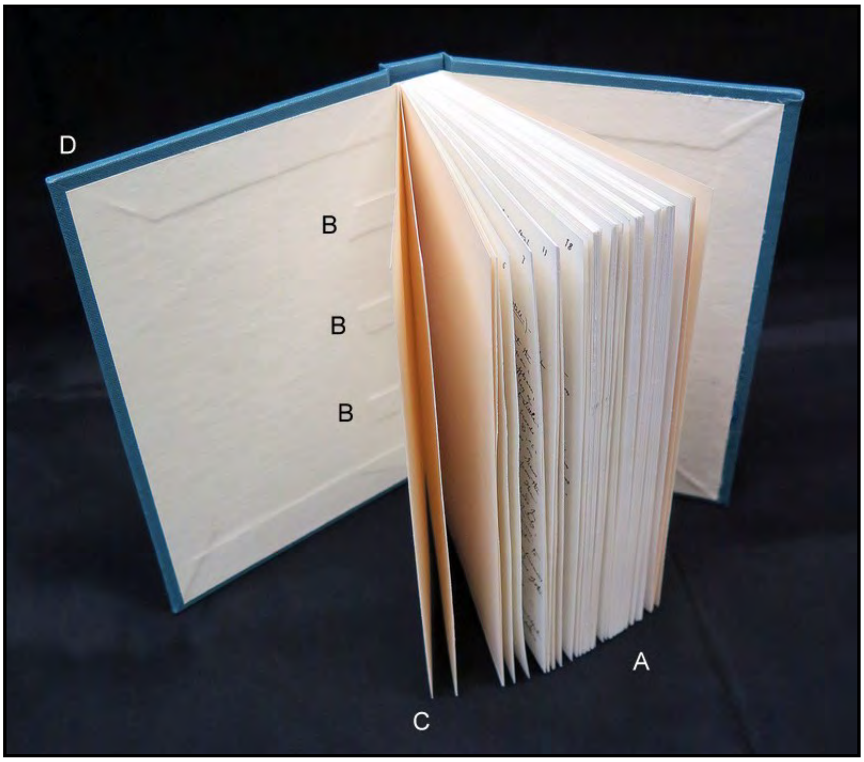

Figure 2. Example of a case bound book. (A) Multiple sections of folded paper. (B) Sewing supports. (C) Endpapers, the outermost of which is adhered to the case. (D) Case of the book which is made separately to the book block. © University of Cambridge.

endpapers were used. These are a collection of leaves at both the beginning and the end of a text block which are separate from a printed or written text. The spine was lined with layers of thick paper or card for strength and flexibility. Decorative marbled endpapers sewn into the text block as the first and last sections were then adhered to a case made of solid pieces of board and a flexible incised vellum covering material.

The notebook is in good condition. The vellum cover is lightly soiled and has warped slightly owing to its susceptibility to changes in humidity, but it does not affect the opening of the book. The stiff spine is likely due to the use of animal glue as part of the spine lining. Care must be taken not to open the pages too far as this could cause the lining to crack. Two copper alloy clasps had been attached to the covers to help keep the book closed and protect against the penetration of dust and light, the lower clasp, however, is no longer present.

Aims and considerations in producing the facsimile

The primary consideration for the facsimile was that the reproduction must act as a surrogate for display and for any outreach activities. This meant that it had to have the same construction and aesthetic as the original to ensure that it could be perceived as a journal used day to day in the field. Printed excerpts from the book, although effective in conveying information, would give no indication of the deliberateness of Jenyns in compiling the body of work that *is Entomologia Cantabrigiensis*. The facsimile had to be durable to facilitate handling and be constructed from materials that would be relatively resistant to environmental conditions whilst on display. It was hoped to remain as close to the aesthetics, materials and binding structure of the original as possible.

As a display item, the facsimile should hold the same gravitas as the original and should use the same format. If, in the unfortunate situation that the original and all information relating to it were lost, a surrogate would provide a record of its materials and composition, as well as its contents. As time was a factor in preparing for the museum's opening, the project had to be completed within a certain timeframe and with the materials and equipment readily accessible for conservation.

Binding process

The original notebook was scanned and printed externally by Cambridge Print Solutions. This step may perhaps have warranted more thought with respect to the quality and long-term performance of the paper and ink. The author was not involved in the project at this stage and as the composition of the paper or ink was not known, it would be difficult to judge how the materials would react or last over time. However, considering some common faults with case bound books, the quality of construction from this point onwards would perhaps play a greater role in how well the facsimile is preserved. For example, the sections of commercial case bound books today are frequently held together with adhesive rather than by being sewn. To keep costs as low as possible, inferior materials are often used and certain structural components ignored. This means the cover is not adequately attached to the text block, an area critical to it fulfilling its purpose as a protective enclosure (Milevski, 1992). A consideration of these points in its manufacture would ensure the facsimile would be fit for purpose for the foreseeable future.

Suitable endpapers were then selected. They can be quite important for a cased-in book where the endpaper is the only attachment of the book boards to the text block. They strengthen the book as a whole and give one final element of support to the joint of the case (Blaser, 1994). A rather thick and heavily weighted endpaper was selected. This would create a stronger attachment to the case. The endpapers do not resemble the marbled papers of the original and although this selection was contrary to the aim of maintaining the aesthetics of the original, it was the most viable considering time constraints and limited resources. Indeed, sections of the book which would be selected for display will include pages from within the book and not likely the end page areas.

Sewing

Prior to sewing the sections together thought was given to the materials to be used for the sewing supports as well as their placement on the spine of the text block. As mentioned, sewing supports act as points of attachment between the spine of the text block and the book covers. They are the *hinged areas* (Figure 3), the joints where the covers open and close and must hold the book together while also allowing it to open freely (Middleton, 1994). Weakness in these areas can lead to the text block becoming loose in its cover and the two can ultimately detach (Milevski, 1992). It should not be assumed that all case bound books exhibit sewing supports. In such books the pastedowns at the front and back of the text block are adhered to the case and this serves as the only form of attachment. As such, the joint indicated in Figure 3 will be much weaker and as there is no support across the spine to hold it in shape, a phenomenon occurs whereby the spine becomes concave, pushing out the pages beyond the cover and leaving them exposed (Szirmai, 1999).

Linen tape was selected owing to its strength and flexibility, and three pieces of tape were placed equal distances apart (Figure 4). This would give enough support in proportion to the size of the book. A template was used to mark the sewing stations, the holes through which thread is passed to tie the sections together. One set of sewing stations was marked at both the head and tail of the book and three pairs of sewing stations along the spine which, after sewing, held the linen tapes in place. These markings were then pierced, and the sections sewn, the thread passing on the inside of a section, out over each tape, tied to another section that is placed on top of the previous and the process repeated in the opposite direction.

Lining the spine

After the book was sewn the spine was lined in a laying press (Figure 5). It takes rather a lot of hand strength and accuracy to make sure the spine is nicely aligned between two pieces of board before placing in the press and tightening. Prior to lining, a satisfying step is to burnish the sections of paper with a Teflon bone folder so they lock together and give a flat compact spine. This also prevents

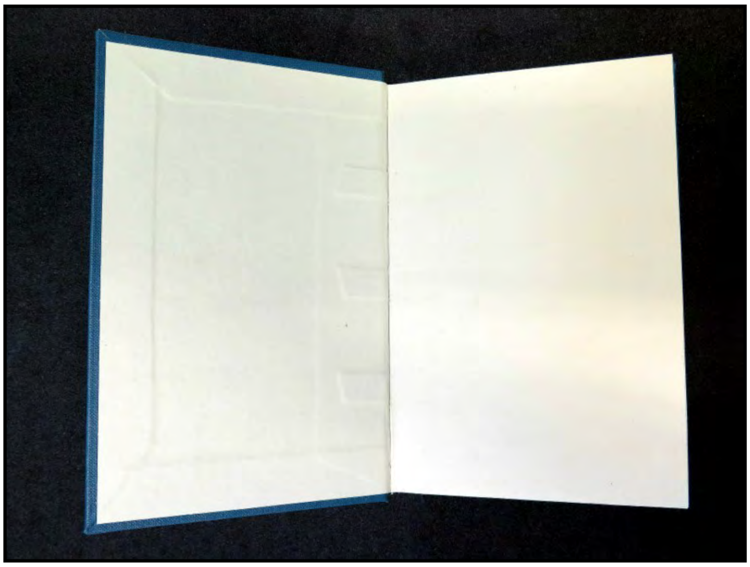

Figure 3. The sewing supports help from a joint, the centre crease, between the text block and case.
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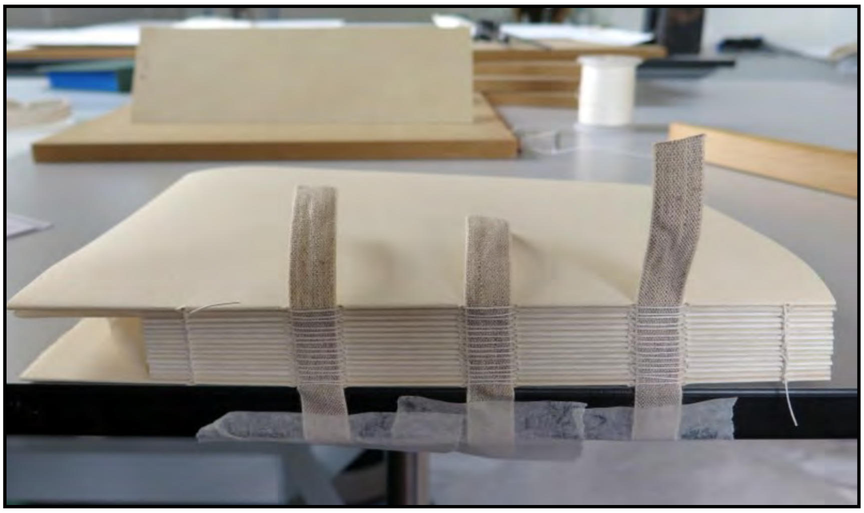

Figure 4. Sections sewn together over tapes. These support the sewing and help attach the text block to the case. © Sammuel Suarez Ferreira.

any paste used to attach the spine lining getting into the pages and causing them to stick together. The spine was then covered with a layer of Japanese tissue using starch paste that was thick in consistency, almost gel like, again for ease of application and to prevent it from flowing between the pages. A layer of cambric, a lightweight, sized cotton cloth, was adhered on top of this with ethylene vinyl acetate (EVA), adding further support and flexibility to the spine. Finally, a piece of Manila paper was added using EVA to provide rigidity and structure.

Casing-in

The final stage was to create the case cover for the book block which became the biggest visible diversion from the original. It would have been preferable to use vellum and include metal clasps to replicate the original materials and aesthetic of Jenyns' notebook, however, none were available and there was little time to source them. Moreover, vellum can be a tricky material to work with as when it comes into contact with an adhesive, it can slip and stretch and can be difficult to manipulate for those with little experience of handling it. The material selected was an acrylic coated buckram. Buckram is a book cloth made from cotton, sometimes linen. It is a closely woven fabric that is filled or coated and pressed between rollers to give a smooth finish. In the past it was filled with starch or pyroxylin but is commonly coated today with acrylic (Roberts and Etherington, 2011). This makes the fabric very durable and water-resistant, factors which were ideal when considering the facsimile as an instrument for public outreach sessions. The only cloth available, however, was a blue/green colour. This was not preferable in trying to imitate the original as closely as possible. If more time had been available prior to the notebook being displayed, it would have been desirable to attempt using vellum and failing that, at least a book cloth more sympathetic in colour. Despite these visual limitations, the real motivation in producing the facsimile, was in making Jenyns' information more accessible through outreach and for public display. The book will always be open at a particular page and little emphasis would ever be placed on the decorative elements.

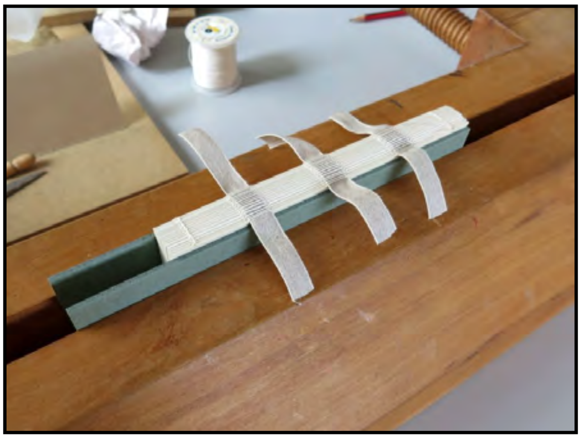

Figure 5. Lining the spine in a laying press. © Samuel Suarez Ferreira.

The choice of book board was also considered. Almost any rigid board can be used as a casing but its lifespan, like anything, is dependent upon the quality of the materials. Millboard is commonly used by bookbinders, so called because of its smooth surface produced by rolling or milling under pressure (Roberts and Etherington, 2011). Previously made from old rope and other fibrous materials, it is now composed of recycled paper or wood pulp. A defect which may become visible on books made from millboard is that the material can split due to excessive lamination when placed under pressure (Roberts and Etherington, 2011). It remains, however, more dependable than materials such as grey board, and is less prone to warping.

The boards that make up the front and back covers as well as a thinner piece of board for the spine were cut to a size slightly larger than the text block. This would ensure the pages are encased completely from external damage. A piece of book cloth was cut to size and the pieces of board adhered at predetermined distances apart using EVA. These distances are significant as they ensure that the spine of the text block is in accordance with the spine of the case and ensure the cover boards hinge easily around the text block so that the book closes flat (Milevski, 1992). The book cloth was turned over the edges of the boards and pasted down to leave a neat border. EVA was then brushed evenly over the front and back boards and the back of the text block pressed firmly on top of the back board. The front board was then folded around to meet the front of the text block and the book placed in a nipping press so that the adhesive could dry without warping the pages or boards. Finally, a scan of the original book label was affixed to the front cover using EVA to complete the facsimile (Figure 6).

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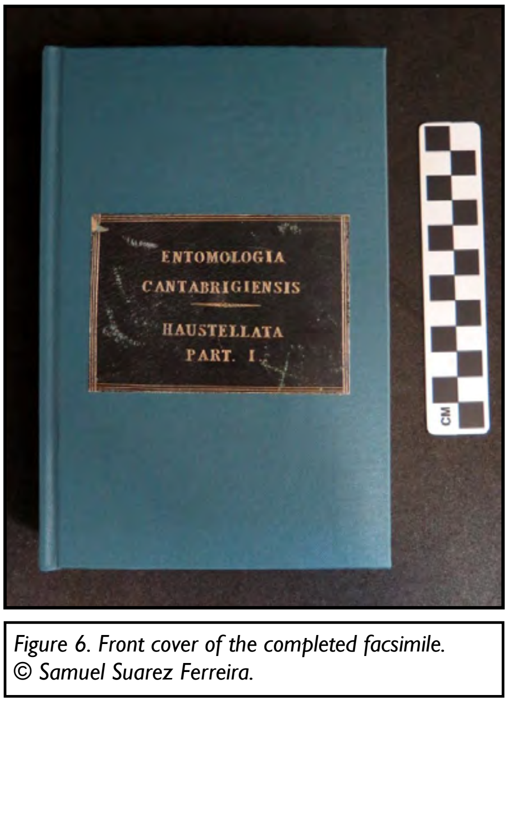

Figure 6. Front cover of the completed facsimile. © Samuel Suarez Ferreira.

Summary

As conservators, curators, or collections assistants, we are frequently faced with specimens and objects that we do not fully understand. Conservators often have material placed on their benches that they have limited experience of working with. In many cases they do not have the luxury of refusing intervention based on a lack of knowledge. Although books and works on paper are generally treated by specialists in those fields, the materials are likely represented in every collection. By possessing a working knowledge of how they behave, the conservator ensures that they are handled and cared for in a manner that extends their working life. Through this paper I hope to have made the reader a little more curious about the books present on a shelf. Why has a book been made in a specific way, how does it work, and what damage might occur if you use it in a way in which it was not intended? Every book on a shelf is subtly different from another and although there are some general guidelines for handling books, different types can benefit from specific measures to ensure they receive the best care.

Acknowledgements
I would like to thank staff at the Museum of Zoology, particularly Matt Hayes for involving me in the project and for providing answers to the many questions I had relating to Leonard Jenyns. I am indebted to Edward Cheese of the Fitzwilliam Museum, Cambridge for help in identifying the binding and the methods through which I could create the facsimile, his offer to take me through the process was most generous. Thanks also to John Lambert, Archive Conservator

at Cambridge County Council, for proof reading the sections on bookbinding. A final thanks to my wife, Rebeca Suarez Ferreira, for reading and editing drafts of this paper.

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Useful links

http://www.greatfen.org.uk/
https://www.nationaltrust.org.uk/wicken-fen-nature-reserve/features/wicken-fen-vision

Caring for geological collections: unresolved questions

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Received: 30th Jan 2020

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Accepted: 8th Feb 2021

Citation: Royce, K., and Baars, C. 2021. Caring for geological collections: unresolved questions. *Journal of Natural Science Collections.* **8.** pp.28-38.

Abstract

Caring for geological collections is neither as simple nor as straightforward as widely perceived. Several hundred mineral species are vulnerable to the effects of moisture, temperature, air pollutants, and light. Some species undergo significant changes when exposed to minor deviations from their stability limits. One example—well documented by geochemists, engineers, and conservators alike—is iron sulfide oxidation; whilst reaction products and pathways are well characterised, the precise causes of deterioration of iron sulfide species within museum collections remain largely elusive. There is even less knowledge about the stability of many other susceptible mineral species—such as realgar or lansfordite—within the museum sector. Published guidelines for managing geological materials are often contradictory and evidence the lack of applicable information on optimal storage conditions and suitable conservation actions. In addition, currently available condition assessment methodologies are not always appropriate for the routine monitoring of large collections, and the results of such surveys are not necessarily reproducible. A new approach is required to answer the numerous questions regarding the care of geological collections, and to establish evidence-based conservation guidance, both of which requires substantial research. This paper introduces a framework for a research agenda that would underpin a robust approach to establish satisfactory conservation practices. This includes defining the extent at which material change constitutes damage, categorising damage, developing a protocol for routine condition assessments, determining adequate storage environments, and rigorously testing the suitability of conservation treatments presently available.

Keywords: geological collections, stability limits, minerals, environmental conditions, conservation

Introduction

The chemical and physical properties of each species of rock, mineral, and fossil are unique and determine the material's stability under various environmental conditions. Under typical museum storage and display environments many specimens in geological collections may be unstable.

Unsuitable storage conditions may have a number of deleterious effects (Table 1), which can result in damage, dissociation from contextual information (for example, damaged or corroded labels), or even complete specimen loss.

Agent of Deterioration	Potential Impact on Specimens	Mineral Examples	Citation
Temperature	Decrepitation	Sulfur	O'Donoghue, 1983
	Dissociation	Nesquehonite	Robie and Hemingway, 1972
	Phase Change	Tin	Ojima *et al.*, 1993; Zeng *et al.*, 2004
Relative Humidity	Carbonation	Massicot	Aze *et al.*, 2007
	Corrosion/Oxidation	Pyrite	Howie, 1992b; Guevremont *et al.*, 1998a; Rosso *et al.*, 1999; Jerz and Rimstidt, 2004
	Dehydration	Sulfates such as chalcanthite & melanterite	Waller, 1992; Chou *et al.*, 2002
	Deliquescence		
	Efflorescence		
	Hydration	Clay minerals such as montmorillonite & sepiolite	Howie, 1984
	Water film formation	Calcite	Stipp *et al.*, 1996; Al-Hosney and Grassian 2004, 2005; Usher *et al.*, 2007
Light	Darkening	Rutile	Nassau, 1992
	Fading	Quartz varieties, including amethyst	Currier, 1985; Kane, 1985; King, 1985; Nassau, 1992; Rossman, 1994
	Loss of colour/ fluorescence	Fluorite	Nassau, 1992; King, 1985
	Photodecomposition	Silver halides, including chlorargyrite, bromargyrite, iodargyrite, & miersite	Nassau, 1992
	Photo-oxidation	Proustite	Howie, 1992c; Nassau, 1992; King, 1983; King, 1985
	Structural Alteration	Realgar	Douglass *et al.*, 1992; Kyono *et al.*, 2005; Kyono, 2007; Jovanovski and Makreski, 2020
Pollutants	Alteration	Hematite & goethite	Drosdoff and Truog, 1935
	Corrosion	Metals such as lead & copper	Scott, 1990; Tétreault *et al.*, 1998; Raychaudhuri and Brimblecombe, 2000; Scott, 2000; Tétreault *et al.*, 2003
	Efflorescence	Calcite	Krueger, 2003; Al-Hosney and Grassian, 2004, 2005; Al-Hosney *et al.*, 2005; Usher *et al.*, 2007; Prince *et al.*, 2008

Table 1. Some effects of different agents of deterioration on mineral specimens. For further effects, please see Howie 1992a and Child, 1994a.

This paper provides a brief overview of the current knowledge available regarding the susceptibilities of geological materials, chiefly minerals, and introduces a research agenda devised to address some current knowledge gaps. Further thoughts on the topical unresolved issues surrounding the conservation of geological collections were published by Baars and Horak (2018).

Vulnerability and instability

Of the 5,673 known mineral species (International Mineralogical Association, 2021), at least 10% are susceptible to damage under museum conditions (Howie, 1984; Walker, 1992). Deterioration may present itself as physical change, yet chemical changes are equally possible. Additionally, some specimens may seem unaffected, but closer inspection and analysis may reveal that unwanted changes have taken place.

Temperature

A number of polyhydrated mineral species dissociate into a lower-hydrate mineral and water vapour, regardless of the relative humidity (RH) level, if exposed to sufficiently high temperatures. This process results in an irreversible change to the crystalline structure. One such example (Figure 1) is lansfordite ($MgCO_3 \cdot 5H_2O$) which dehydrates to nesquehonite ($MgCO_3 \cdot 3H_2O$) if temperatures are above approximately 10°C, even under 100% RH (Waller, 1992). Other examples of minerals with temperature-dependant changes into lower hydrates include epsomite, natron, and nitrocalcite (Waller, 1992).

Rapid changes in temperature can also lead to fracture within specimens (Child, 1994a; Stanley, 2004). Differential temperatures between a specimen's interior and exterior result in stresses which may be released through cracking or spalling (Walker, 1992; Horak, 1994). Waller (1992) lists further physical characteristics that increase the likelihood of fracture, including easy cleavage and high brittleness. Some brittle minerals include carrollite, polybasite, sartorite, colemanite, and gaylussite.

Relative humidity

The effects of low, high, or fluctuating relative humidity may produce a variety of unwanted changes in minerals, such as alterations in hydration state, efflorescence, deliquescence, and oxidation. Some polyhydrated mineral species, such as melanterite and other sulfates, may Dehydrate - that is, move from a higher hydration state to a lower one - often producing a powdery efflorescence on the mineral surface (Waller, 1992). Not only can dehydration change a specimen's chemical composition, but the loss of structural water can lead to shrinkage, fracture, and even disintegration (Child, 1994b).

The migration of soluble salts from the interior of a porous object to its surface is also a form of efflorescence. This type of efflorescence has been documented to affect archaeological material (Wheeler and Wypyski, 1993) and building stone (Franzen and Mirwald, 2009), yet can also affect porous minerals such as turquoise, chalcedony, agate, and clay minerals. Salt migration occurs during cycles of fluctuating RH. When the humidity is above the salt deliquescence point, it absorbs atmospheric moisture and enters solution. During this liquid phase, the salt migrates to areas of lower salt concentration, such as the object's (near) surface. Once the RH drops below the salt's deliquescence point, the salt recrystalises (Howie, 1979; Walker, 1992).

Deliquescence occurs when a substance absorbs water from the atmosphere and subsequently dissolves into a solution (Brunton *et al.*, 1984; Erhardt and Mecklenburg, 1994). Halite (NaCl) is a prime example, entering solution at approximately 75% RH (Erhardt and Mecklenburg, 1994). When deliquescent conditions are temporary, the specimen may slump, round (Figure 2), or flatten whilst in a semi-liquid phase (Waller, 1992). But if permanent, the deliquescent mineral will cease to exist and adopt a liquid form.

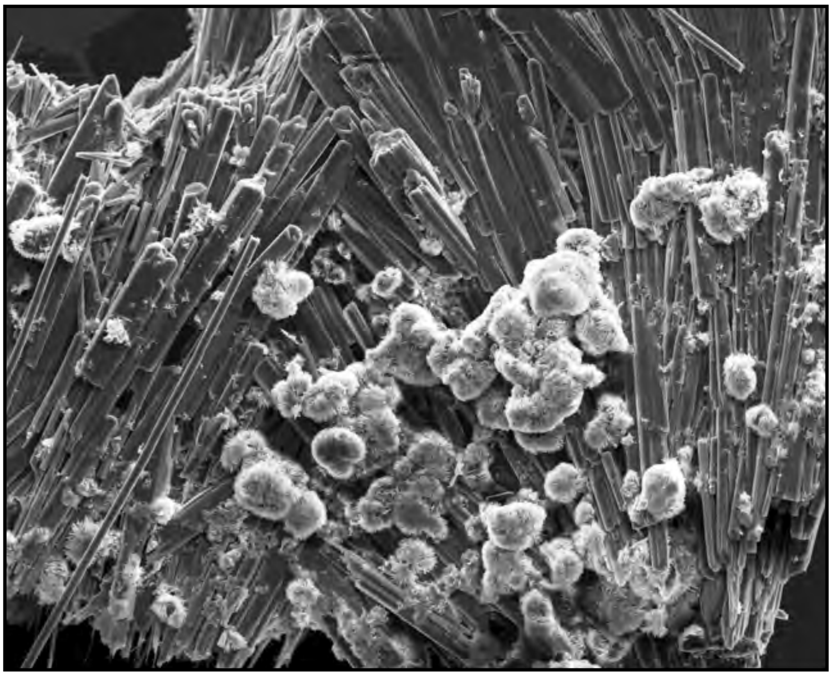

Figure 1. Electron micrograph of prismatic nesquehonite pseudomorphs after lansfordite (needles) and feathery hydromagnesite (globules). Image courtesy of Tom Cotterell, National Museum Cardiff.

Figure 2. Halite specimen which was subject to repeated cycles of high and low relative humidity, consequently partly deliquesced and now with rounded edges. Length of specimen: ca. 65mm. Image National Museum Cardiff.

Example: Pyrite

Pyrite is found in many rock types (Kullerud and Yoder, 1959; Howie, 1992b; Larkin, 2011) and is the most abundant metal sulfide on earth's surface (Kullerud and Yoder, 1959; Lowson, 1982; Eggleston *et al.*, 1996; Guevremont *et al.*, 1998; Rimstidt and Vaughan, 2003; Dos Santos *et al.*, 2016; Miles, 2019). Due to its abundance, pyrite is ubiquitous in geological collections as mineral specimens and as inclusions in rocks and fossils. In its various forms, pyrite is notoriously unstable, and its oxidation is the most commonly documented mineral deterioration process in museum collections.

A simplified description of the pyrite decay reaction is the oxidation of sulfide to sulfate in the presence of water and oxygen (Lowson, 1982; Guevremont *et al.*, 1998; Rosso *et al.*, 1999; Rimstidt and Vaughan, 2003). Oxidation rates may accelerate with increasing RH and surface area (Howie, 1992b; Larkin, 2011; Caracanhas Cavallari *et al.*, 2014). Various sulfates may be formed melanterite, copiapite, jarosite, gypsum, etc.) depending on specimen composition and moisture availability (Howie, 1992b; Jerz and Rimstidt, 2004; Rouchon *et al.*, 2004). The formation of these oxidation products is frequently associated with a volume expansion (q.v. Wiesse *et al.*, 1987; Howie, 1992b; Jerz and Rimstidt, 2004), inducing significant stresses within the surrounding material. These stresses are released through cracking and spalling (Figure 3), and may result in disintegration if deterioration is sufficiently sever (Wiese *et al.*, 1987; Howie, 1992b; Blount, 1993; Jerz and Rimstidt, 2004; Larkin, 2011; Miles, 2019). In addition, pyrite deterioration also produces sulfuric acid, which may damage other minerals, labels (Figure 3), and storage or display materials (Howie, 1992b; Larkin, 2011; Miles, 2019).

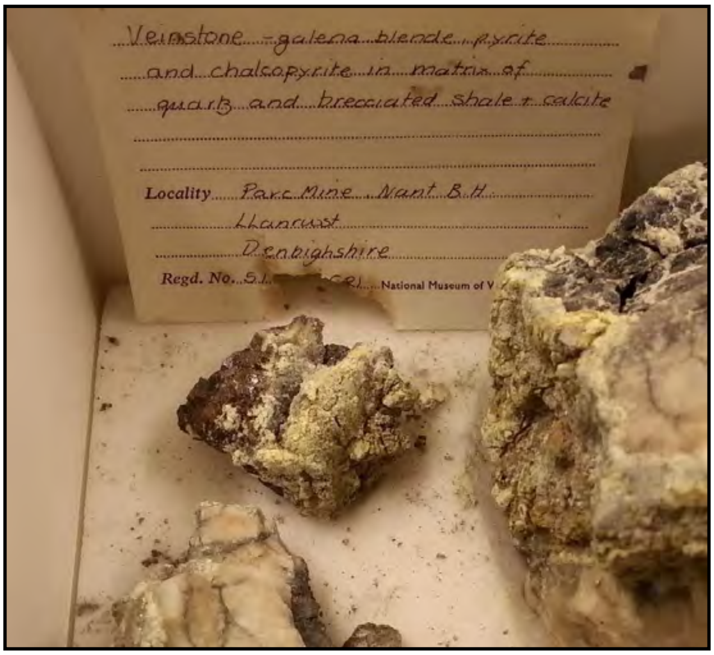

Figure 3. Image of a veinstone specimen affected by pyrite decay. Part of the specimen has spalled off. All parts feature characteristic yellow and white sulfate efflorescence. Also note the 'scorching' of the label caused by sulfuric acid, which has defaced the accession number, potentially resulting in dissociation of specimen and contextual information. Image National Museum Cardiff.

Light

Exposure of some mineral species to light may cause colour change or loss, or activate and accelerate reactions with other decay agents (Nassau, 1992). This sensitivity can be inherent to the mineral or be caused by the presence of elemental impurities or substitutions (e.g. cinnabar). Some colour changes may be reversible upon removal of the light source or through irradiation (Nassau, 1992; Horak, 1994), and usually do not alter the physical or chemical properties of the specimen. This is true for a number of quartz varieties (Rossman, 1994). However, light may cause chemical decomposition via the transition of one mineral into another - for example, realgar to pararealgar (Brunton *et al.*, 1984; Nassau, 1992) - or liberation of volatile elements, such as silver or mercury (Howie, 1992a; Nassau, 1992).

Pollutants

Atmospheric pollutants are unwanted gases or particulates that cause or accelerate deterioration. Internal sources of these pollutants include human activity, display and storage materials, and sometimes even geological specimens (Waller *et al.*, 2000; Eggert *et al.*, 2004; Stanley, 2004; Grzywacz, 2006). Some minerals may release sulfur, silver, copper, or mercury as volatile decay products (Howie, 1992a; Waller *et al.*, 2000). A well-known example of this is sulfide minerals, such as pyrite, which may release volatile sulfur acids upon oxidation (Howie, 1979b; Waller *et al.*, 2000; Lussier and Smith, 2007) that may damage adjacent minerals and materials (Waller *et al.*, 2000).

Example: Carboxylic Adids

Carboxylic acids (formic and acetic acids, formaldehyde, and acetaldehyde) are emitted from all wood and wood products, some adhesives, and common housing materials used for the display and storage of collections (Waller *et al.*, 2000; Grzywacz, 2006). These acids affect some metals (Tétreault *et al.*, 1998; Raychaudhuri and Brimblecombe, 2000; Tétreault *et al.*, 2003), and are documented to react with calcareous materials, such as ceramics, shells, and stone (Tennent and Baird, 1985; Child, 1994b; Waller *et al.*, 2000; Caracanhas Caallari *et al.*, 2014). This reaction, known as 'Byne's disease', occurs when calcareous material reacts with acetic or formic acid to produce white or grey efflorescent calcium acetate or formate salts (Fig. 4) on the specimen's surface (Tennent and Baird, 1985; Waller *et al.*, 2000; Caracanhas Cavallari *et al.*, 2014). As the relative humidity increases, atmospheric moisture can condense to form a layer of liquid water on the object's surface and penetrate porous materials, allowing for reactions to occur within the matrix. Salt crystallization within the specimen may cause volumetric expansion (Caracanhas Cavallari *et al.*, 2014), often resulting in the fracture (Figure 4) and decrepitation of the specimen.

Research agenda

Pyrite decay has been recorded as a problem for more than one hundred years (Parsons, 1922; Bannister, 1937; Torrens, 1977; Lowson, 1982). Its reputation stems not just from damaged museum specimens and collections, but also environmental effects through its role in acid mine drainage (Bonnissel-Gissinger *et al.*, 1998, Bigham and Nordstrom, 2000, Frost *et al.*, 2006, Qian *et al.*, 2017). Yet despite numerous - mainly observational - studies on pyrite decay, few publications address the initial catalyst and subsequent decay mechanisms in non-aqueous, relatively cool and dry environments such as those within museums.

Despite these gaps in knowledge, pyrite remains the best studied mineral. Many other environmentally susceptible mineral species have not been studied at all in relation to museum storage. It may be possible to glean potential conservation insights from the results of some stone, metal, and pigment deterioration studies (such as Scott, 1990; Scott, 2000; Cole *et al.*, 2004;

Figure 4. A calcite ($CaCO_3$) sample displaying spalling, cracking, and efflorescence following exposure to acetic acid within severe accelerated aging conditions.

Lussier and Smith, 2007), but such research is insufficient to fully resolve the difficulties posed by unstable geological specimens. The lack of published studies regarding the instability of geological materials reflects the state of knowledge concerning the care of geological collections more generally and has hindered the development of appropriate collection care strategies.

It is evident that we require a better understanding of the collection care needs of geological collections. As such, we have begun a four-year research project with the aim of addressing current knowledge gaps through identifying:

- which minerals are vulnerable to museum environments,
- the stability parameters for these mineral species, and
- potential preventive measures to ensure mineral longevity in museum collections.

To achieve this, it is important that we first define what is meant by 'damage'. Without a clear definition, it is impossible to draw the line between acceptable and unacceptable change. Consequently, it would be impossible to meaningfully measure whether change has indeed occurred without first determining what constitutes a significant change. Secondly, the efficacy of both interventive and preventive treatments require assessment. Are current methods effective and appropriate? Thirdly, condition and risk assessments are to be re-evaluated, along with current collection care standards, in order to better fulfil the needs of the collections and their caretakers.

Defining damage

'Damage' is a complex term in heritage and museum conservation. This is because it encompasses two aspects: the material and the intangible. The former is change to intrinsic properties - or the physical state - of an object (Ashley-Smith, 1995), which is often quantitatively perceptible and measurable. The latter regards perceived changes in value and use; extrinsic concepts applied to an object by its stakeholders (Ashley-Smith, 1999; Appelbaum, 2007).

To best embrace these two aspects, 'damage' may be defined as unacceptable degradation. The inclusion of the word 'unacceptable' (or 'undesirable'; Ashley-Smith 1995) acknowledges that there could be an acceptable amount of change that can occur before value is negatively affected (Appelbaum, 2007; Strlič *et al.*, 2013). It is important to determine what constitutes unacceptable change in order to define appropriate conditions and suggest when intervention and treatment becomes necessary (cf. Baars and Horak, 2018). One way to address this is a proposed 'plot of total damage' (Figure 5); a hypothetical solution requiring future exploration. Reflecting the above definition of damage, the 'plot of total damage' embraces both the quantitative and qualitative aspects of damage, graphically depicting the magnitude and perception of change that has occurred with 0-100 scales for each axis.

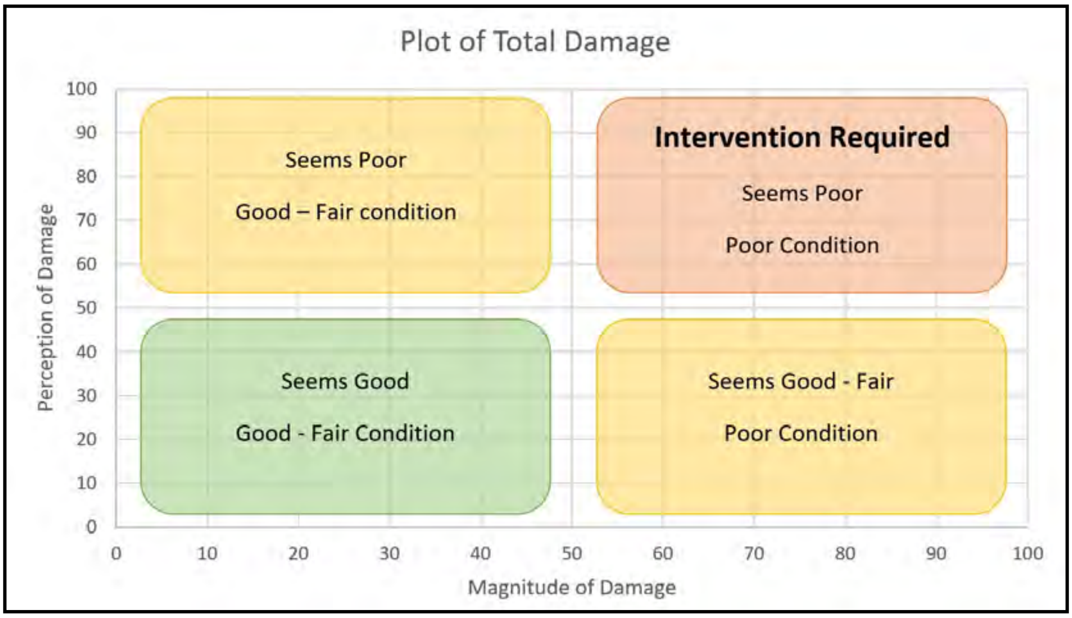

Figure 5. The 'Plot of Total Damage' - a graphic depiction of the proposed relationship between perceived and measured damage. Categories are roughly assigned to quadrants, but the actual thresholds have yet to be determined and may lie elsewhere on the plane.

The magnitude of change would be determined by the extent of change that has occurred to a specimen, identified by the qualitative, analytical study of the specimen's chemical, physical, and optical properties. Potential analytical techniques include:

- X-ray diffraction (XRD)
- Fourier transform infrared spectroscopy (FT-IR)
- Scanning electron microscopy (SEM) with energy dispersive x-ray analysis (EDX)
- Raman spectroscopy
- 3D imaging and reconstruction
- X-ray absorption near edge structure (XANES)

Of course, it is unrealistic to assume that all, if any, of the techniques listed above are available to the majority of museums. Even if they were, capacity limitations may preclude each new specimen being examined in detail. This is a very practical problem for the majority of museums and potentially affects the accuracy of species identification, which is crucial to determine the most appropriate storage conditions.

As for the other axis, damage perception may be defined more closely through discussion of common uses of geological collections, identifying how they are valued by different users, and at what degree of change a specimen become unusable. User involvement is crucial to determine intervention thresholds, as the value of a specimen may be considered to lie in contextual information (i.e. collector, locality, collection date) rather than the specimen itself (Allmon, 1994, Baars, 2010, Robb *et al.*, 2013). This is an area which requires further investigation, perhaps at a larger scale than previously studied (cf. Robb *et al.*, 2013).

With the two axes of the damage plot defined, it should then be possible to map the total damage of specimens or collections. If the total damage plot lies above the threshold of acceptability, intervention would be required. The current thinking is that this graph could assist in decision making and may lead to objective choices on intervention and prioritisation of treatments.

Condition surveys and risk assessments

A condition survey is an important collection management tool used to develop strategies and measures to preserve collections. It acts as the basis for recommending preventive conservation, maintenance, and immediate repairs. Routine surveys of collections for damage can only be undertaken if a consensus exists on observable damage indicators. Pyrite decay, for example, appears to manifest itself in tarnish, cracking, sulfurous odour, and efflorescence. If it can be proven that pyrite decay follows a sequence of changes that always starts with tarnish, followed by cracking and later by efflorescence, it would be possible to establish 'tarnish' as an early indicator of change. The certainty of tarnish being followed by further signs of damage would then trigger a response by the conservator or curator to intervene and undertake steps to prevent any further changes to the specimen. This relationship is currently not established for most minerals (Baars and Horak, 2018).

At present, condition surveys of geological collections rely heavily on non-objective methods, such as the visual examination of specimens by an experienced curator or conservator. The results of such assessments are subjective and therefore not necessarily comparable in time nor reproducible, even if undertaken by the same person, and less so across collections and museums if undertaken by different people (cf. 'intersurveyor differences' in Taylor, 2005). Focussing on chemical, physical, and optical changes to specimens - such as the presence and or absence of oxidation, hydration, or dehydration products that could be analysed non-invasively and in situ – would result in more objective determination of changes. Naturally, the technologies that enable such analyses would need to be affordable and easy to use, and accessible even to museums with limited specialist technical expertise.

It is, of course, impossible to determine retrospectively whether a particular specimen is damaged because it reacted in a linear fashion over a period of time to something, such as conditions of permanently elevated RH, or whether it responded catastrophically to a single short-term incident, such as a sudden and large fluctuation in RH. Therefore, a more nuanced approach is required to condition checking which would include the assessment of past storage conditions, where such data exist. Risk assessments can help categorise the vulnerability of parts of a collection and help target conservation resources most effectively. Whilst condition surveys provide information on a collection's current condition, risk assessments add predictive aspects regarding the collection's potential for deterioration. Probable causes of damage identified by a condition survey can be linked to the agents of deterioration identified by a risk assessment. Combining these two complementary assessments is a powerful tool to clarify priorities for the collection's management goals (Taylor, 2005; Fry *et al.*, 2007).

Conservation treatments

Whilst recommendations exist for strategies of how to protect vulnerable materials including minerals (Larkin, 2011), a systematic evaluation of the long-term success of packaging these materials in microenvironments is still outstanding. There is presently only circumstantial evidence (Fenlon and Petrera, 2019, Irving and Hadland, 2019) that the use of microenvironments in geological collections has brought about improvements in their long-term preservation. Contrastingly, there is some evidence that specimens sealed in microenvironments using barrier films with low gas permeability may suffer accelerated, sometimes catastrophic, damage compared to similar specimens stored in the same store but under ambient conditions (Tom Cotterell pers. comm. 2016).

Guidelines and standards

The aim of researching mineral deterioration is to establish standards that best reflect the needs of geological collections to increase their longevity and aid conservation measures. This is achieved through clear and specific recommended conditions that are tailored to each species. Guidelines for the care of museum objects almost always include recommended conditions specific to material type, such as paper, metals, or photographs (PAS198: 2012). Just as various types of photographs are stated to have their own ideal conditions, so do geological materials. This has been acknowledged to an extent in Appendix E of the 'Standards in the Museum Care of Geological Collections' (Stanley, 2004), dividing the RH and temperature recommendations by material type. While the table references some notable works (i.e. Waller, 1992, Shelton and Johnson, 1995), its brevity amplifies the lack of research. Only four categories of specimens are suggested: 'general', 'sensitive', 'pyrites and marcasites', and 'sub-fossil bone, tusks, teeth, fossils with shale or clay matrix'. These categories do not account for the complexity of geological materials and their requirements, as highlighted throughout 'The Care and Conservation of Geological Material' (Howie, 1992b), and are therefore insufficient. Additional guidelines were reviewed by Baars & Horak (2018) who concluded that addressing open questions in relation to the conservation of geological questions must result in updated sector guidance.

Conclusions

Caring for geological collections is neither as simple nor as straightforward as widely perceived. Geological materials are by no means collectively stable under typical museum storage and display conditions. At least 10% of known mineral species are vulnerable to environmental conditions (Howie, 1984, Waller, 1992), some even undergoing significant changes if conditions deviate from their stability limits. While pyrite and other sulfur mineral deterioration have been described in multiple case studies, the empirical research is still limited in scope and little published work can be directly applied to museum specimens. Many other vulnerable mineral species have yet to receive quantitative assessment of their stability parameters in the context of museum collections. Published guidelines for the management of geological materials are sparse and insufficient. Experimental investigations of decay mechanisms and environmental thresholds are needed to rectify this. This involves defining damage and how to assess and measure it, and evaluating conservation treatments. Lastly, conservation guidelines and standards need to be updated to reflect best practice based on comprehensive research. This is an undertaking that is likely to take a considerable amount of time and resources, but is necessary to ensure important improvements in the care and conservation of geological collections.

Acknowledgements

This work forms part of Kathryn Royce's postgraduate research project. We are grateful to Heather Viles (University of Oxford), Tom Cotterell and Jana Horak (both National Museum Wales) for encouragement and support. We would also like to thank the industrial partners, BSRIA and OR3D, and the project funders Engineering and Physical Sciences Research Council (EPSRC), Pilgrim Trust, Barbara Whatmore Charitable Trust, and National Conservation Service for their generous support.

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Anthrenus flavipes LeConte, 1854 (Coleoptera; Dermestidae); a destructive pest of natural history specimens

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Received: 21st July 2020

Accepted: 7th Jan 2021

Citation: Holloway, G. J., and Bakaloudis, D. 2021. *Anthrenus flavipes* LeConte, 1854 (Coleoptera; Dermestidae); a destructive pest of natural history specimens. *Journal of Natural Science Collections.* **8.** pp.39-43.

Abstract

An important component of integrated pest management is vigilance. There is always the scope for pest species from other parts of the world to become established outside of their natural range. Here we report on a damaging infestation of natural history specimens by the Dermestid beetle *Anthrenus flavipes* LeConte 1854. The beetles caused considerable damage to caprid horn in the collection of stuffed vertebrate specimens held in the Aristotle University of Thessaloniki, Greece. Identification features of *A. flavipes* are described and comparisons with other pest *Anthrenus* species made.

Keywords: *Anthrenus*, *verbasci*, *sarnicus*, *fuscus*, *museorum*, IPM, pest management, carpet beetle, taxidermy, horn

Introduction

Managing the threat from pest species of natural history collections is a continual occupation. The management of this threat in modern museums has developed into something of an art in the form of integrated pest management (Pinniger, 2015; Querner, 2015). Integrated pest management involves much more than simply destroying the pest insects that happen to be found. Attention is paid to the security of the buildings and cabinets in which the specimens are housed, temperature and relative humidity, pest numbers are continually monitored to intercept outbreaks quickly, and insect populations are controlled. Part of this process is the identification of pest species existing at low, background population levels, and responsible for any outbreaks. Appropriate management procedures are dependent on correct identification. All insect species exhibit different life histories and require different conditions to complete their life cycles. Consequently, misidentification could result in inappropriate management methods being deployed, perhaps even spending time, money, and resources dealing with a problem that does not really exist.

In the UK, the principle *Anthrenus* pests are *Anthrenus verbasci* Linnaeus 1767 and *A. sarnicus* Mroczkowski, 1963. *A. fuscus* Olivier, 1789 sometimes occurs in buildings, *A. museorum* Linnaeus, 1761 almost never does, but neither are generally serious pests in natural history museums. Holloway and Pinniger (2020) illustrate these species and how to distinguish between them. At more southerly, warmer latitudes, different *Anthrenus* species enter museums and can cause problems, such as *A. coloratus* Reitter, 1881 in Iran (Shahrabi *et al.*, 2018), Italy (Nardi and Háva, 2019), and Russia (Kovalenko, 2019), and *A. flavipes* Leconte, 1854 in India (Kumar *et al.*, 2013). Here we report on an infestation of *A. flavipes* in caprid horn held in the Aristotle University of Thessaloniki, Greece.

Natural History Collection Aristotle University of Thessaloniki, Greece

An extensive collection of stuffed animals is housed at the School of Forestry and Natural Environment in the Aristotle University of Thessaloniki, Greece. The building housing the collection (Figure 1) was opened in 1992 and the collection hall covers approximately 500m^2. The building sits amongst other university buildings within a forest-botanic garden. Prior to 1992, the specimens were scattered throughout the old university buildings, but in their current cabinets. Many of the specimens date from 1935-1950, although the caprids were added to the collection 2002-2005. The collection consists almost exclusively of vertebrates principally mammals (20 species) (Figure 2) and birds (236 species) (Figure 3), but also a small number of reptiles. As well as undergraduate students at the university, between 1200 and 1500 school children from the surrounding area visit the collection each year. All specimens have been very well prepared and presented, including some beautiful dioramas illustrating the avifauna and mammals associated with different habitats in Greece (Figure 4).

During a visit to the collection in May 2019, a heavy infestation of carpet beetles was noted in cases containing the skulls of different species of caprid (Figure 5). The pest species was subsequently identified as *A. flavipes*. The beetles had caused a great deal of damage (Figure 5). The larvae were concentrated in the younger keratin layers close to the bone whilst the tougher, outer horn was largely undamaged. The infestation must have been present for at least two years since

Figure 1. *Natural history collection, Aristotle University of Thessaloniki.*

Figure 2. *Cases containing stuffed mammals in the natural history collection, Aristotle University of Thessaloniki*

Figure 3. *A case containing stuffed birds in the natural history collection, Aristotle University of Thessaloniki.*

Figure 4. *A diorama illustrating typical avifauna in Greek wetlands, Aristotle University of Thessaloniki.*

***Figure 5**. Damage to horny material on wild goat (Capra aegagrus) skulls by* Anthrenus flavipes*, Aristotle University of Thessaloniki. Many larval exuviae and adult insects, along with dust from feeding activity, can be seen around the specimens.*

***Figure 6.** Wooden casing used to house natural history specimens, Aristotle University of Thessaloniki.*

many live larvae at different stages were present along with dead adults and the life cycle takes one year to complete in India (Kumar *et al*., 2013). It is not clear how the carpet beetles got into the caprid case. Although the case is never opened, it is unlikely that the caprids were introduced into the cabinet in an infested condition since they were brought into the collection at least 15 years ago. *Anthrenus* species are found on the wooded university campus, but mostly *A. verbasci* and *A. isabellinus* Küster 1848 (Holloway *et al*., 2020). Whilst *A. verbasci* is a serious museum pest, *A. isabellinus* is not.

All specimens are housed in wooden cases that consist of a box to raise the specimen(s) from ground level, a four-sided frame on top of the box with glass sides, and a heavy-duty piece of glass laid on top to close the top of the frame off (Figure 6). The specimens are inspected periodically by undergraduate students of Forestry and Natural Environment, but the specimens are never removed from the cabinets. Once a year, a routine inspection of the specimens is carried out. Pest insects are controlled using camphor and carbamate (Baygon). In addition, thermal pest management is sometimes carried out. Other than these annual treatments, no continual IPM activities are performed.

Identification of *Anthrenus flavipes*

Holloway and Pinniger (2020) described how to identify the species of *Anthrenus* likely to be found in museums in the UK. The common species encountered are *A. verbasci* and *A. sarnicus*. *A. fuscus* is occasionally found inside buildings. Despite the name, *A. museorum* is virtually never found indoors, at least in the UK.

Both *A. fuscus* and *A. museorum* are chocolate brown dorsally with some golden coloured scales (Holloway and Foster, 2018; Holloway and Pinniger, 2020). *A. sarnicus* has a greyish coloration and is, again, distinctive. *A. flavipes* has the same-coloured scales as many examples of the highly variable *A. verbasci*, but the dorsal colour patterns of the two species are different. Figure 7 shows examples of *A. flavipes* and *A. verbasci*. Both species possess black, white and orange scales (although note that some *A. verbasci* have largely only white/pale grey and black scales, whilst other examples might display black, white and yellow scales. See Holloway and Pinniger (2020) for colour pattern range). However, *A. flavipes* has a striking and quite beautiful colour pattern (Figures 7 and 8). The orange scales of *A. flavipes* are intensely coloured, whilst the white scales are dazzling, almost silver white, and arranged in well-defined spots along both elytra. The dorsal colour pattern of *A. verbasci* is highly variable (Holloway and Pinniger, 2020). There is very little colour pattern variation in *A. flavipes*, in particular all individuals retain the very obvious white spots on the dorsal side.

The scales on the ventral side of *A. flavipes* are bright, silvery white with golden scales along the legs (Figure 8). The scales on the ventral side of *A. verbasci* are greyer including the scales on the legs (Figure 8).

With access to a stereomicroscope, the shapes of the scales on the dorsal surface can be examined. There is considerable difference between the shapes of the scales of *A. flavipes* and *A. verbasci*. *A. flavipes* has broad, overlapping, leaf-shaped scales (Figure 9), whilst *A. verbasci* has narrow, lozenge-shaped scales (Figure 10).

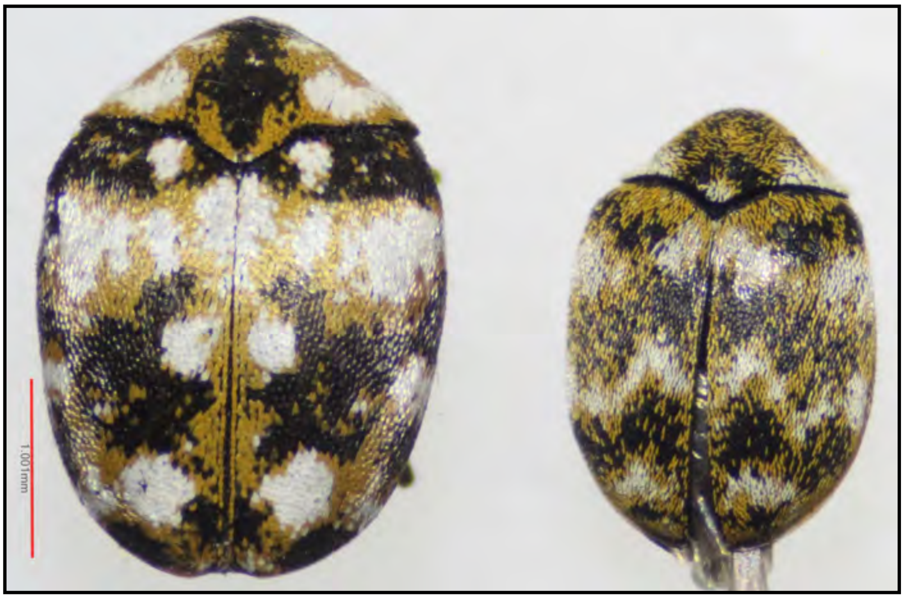

***Figure 7.** Dorsal surfaces of* Anthrenus flavipes *(left) and* Anthrenus verbasci *(right). Scale = 1mm.*

***Figure 8**. Ventral surfaces of* Anthrenus flavipes *(left) and* Anthrenus verbasci *(right)*

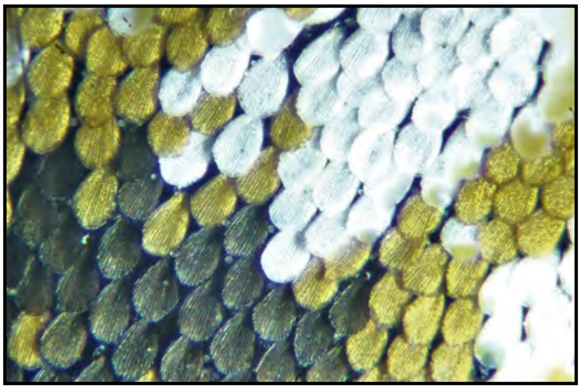

***Figure 9**.* Anthrenus flavipes *elytral scales (x200 magnification).*

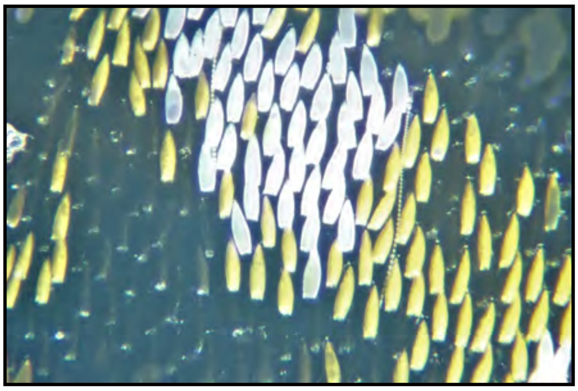

***Figure 10**.* Anthrenus verbasci *elytral scales (x200 magnification).*

A. flavipes are 20% longer than *A. verbasci*. *A. flavipes* averages 3.11±0.05mm (mean ± standard error, n=30) versus 2.57±0.04mm (n=30) for *A. verbasci*; the difference is statistically significant ($F_{1,58}$=68, $p<0.001$). 95% of *A. verbasci* are under 2.8mm long, whilst 95% of *A. flavipes* are over 2.8mm long. There is limited scope for size overlap.

Discussion

This account highlights how enormously destructive *A. flavipes* can be to natural history collections when left unchecked. As with many other species of Dermestidae, *A. flavipes* feeds on proteinaceous material as a larva (Modarres Awal, 1997; Beal, 2003), such as wool, leather, horn and some stored products. Given the right conditions, it is easy to see how it could be a problem in natural history (and other) collections.

A. flavipes is a species typical of hotter conditions. *A. flavipes* is known from India (Kumar *et al*., 2013) and Iran (Ghahari and Háva, 2017). In Europe it has been recorded from Italy (Nardi and Háva, 2013) in the Mediterranean region and further north in the Czech Republic (Háva 2011). In fact, it has also been recorded in the UK (Peacock, 1993), but only as an occasional import. Háva (2020) states that *A. flavipes* is sufficiently widely distributed to be considered cosmopolitan. Since it is a pest of stored products, it has been recorded in many countries as an import, such as the UK (Peacock, 1993). In the UK, there is no evidence that conditions are suitable to maintain a self-sustaining breeding population and as a result the species has been removed from the British list (Holloway, 2020).

The distributions of pest species in museums have been tracked with great accuracy and we know when most species entered the country and what their progress across the country looks like (see, http://www.whatseatingyourcollection.com/). For Dermestidae under wild conditions this level of detail is not available. Our knowledge of distribution is coarse, at a scale of individual countries with data derived from museum specimens (Háva, 2020). As far as we are aware, the distributional change of only one *Anthrenus* sp. across Europe has been considered, *A. angustefasciatus* (Foster and Holloway, 2015). Foster and Holloway (2015) suggested that the spread of *A. angustefaciatus* north and west across Europe could have been mediated by climate change with the species reaching the UK. This being the case, it is entirely possible that other species found naturally in warmer parts of Europe, such as *A. flavipes*, could spread north under their own volition. Where *A. flavipes* manages to establish self-sustaining breeding populations, the capacity for the species to develop into a serious pest of natural history collections is greatly enhanced. As always, museum workers should remain vigilant to the possibility that new pest species could enter the system and *A. flavipes* could be a most unwelcome newcomer.

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Legacies of colonial violence in natural history collections

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Received: 21st July 2020

Accepted: 7th Jan 2021

Citation: Ashby, J., and Machin, R. 2021. Legacies of colonial violence in natural history collections. *Journal of Natural Science Collections.* **8.** pp.44-54.

This paper includes references to terms and descriptions that may be culturally sensitive or are considered inappropriate today. Aboriginal and Torres Strait Islander people are advised that this paper contains names of individuals who are now deceased.

Abstract

Most stories told by natural history museums inevitably concern natural history, using collections to engage people with biological and geological mechanisms behind life on earth. Such institutions typically aim to inspire visitors and other audiences to care for the natural world. However, including narratives exploring troubling *social* histories attached to the acquisition of *natural* history specimens is an important step towards decolonising natural history museums. Telling these stories is vital in enabling museums to better reflect the societies they serve. In this paper we use the specific histories of two specimens as case studies that involve issues which museums interested in decolonising their collections could explore and share with their audiences. Through a gorilla in Leeds, we consider exploitative attitudes of colonial collectors and the legacy of collecting in today's distribution of natural heritage. Through a springhare in Cambridge, collected by a soldier at a British-run concentration camp during the Second Boer War, we demonstrate how extraordinary acts of military violence took place in amassing Western museum collections. Collecting at or beyond frontiers of imperial invasions can represent a particularly brutal aspect of already violent colonial histories. Finally, we consider the challenge museums face in tackling these issues, including the constraints faced by curators in undertaking research of this kind.

Keywords: Decolonisation, decolonial approaches; history of science; natural history; curation; museum interpretation; museum ethics; social justice; documentation; specimen-based research

Introduction

The involvement of natural history museums in the establishment and maintenance of structurally racist perspectives on history is becoming increasingly acknowledged and discussed within the sector, as demonstrated by the Natural Sciences Collections Association's *Decolonising Natural Science Collections* 2020 conference (papers from which will form a special edition of this journal in 2021; videos of the presentations themselves are available at http://natsca.org/natsca-decolonising). White European men's roles in natural historical discoveries, and the collection of specimens, have long been a disproportionate focus of interpretation in the sector. By contrast, the contributions of people of colour, and women, in those discoveries have often been omitted or underplayed. This view of history through an artificially white lens not only distorts history, passively perpetuating notions of white supremacy, but also disenfranchises non-white audiences (Das and Lowe, 2018). Many museums' visitor demographics do not represent the diversity of the communities they are intended to serve – for example the latest data from the Department of Digital, Culture, Media & Sport's *Taking Part* survey found that 'Black respondents were less likely to have visited museums in 2019/20 (28%) than White, Mixed and Asian respondents (46-63%), a similar trend to previous years' (Department for Digital, Culture Media and Sport, 2020) – and the biased representation of white-centred histories may be one reason why (Das and Lowe, 2018). Fortunately, there are a number of steps we can take to improve our interpretation and collections management with a hope to mitigate this. At the same time, the museum sector needs to develop robust evaluative tools to demonstrate whether decolonisation does indeed increase audience diversity.

Decolonial practice in museums involves addressing these historical imbalances in the narratives represented in museum galleries and programming (e.g. The Oxford Research Centre in the Humanities, 2020). Such activities are based on breaking down systemic hierarchies where European narratives have typically been considered superior to any others, for example by showing how colonised people's contributions have been side-lined in order to elevate European achievements, or when we go about exploring the ways that museum collections were put together based on unequal power balances as a product of empire. Archival research can uncover the colonial roots by which collections were amassed for museums, in order to inform interpretation. In this paper we revisit the more typical forms of colonial narratives associated with natural history collections, before moving onto more violent examples of where collections come from. The examples which follow are intended as potential case studies for how other museum researchers could approach decolonial practice in natural history museums.

Museums as colonial legacies

As European governments directed exploratory 'voyages of discovery' across the globe, beginning in earnest in the seventeenth century, knowledge of a country's natural history often equated to knowledge of the potential resources – be they animal, vegetable or mineral – that could be exploited there. The European colonial machine sought to identify and export these resources from colonised lands for imperial gain, and museum collections are repositories of their endeavours.

There are geographic biases to these collections. British museums, for example, are far better stocked with specimens from countries in the former British Empire than regions where Great Britain was not the colonial power, such as Russia and China. This is due both to the relative ease with which colonial officials, traders, teachers, missionaries, soldiers, farmers, doctors, miners, foresters etc. could travel to and through 'their' colonised territories and collect and export specimens, and to the political imperative to investigate the potential value of natural resources which could be exploited there (Ashby, 2017). In addition to the scientific and economic value tied to research specimens, game-hunting was another factor driving the opening of in-roads into countries' interiors (e.g. Evans, 1822) or closely followed initial settlement. Trophy specimens such as mounted heads and taxidermy specimens are a legacy of this activity (Machin, 2020).

In recent decades, museums have struggled to find ways to display mounted trophy heads within interpretative frameworks focusing on themes such as animal biology or the environment. The mission statements of twenty-first-century museums typically explicitly reference the institution's role in engaging audiences with the natural world and inspiring them to take action to protect it. Mounted heads are so obviously associated with hunting for pleasure that they arguably undermine museums' conservation messages unless carefully interpreted. These specimens have regularly been confined to storerooms rather than public display, presumably because they are increasingly considered distasteful (Wade, 2016). Strategies to more openly explore the social histories, as well as natural histories, of zoological collections could find a new use for these unfashionable specimens by making them a focus of decolonial interpretations. Rather than avoiding our colonial past in natural history galleries, looking at our collections from a decolonial perspective could help museums to reinterpret and update them for a broader diversity of audiences.

Mok the gorilla: exploitative attitudes

A popular specimen displayed in Leeds City Museum's (LEEDM) Life on Earth gallery is a western lowland gorilla *Gorilla gorilla gorilla* Savage, 1847, known as Mok, an abbreviation of Mo Koundje (LEEDM.C.1938.40.1.4079) (Figure 1). His articulated skeleton (LEEDM.C.1938.40.2.4080) is stored at Leeds Discovery Centre. He is unusual in the Life on Earth gallery in that his interpretation comprises information about his individual history, rather than more general information about gorillas. This gorilla is a good example of how the history

Figure 1. The taxidermy mount of Mok the Western Lowland Gorilla at Leeds City Museum. (LEEDM.C.1938.40.1.4079). © Leeds Museums and Galleries.

and interpretation of a museum specimen can be used to help visitors look more deeply at the legacy of colonialism. The current label reads: 'This is "Mok". He lived at London Zoo in the 1930s. You can see his skeleton at Leeds Museum Discovery Centre'. Mok's previous owner, André Charles Capagorry (1894-1981), was a colonial administrator in what was the French Congo, now Republic of the Congo (also known as Congo Brazzaville). He had kept Mok as a pet for two years, alongside a female gorilla named Moina Massa, before selling them to London Zoo in 1932. Details of Mok's life have been gathered from British and French press archives, archives of the Zoological Society of London, the Natural History Museum, London, and the Archives Nationales d'Outre-Mer, France. Mok's life, including his journey from Africa to London, and life at London Zoo, forms the focus of a future publication (Machin, in press).

Mo Koundje is thought to mean 'little chief' in a Congolese language (Boulenger, 1932). Using an African language to name the gorillas may simply have been a mark of respect to colonised Africans, or an acknowledgement of the gorilla's home country, comparable to the modern practice of European researchers giving African names to gorillas in habituated groups, or in zoos. However, it is also possible that Mo Koundje's name was meant to mock the appearance of the local people living under colonial control. For example, Merfield (1956) recounts being given a young gorilla who had been named after a 'particularly ugly chief' of a nearby village. While a pet, Mok was fed a 'European' diet, including food imported from France (Baker, 1932). It is likely that he was better fed and sheltered than most Congolese people under French rule, including those employed to help care for him. Accounts of gorillas kept as pets in colonial Africa include several examples of gorillas who ate with white families 'at table', using cutlery (e.g. Zwilling, 1956), and sleeping in beds in their white owners' houses (e.g. Geddes, 1955).

The existence of gorillas and other animals in British and other European museum collections is inextricably linked to colonialism, and violence. The more deeply colonisers penetrated the Congolese forests, attracted by ivory and other natural resources (MacKenzie, 2017), the more vulnerable gorillas became to human threats, including hunting for trophies, museum specimens and bushmeat, and conflict over resources. The impact on gorillas of collecting for museum collections is documented by hunters' accounts, and by gorillas' corporeal remains displayed in museums (e.g. Akeley, 1923; Merfield, 1957). But hunting expeditions also exerted huge tolls on colonised people in Africa and elsewhere. Hundreds of people travelled long distances from their homes and families, and paid meagre wages to work in dire conditions, undertaking work such as carrying heavy equipment for hundreds of miles, clearing undergrowth, or skinning and preserving carcasses. In Mary Hastings Bradley's (1922) account of Carl Akeley's (1864-1926) 1921-22 expedition to the former Belgian Congo (now the Democratic Republic of the Congo, also known as Congo Kinshasa) to film and collect gorillas for the American Museum of Natural History, the treatment of colonised Africans is all too often, albeit casually, laid bare, as they knowingly made African people vulnerable to exposure from cold, predation, exhaustion and malnutrition. Hundreds of African men, labelled as 'boys', were hired as porters, their status described by Bradley as 'voluble chattels'. Carrying huge volumes of unnecessary luxuries such as cups and saucers, tinned soft cheese and jam, porters subsisted on daily rations of basic food such as plantains. Bradley's five-year-old child accompanied the expedition, adding nothing to its scientific value but adding to the burden on other expedition members. White hunters were carried over rivers 'on the backs of the nearest natives'. It seems white hunters sometimes had more regard for the animals they were hunting than the welfare of the African people essential for the success of their expeditions. The goal of acquiring the gorillas wanted for the museum, and indeed personal hunting ambitions, seemed to take precedence over the humane treatment of African employees.

Despite the independence of African countries from European empires, the worldwide distribution of African natural history collections in museums in the global north, and their comparative lack in Africa, forms a colonial legacy that perpetuates an unequal power relationship. While many museums have gorilla remains in their collections, there is a dearth of gorilla material in African museums. For example, forty British museums contain gorilla material, compared to just seven in the whole of Africa, none of which are in countries where gorillas are native (Cooper and Hull, 2017). Researchers and the public in Britain continue to be able to access and learn from gorilla specimens such as Mok, while people in Republic of the Congo, his homeland, do not have access to any gorilla specimens in museums. Although natural heritage, in the form of museum specimens, is shared, it is not equally, nor fairly, distributed.

Recent advances have made data from biological specimens far more accessible wherever they are held in the world, through the sharing of genetic sequences and 3D- and surface-scanning data. Making these valuable data freely accessible through online repositories can be viewed as one way of decolonising natural history collections, by reducing barriers to access. In other parts of the museum sector, repatriation of objects to once-colonised countries is regularly discussed as one possible outcome of decolonisation work. It seems increasing likely that this could become more common in natural history museum discourses, in order to help return some of the natural heritage and its associated intellectual capital to countries of origin. The effects of colonialism on the conservation of endangered wildlife in Africa are ongoing (Garland, 2008). While museum curators in countries such as the UK often use collections to help inspire people to conserve biodiversity, perhaps we should consider the benefits they could bring to people (and biodiversity) in previously colonised nations.

Violence and collecting

Although the terms 'settlement' and 'settler' are commonly used when discussing the migration of European colonisers to colonised territories, this language suggests a gentle movement, rather like settling snow (similarly, 'collecting' serves as a sanitised euphemism for what most people call 'killing'). However, imperial expansion was a typically violent process involving military and non-military force, and/or the threat of it. As such, one approach to decolonisation could be for museums to acknowledge that violence against Indigenous peoples was one factor that ultimately led to the collection of specimens in their care. The causal strength of that link depends on the specific history of how they were collected and by whom. For instance, the people who collected specimens were either passive beneficiaries of the violence, collecting in a post-frontier landscape after Indigenous populations had been dispossessed of their land and/or sovereignty (although often in collaboration with them); or direct agents in it, simultaneously collecting and dispossessing. These two categories are not always easily separated, but here we explore different roles played by individuals operating in colonised regions, in amassing collections and contributing to the violence as examples to illustrate part of the spectrum of the links between violence and collecting.

Early European collecting in Australia

Shortly after the invasion of Australia by the British in 1788, Joseph Banks (1743-1820) employed and enlisted collectors to build natural historical knowledge of Britain's newly acquired lands. Banks himself had been the naturalist aboard the HMS *Endeavour*, under the command of James Cook (1728-1779), which arrived on the southeast coast of New Holland in April 1770. Although Aboriginal and Torres Strait Islander people had lived there for at least 60,000 years, Cook subsequently took possession of the east coast of what would become known as Australia for the Crown. As a result of two weeks of collecting plants around the location where they first made landfall, Cook renamed the site Botany Bay (its existing Indigenous name was Kundul). Banks then went on to recommend to parliament that Britain should establish a colony there (although when the First Fleet arrived in 1788, they were decidedly unimpressed with the site Banks suggested, and New South Wales was founded with a settlement slightly further round the coast at Port Jackson) (McHugh, 2006).

Banks maintained a close interest and control of Australian scientific discovery (Moyal, 1986). For example, he employed George Caley (1770-1829) to travel to New South Wales specifically to gather knowledge and specimens of the fledgling colony's natural history. He arrived in 1800 and the arrangement would last for eight years before Banks approved Caley's return home. Over 500 of Caley's botany specimens are now in London's Natural History Museum (Natural History Museum, 2020a).

Caley made the journey from England aboard the HMS *Speedy* along with Philip King (1758-1808), who was being installed as the colony's third Governor, and Caley stayed with King in Government House when they first arrived. Both men had been mentored by Banks, and both would write to him regularly with natural history updates throughout their time there (Olsen and Russell, 2019). It was King who sent Banks – and Europe – the first complete preserved specimen of the Platypus *Ornithorhynchus anatinus* Shaw, 1799, a species which had become a central interest of European naturalists. Banks had previously been sent platypus skin specimens by King's predecessor, Governor John Hunter, who was credited with the 'discovery' of the first specimen he sent, although in reality it had been caught by a Darug man Hunter had been watching (Home, 1802) (the Darug are a group of Indigenous Australians from the area that now incorporates Sydney).

Perhaps reflective of their different roles in the new settlements, Caley and King had very different approaches to relationships with the Indigenous population and how that interplayed with specimen -collecting. King and the people working under him used extreme violence to suppress Indigenous resistance to white settlement. As a result, the history of the platypus becomes associated with the actions of the man that supplied the landmark specimen.

In their exceptional 2019 book on Indigenous Australians' contributions to early zoology, *Australia's First Naturalists*, Penny Olsen and Lynette Russell describe how Pemulwuy (c.1750-1802), the Eora resistance-leader (Eora is the name given to the people whose country includes the areas that the British first settled, near what is now Sydney), had been shot dead in June 1802, after a reward had been offered for his killing. King sent his head as a trophy to Banks, writing, 'understanding that the possession of a New Hollander's head is among the desiderata, I have put it in spirits and forwarded it by the *Speedy*' (in Olsen and Russell, 2019). In essence, this suggests that King and Caley had been sent to Australia with a list of things that would be of interest to Banks (Banks was in the habit of providing such lists for his collectors in other parts of the world (Warren, 1958)), and that list included not only platypuses, but an Aboriginal person's head. King used the opportunity provided by the killing of Pemulwuy by the military to fulfil Banks' order. In requesting an Aboriginal person's head be sent to him in England, Banks must have been aware that this would most probably result from an act of deadly violence.

It would obviously be overstatement to imply that all colonial collecting was so closely linked to such violence. As a contrasting example, Caley was one of the Europeans in the colony who didn't want any of this unrest and made clear his intention to establish good terms in order to be able to exchange information about plants and animals in return for food and tools. Within two years he had learned enough language to communicate with a number of the local Eora groups and to an extent mixed freely with them. It is important to note, however, that this doesn't necessarily mean that Caley was trading with Aboriginal Australians on equal terms, and his attitudes were unquestionably paternalistic and proprietary (Olsen and Russell, 2019). Nonetheless, he protested that conflicts with 'the natives' – which he considered to mostly have been instigated by the colonisers – were hampering his ability to build the relationships he considered so vital to collecting facts and material to send back to Banks. Caley clearly appreciated the value of the natural historical insights of the Eora and other Darug people. He regularly mentioned by name such people who had contributed his understanding, particularly a young Darug man named Moowattin (c1791-1816) who became a close associate over many years (and went on to travel to England with Caley, however following his return he became the first Aboriginal person to be tried and hung in New South Wales, having been found guilty of rape – a crime he insisted he was innocent of), Narrang Jack (who was later proclaimed an 'Enem [y] to the Peace and good Order of Society' for resisting dispossession (Macquarie, 1816) and Cadingera. This mark of respect was often not practised by colonial naturalists around the world. He also told Banks that he 'could single out several that surpass numbers of Englishmen in mental qualifications' (Olsen and Russell, 2019). Collectors with a more egalitarian approach such as Caley – particularly when they name their collaborators – potentially offer museums the opportunity to communicate that people of colour played a major role in scientific discovery in their role as expert naturalists and collectors. This decolonial approach has the potential for a greater diversity of people to feel represented in museums and the history of science (Ashby, 2020).

Collecting in the act of colonisation

To date, the majority of the discourse around colonial collections has centred on stories dating from periods of established colonial rule, typically taking place within the frontiers of colonial settlements or where European administration and control was already well established but limited settlement took place (such as India). However, there is a subset of collections which date from the specific acts of invasion or the expansions of frontiers. These closer associations with colonial violence – in time, space and personnel – provide potential for particularly poignant examples for decolonial practice. Specimens collected by imperial military troops as they were taking possession of other countries represent the particularly brutal end of the spectrum linking museum collecting and violent colonial histories. These could be considered in a similar way to the punitive military expeditions, such as those in Benin, China and Abyssinia, which already form a significant part of the discourse around decolonisation more readily associated with other museum disciplines in the UK and other European countries. Because of their obvious association with acts of colonial violence, these specimens offer tangible foci for decolonial narratives, particularly for audiences that are relatively unfamiliar with museum interpretation exploring decolonisation.

A springhare from a Boer War concentration camp

One example of this kind of collecting is on display in the University Museum of Zoology, Cambridge (UMZC): a taxidermy specimen (UMZC E.1441) of a springhare *Pedetes capensis* Forster, 1778, a large hopping rodent from South Africa (Figure 2). It was collected at a British-run concentration camp during the Second Boer War (1899-1902), by a captain of the 5th Royal Irish Rifles, Gerald Edwin Hamilton Barrett-Hamilton (1871-1914).

Barrett-Hamilton was a child of empire, having been born in India to Irish parents. He went to school at Harrow and studied Natural Sciences at Trinity College, Cambridge. Barrett-Hamilton was later employed by the British Museum (Natural History) (BMNH, now the Natural History Museum (NHM)) and is celebrated as a naturalist, particularly for his contributions to the understanding of British mammals. Among his associates and collaborators were Alfred Newton (1829-1907) at Cambridge, M.R. Oldfield Thomas (1858-1929) at the BMNH and the polar explorer Edward Adrian Wilson who was a member of Scott and Shackleton's Antarctic expeditions (Moffat, 1914).

The springhare in Cambridge has the potential to be an effective specimen for exploring a narrative around the violent and oppressive histories that can be associated with natural history museum specimens. As it was collected in the twentieth century, there is less opportunity for the sanitising effects of time to remove audiences from the violence involved historic collecting.

The term Boer is used to describe colonists of Dutch, French Huguenot and German descent who had first invaded South Africa in the middle of the seventeenth century. In a context where different Indigenous groups had already been impacted by European colonisation, the Second Boer War was fought between two competing white colonial powers. It involved the subsequent invasion and annexation of the South African

Figure 2. The springhare from the University Museum of Zoology, Cambridge, which was collected in a British-run concentration camp (UMZC E.1441).
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Republic (Transvaal) and the Orange Free State by the British Empire, following the discovery of gold in the Transvaal, which the British wanted to exploit (BBC, 2010). As the Boer people fought back, the British worked to quash the resistance by employing Lord Kitchener's 'scorched earth' policy to depopulate the land, destroying homes and crops in order to flush out guerrilla fighters. The tactic removes the ability for fighters to receive shelter and provisions from family farms, effectively starving them out. However, it also renders the land uninhabitable by any of its other residents, in this case thousands of black Africans. In order to weaken the fighters, the British army, alongside troops from Canada, Australia and New Zealand, carried out an attack on civilians at a national scale, creating massive numbers of refugees. Unable to feed themselves, women and children, Boer men who were not fighting (often due to age) and black men were forced from their homes and their farms into concentration camps which were administrated by the British. Separate camps were established for black and white refugees (known as 'black camps' and 'white camps').

The conditions in the camps were abominable and those interred in camps were sometimes forced into labour (albeit paid) (Boer Concentration Camp, Project, n.d). By the end of the war, it was reported that 27,927 Boers (of which 22,074 were children under 16) (van Heyningen, 2015); and 14,154 black people (Lucking, 2004) had died of starvation, disease and exposure.

It was within this context that Barrett-Hamilton, stationed in South Africa as Instructor of Musketry, collected the Cambridge springhare. According to its documentation, it was captured in June 1901 at 'Vredefort Road, Orange River Colony'. Vredefort Road (or Vredefort-weg) was a concentration camp with both 'black camps' and 'white camps'. Records show that there was no water available within three miles of the camp, and very limited rations, which were often rotten. There were far too few tents for the number of people, and those they had were full of holes (Boer Concentration Camp Project, n.d.).

The collection of the springhare that is now in Cambridge was clearly not the result of an isolated opportunistic incident whereby Barrett-Hamilton took a chance to acquire a one-off specimen. Looking at collection records, it appears that that he was using his military deployment in the war to make a major scientific collection. The University Museum of Zoology, Cambridge, has a small number of additional specimens – a springhare (UMZC E.1442) and aardvark *Orycteropus afer* (Pallas, 1766) (UMZC E.1327, UMZC E.1338 and UMZC E.1339), which Barrett-Hamilton collected around Vredefort Road at this time. He donated a more significant collection from his Boer War deployment to the British Museum (Natural History), including over 1,100 birds (for example, NHMUK 1901.9.20.1-20 and NHMUK 1905.12.28.1-900) (Sharpe, 1906). Of these, around 300 are currently recorded as having been collected by him at this same camp in 1901 and 1902 (Natural History Museum, 2020c). (This count is intended to be illustrative of the scale of his wartime collecting – it was retrieved from the NHM Data Portal, which is not comprehensive and so many more may have originated from this location). In terms of logistics of how to transfer specimens overseas from a military garrison, the aardvark, at least, was sent to Cambridge via the British-born curator of the South African Museum, William Sclater (1863-1944) (Barrett-Hamilton also contributed specimens to the South African Museum, for example over 100 entomology specimens are listed on GBIF as having been collected by him, including from Vredefort Road (GBIF.org, 2020)).

Both receiving museums were aware of the military source of these collections. The UMZC Accession Register for September 3rd 1901 includes, 'at present serving with the forces in S. Africa' next to Barrett-Hamilton's name. An internal note from one of the curators to the Museum's superintendent comments on the arrival of the aardvark, making clear a link between military action and diminished conservation concerns: 'You know of course the beast is now vigorously protected and scheduled, but soldiers in Boer-land can and may do many things' (Gadow, 1901). A Natural History Museum list of donors includes this biographical line for him: 'In April, 1901, he accompanied his regiment, the 5th Battalion Royal Irish Rifles, to South Africa, and remained there till the close of the war. Being in charge of some of the block-houses, he utilised his leisure time in collecting specimens of natural history, and presented to the Museum a fine series of birds' (Sharpe, 1906). In addition to Vredefort Road, most of the other localities for his NHM specimens are also the sites of concentration camps (Bloemfontein, Heilbron, Kimberley, Klerksdorp, Nylstroom, Rhenoster, Roodewalspruit, Warrenton and Wolwehoek) (Natural History Museum, 2020b; Boer Concentration Camp Project, n.d.). This suggests that as he was posted at different military garrisons, he spent time specimen-collecting in his 'leisure time'. This all took place against the backdrop of a major refugee crisis which had been deliberately orchestrated by the destruction of homes and livelihoods, and in which over 40,000 civilians died in the camps alone (let alone civilian and fighter deaths outside the camps) (van Heyningen, 2017).

Discussion: Interpreting colonial violence

Collecting by active members of the military on assignment is not particularly unusual (see, for example, the wealth of objects in museums collected by soldiers and other employees of the East India Company (MacGregor, 2018). Nor is it surprising that soldiers spent their free time collecting as they explored their surroundings whilst posted abroad. And given that military expeditions provided clear opportunities to expand national collections, it is to be expected that museums welcomed the donations that resulted from them. However, any museum professional today knows that one of the most common questions we hear from our visitors is, 'How did you get all this stuff?'. It would be unreasonable to assume that most audiences were aware of the close links between museum collections and conflict.

As such, when museums have direct examples of which specimens were collected in this way, it provides an opportunity to tell these stories in an honest way. A key strand of public engagement work underway at UMZC (planned for when visitors can explore more freely after the end of restrictions related to covid-19 pandemic) is to introduce a series of trails and labels intended to diversify the range of voices represented in the galleries, co-produced with different partner groups. One will explore the colonial history of the collection, highlighting the diversity of people responsible for amassing the specimens (but who so far have not been well represented in museum interpretation) as well as the hitherto less-well communicated – often problematic – stories such as links with colonial violence, including the springhare. That specimen may also feature in a temporary exhibition organised across the University of Cambridge Museums about the legacies of empire.

Similarly, Leeds Museums and Galleries hope to include Mok's story and its links to colonial history in a temporary exhibition in 2021. Subject to successful funding bids, a proposed redevelopment of the Life on Earth gallery would take a decolonial approach, highlighting individual stories such as Mok's in ways that help visitors understand more about the legacies of colonial violence in our collections.

Discussion: How do natural historians come to learn these histories?

Incorporating decolonial interpretation of specimens like the above examples in museum galleries and programmes is likely to prove a significant challenge for the sector. This is not simply because it is likely to require changes to interpretation strategies, or expenditure on labels and text panels. Another, perhaps greater barrier is the resourcing of specialist research into collection histories.

This research is dependent on museum staff learning or identifying which parts of the collections are likely to benefit from a decolonial approach. This is not straightforward. It is unlikely that natural history museum staff principally trained in natural science subjects will have the background historical knowledge to automatically recognise relevant themes from the historical events associated with all the regions represented in their collections. Although the national curriculum for England (Department for Education, 2013) does now include 'follies of mankind', in primary schools, this is currently taught within the context of the Roman Empire, with no explicit mention made of the British Empire until secondary school (although doubtless many teachers do raise it as part of other topics). However, this is at least an improvement on the authors' history education, from which British colonial history was absent. Naturally, museum visitors of different ages and backgrounds will have different experiences depending on the local educational practice at the time, and their teachers' varying scope for individual choice of topics. Pupils of any generation would not be expected to learn all the facts about all instances in history during their education, however our point here is that biologically-trained curators looking at a specimen are less likely to instantly spot touch-points for a given decolonial or historical theme in the same way that they might spot a potential link to a given natural historical theme.

Research on Mok's story and its colonial links was predominantly undertaken outside of work hours, resulting from the author's (RM) personal interest in the subject. The history of pets as gorillas in colonial Africa now forms the focus of a PhD, and will feed back into the practice and public outputs of Leeds Museums and Galleries. Using the example of the springhare, the author (JA) was only made aware of the specimen's history through complete happenstance. Having posted a picture of the springhare on Twitter (completely unrelated to decolonisation), one respondent

(@Goatlips) chose to look the specimen up on the Museum's online catalogue. They saw the collection locality was recorded as 'Vredefort Road; Orange R. Colony' and replied to the tweet to point out that this was a Boer War concentration camp, and that the dates matched the period of the war. The author was completely ignorant of the details of the Boer War. Only as a result of this chance online interaction did this story come to light, which prompted further research into the history of the specimen, most of which took place outside of work time.

While this demonstrates the value of online engagement, the democratisation of knowledge and museums making their collections records available online, it also illustrates the challenge museums are facing. When tackling the transcription of data from thousands of specimen labels, in order to identify avenues for decolonial research we need to be aware that some place names used at the time of collection are no longer valid or appropriate. Some countries have been renamed since independence from empire, and old names or spellings of locations may become offensive. This becomes relevant for collections managers undertaking documentation. While some museum database software enables a distinction between original and updated geographical terms, others require curators to manage this information as best they can (online resources such as the Getty Thesaurus of Geographic Names (https://www.getty.edu/research/tools/vocabularies/tgn/) can be useful here).

Likewise, taxonomic terms curators may encounter could be problematic, by incorporating colonial or racist epithets. Others have pointed out the historical links between taxonomy and scientific racism generally (Das & Lowe, 2018). However, when a specific taxonomic name includes a racist term, should a specimen's documentation reflect this too? In any case such instances open up a further opportunity to engage audiences in a dialogue about the colonial narratives in museums. Other museum typologies have been treated in this way in museum disciplines outside of natural history. For example, the Labelling Matters project at the Pitt Rivers Museum explores potentially problematic language in an anthropological collection. It recognises that the labels themselves are an historical part of the objects, and 'thus the project is seeking ways to create interventions within the museum that does not erase the history of those labels but uses them to explore the processes, such as colonialism, that uphold hierarchical ideologies and stereotypes' (The Oxford Research Centre in the Humanities, 2020).

The intersection of documentation, collections management systems and decolonisation is an emerging discourse at this time, having regularly been mentioned at recent conferences (see e.g. the Collections Trust 2020 conference paper by Errol Francis, 'Decolonising the database' https://youtu.be/MbrC0yvBCNo), but with firm practices yet to be established.

Museum staff regularly come across the names of people and places on specimen labels that are novel to them – or taxonomic terms that they may not realise could be seen as problematic – and they are unlikely to be able to research every name and location they encounter. At present, time to research collections is hard to come by in most museum professionals' work plans, particularly when it is untargeted. Unless someone had opted to search for South African specimens collected during the years of the Boer War, it is extremely unlikely that the UMZC springhare's history would have been uncovered. And whilst Barrett-Hamilton is well known among historians of British mammalogy, his army career is not. It is hard to imagine how this specimen would have been identified as one for a decolonial approach through the narrowing of *a priori* parameters.

There are potential approaches that museums could take to actively search for colonial histories associated with their collections, such as systematically targeting individuals or locations of former colonies. Resources such as the database of slave-owners published by UCL (https://www.ucl.ac.uk/lbs/) could be useful tools or starting points for research. Nevertheless, given the breadth of potential locations across the former British Empire, and the number of people involved, museums are likely to need to delineate the scope of any investigations rather than start with a blank page.

If museums are serious about decolonising their collections, it will be necessary to resource time to research their specimen histories and collaborate with communities and specialists in other disciplines to help unlock and interpret the stories. Unless museum funders are to support such work to invest in decolonisation in a sustained way, museums may need to reallocate resources from other areas of work to achieve this.

Discussion: Additional outcomes for decolonisation

Decolonial practice in museum interpretation often seeks to break down systemic hierarchies which have elevated certain Eurocentric narratives above others. It is typical for the goals of such work to include better representing the contributions of a greater diversity of people in museums', science's and society's histories, particularly in order to better enfranchise people of colour. At the same time, more accurately telling the histories of our collections and institutions is considered vital – and morally necessary – in order to have honest conversations. Or put another way, to fail to do so would be dishonest and risks engendering mistrust between an institution and its intended audiences: it is simply the right thing to do. The implicit assumption behind these goals is that a primary audience for decolonisation work is people of colour or other groups who have traditionally been under-represented in these environments.

In thinking about the challenges facing museum staff with limited historical expertise – which in part is reflective of colonial biases remaining in school curricula – we identify a further benefit to decolonisation practice in museums and elsewhere. Decolonisation – as well as other practices related to equality and inclusion strategies – or actions in support of the Black Lives Matter movement, for instance – has experienced significant resistance from some members of the public. For example, calls to remove or reinterpret statues of problematic individuals have regularly met with accusations that history was being 'rewritten'. We suggest that such responses are, at times, a subconscious symptom of the ingrained, systemic narratives that subtly elevate notions of white supremacy and nationalism that decolonisation practice seeks to address. Because most people have been taught so little about the violent history of the British Empire, it is not surprising that many are resistant to actions that hold that history as their starting point.

As such, by more accurately representing troubling instances in British history (or other nations with similar imperial histories) in their displays, by telling the *social* histories of their specimens as well as the *natural* histories, museums can improve the general level of public knowledge about problematic instances in the country's past. We may hope that this encourages a better understanding of why this work is necessary. It is reasonable to suggest that resistance to decolonisation is based in part on a lack of knowledge of historic injustices. Museum curators have been found to be among the most trusted professionals in the UK (Kendall Adams, 2020). By being honest about their links to acts of colonial violence, invasion and oppression, museums have the opportunity to better inform the public about the true nature of British history. This isn't *retelling*, it's simply telling our story more accurately.

Acknowledgements

The authors would like to thank the museum and archive staff that were extremely helpful in providing collections information: Mathew Lowe at the University Museum of Zoology, Cambridge for locating the archival records of the springhare; Alex Bond at the Natural History Museum, London for his help in identifying Barrett-Hamilton specimens there; Mary Horodyski at the University of Manitoba Archives & Special Collections for attempting to find mention of his time in South Africa in Barrett-Hamilton's personal archives. Thanks also to Twitter-user @Goatlips for identifying the springhare's collection locality as a concentration camp. We are also very grateful for the anonymous peer reviewers and the Journal's editor to the suggestions they made which have led to an improved manuscript.

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The Edenhall Collection: the origins and composition of a sporting family's collection of bird and mammal taxidermy

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Received: 24th June 2020

Accepted: 27th Jan 2021

Citation: Jackson, S., and Sellers, R. M. 2021. The Edenhall Collection: the origins and composition of a sporting family's collection of bird and mammal taxidermy. *Journal of Natural Science Collections.* **8.** pp.55-65.

Abstract

Two generations of the Musgrave family of Edenhall near Penrith, in what was then Cumberland, assembled a collection of bird and mammal taxidermy between about 1830 and 1880. When the estate was sold in the 1920's, a substantial part of this material was donated to Tullie House Museum and Art Gallery in Carlisle where it forms part of the Museum's taxidermy collection. The bulk of the latter collection originated from specimens donated by naturalists but the Edenhall material is unusual in that it was created by people who were primarily sportsmen rather than true naturalists. This paper describes the composition and geographical origins of the Edenhall Collection based on a catalogue prepared by Museum staff at the time it was donated to the Museum. In total the Edenhall Collection comprised 154 specimens of 111 species of bird and 15 specimens of 10 species of mammal. Of those for which the locality was recorded, the majority had been obtained in Cumberland with a lesser but still significant proportion from Caithness in the north of Scotland, together with a small number from other areas. Around 38% of the bird specimens, however, were of unknown provenance but most were probably from Cumberland. Birds of prey and quarry species were well represented and so too were ardeids (herons, bitterns and egrets); by contrast small birds, mainly passerines, were under-represented. The collection also contained a number of locally-taken rarities, notably Honey-buzzard *Pernis apivorus* (Linnaeus, 1758) and Two-barred Crossbill *Loxia leucoptera* Gmelin, 1789, as well as the first Lakeland records of Purple Heron *Ardea purpurea* Linnaeus, 1766 and Squacco Heron *Ardeola ralloides* (Scopoli, 1769). Overall, about a half of all the bird species represented were those with small local populations and which were therefore most at risk from shooting and associated pursuits.

Keywords: birds, mammals, taxidermy, skins, collections, sportsmen, Cumberland, Caithness

Introduction

Tullie House Museum and Art Gallery in Carlisle has a collection of approximately 4,500 bird and mammal skins and taxidermy specimens, which forms part of the Arts Council England Designated Natural Science Collection (see Jackson, 2020 for a description of the overall Designated Collections). Much of this material was donated to the Museum by amateur and professional naturalists, ornithologists or mammalogists. One substantial donation was the Edenhall Collection assembled by the Musgrave family, owners of a large estate near Penrith, in what was then Cumberland, and who were primarily sportsmen, with some interest in the natural world. The composition of these private collections, particularly those assembled by persons who were not naturalists in the true sense of the word, has received little attention from historians of natural history, yet sportsmen were one of the five main groups of people (the others were gamekeepers, collectors (including naturalists), gunners and trappers, although some overlap between these various categories existed) responsible for much of the direct destruction of wildlife that took place in Britain between the middle of the eighteenth century and the middle of the twentieth century (see, for instance, Bourne, 2006; Lovegrove, 2007; Shrubb, 2013). Here we describe a case study of the composition and origins of a provincial collection of bird and mammal taxidermy based on the Edenhall Collection assembled over two generations by a family of wealthy landowners who were primarily sportsmen.

Catalogue of the Edenhall Collection

When a substantial part of the Edenhall Collection was donated to the, then, Carlisle Museum in 1927 (accessioned as CALMG:1927.42) a summary of its contents was prepared, and it is to this document that the 'Catalogue of the Edenhall Collection' refers (with the same accession number as the rest of the collection), or, to give it its formal title, the 'List of Birds Presented by Sir Nigel Courtenay Musgrave to Carlisle Museum in 1927'. In practice, it lists all birds and mammals in the collection, differentiating between those accepted into the Museum's collection ("Specimens Retained Mounted and Placed in the Museum Habitat Groups", and "Specimens Reduced to Cabinet Skins", those destroyed because they were in poor condition, and those retained by the Musgraves. The document is currently held in the natural history archive at Tullie House, and because of its poor condition, we have prepared a transcript of its contents (further details in Jackson and Sellers, 2020). Although this version was clearly prepared by Museum staff, the 'Preface' states that the main (first) list was probably based on an earlier one drawn up by Sir Richard Courtenay Musgrave. The remaining sections were presumably based upon information provided by the Musgrave family, but were not transcribed verbatim, as different common names for species are used whilst mistakes were corrected. Tucked loose inside the catalogue is a two page, handwritten letter from Mrs Hope to her son, L.E.Hope, the Museum's Director at the time, providing some information about how one of the birds, a Gyr Falcon *Falco rusticolus* Linnaeus, 1758, came to be in the Edenhall Collection.

Many of the catalogue entries provide at least some information about the provenance of the specimens. This includes 102 specimens (60% of the collection) with locality details. In rare cases, dates are also included (for 11 specimens or 6.5% of the collection). Collector information is known for 36 specimens (21%), and where this is not known, the acquisition source (*e.g.* purchased from) is listed for a further 11 specimens (6.5% of the collection). Additionally, details are often recorded for how the specimens were collected. This is known for 103 specimens (61% of the collection), and in all but one case (where the specimen was found dead), the individuals were killed (documented as "killed", "shot", or "trapped"; see Discussion). Collecting method details are not known for the remaining 39%.

Unfortunately, there are some inconsistencies between the various lists in the catalogue. For instance, a Honey-buzzard *P. apivorus*, taken at Netherby, Cumberland, is listed in the 'Specimens not included in the gift to the Museum' section of the catalogue, yet what is plainly the same bird is shown in the Museum's records as Accession No. CALMG:1927.42.15. In view of these discrepancies, and to provide a clear basis on which to analyse the data, we have prepared our own list of the contents of the collection and its 169 specimens. This provides our best estimates of the number of specimens for each individual species, and their assumed fates; further details are given with the transcript of the Edenhall catalogue (Jackson and Sellers, 2020) and are summarised here in Appendices I and II.

History of the Edenhall Collection

The 'Preface' to the catalogue states that the collection was started by Sir George Musgrave, Bt (1799-1872). It comprised mainly birds taken from the area around Edenhall, between about 1830 and 1880 (roughly the period between when Sir George Musgrave was a young man and the death of the younger of his sons who shared his interest in birds and mammals) and probably shot on the Edenhall Estate itself, which extended almost as far north as Armathwaite, 15 km from Edenhall. Philip Turner, a taxidermist in nearby Penrith, active in the 1840s and 1850s, is credited with having preserved and mounted this early material (see also Sellers, 2018b). The collection was added to by two of Sir George's sons, Philip Musgrave (1833 -1859) and his younger brother Sir Richard Courtenay Musgrave (1838-1881). The latter is credited with having contributed 18 specimens, some from Lakeland (the modern-day county of Cumbria, as defined in Sellers and Hewitt, 2020), others from Caithness, an area popular with

English sportsmen in the second half of the nineteenth century. The family did not, however, supply all the material in the collection; some were gifts from friends or acquaintances, and there were seven specimens which had been purchased from Henry Shaw of Shrewsbury, a well-known Victorian taxidermist (Morris, 2010).

The catalogue provides limited information on the original style of the collection. However, the various different categories of the catalogue (described above) indicate that they were all initially mounted (apart from one, the Pine Marten *Martes martes* (Linnaeus, 1758), for which information is wanting (Museum records indicate that the specimen was reduced to a skull). Furthermore, the final section of the catalogue, provides a list of specimens which were essentially in cases, which number 65 of the specimens. Some of the specimens including herons, were cased on either side of the inner doorway in the Edenhall entrance hall, forming a fine decoration to the elegant mansion (Fig. 1). This shows two displays of taxidermy birds, many of which appear to be either herons, egrets or bitterns (Ardeidae). Of the seven larger birds depicted, at least five show characteristics of Grey Herons *Ardea cinerea* Linnaeus, 1758, a sixth (the upper bird on the right of the display to the left of the doorway) has the darker plumage and long,

Figure 1. A photograph dating from c.1910 of the doorway between the main entrance hall and the inner hall at Edenhall, showing two displays of taxidermy birds, many of which appear to be either herons, egrets or bitterns (see also comments in text). © Penrith and Eden Museum (Eden District Council).

fine bill typical of a Purple Heron *A. purpurea*), whilst the seventh (at the left-hand side of this same display) is possibly a Bittern *Botaurus stellaris* (Linnaeus, 1758). The catalogue, however, lists only one of each of these three species. Why this material failed to get mentioned in the catalogue, and what happened to it subsequently is a mystery. Of the ten small to medium-sized birds in the photograph, six appear to be herons, bitterns or egrets. It has not been possible to identify the species shown, but the total is consistent with what is quoted in the catalogue.

Composition and Significance of the Edenhall Collection

In total, the catalogue makes reference to 169 specimens: 154 specimens of 111 species of bird, and 15 specimens of 10 species of mammal. According to the catalogue, 72 specimens were not given to the Museum. However, 10 of these have been accessioned, indicating error in the original transcription of the catalogue. This means 62 specimens, or 37%, were actually not given to the Museum. Of the remaining 107 specimens (63%) which were given to the Museum, 60 specimens (36% of the entire collection) were disposed of (according to the catalogue these included specimens listed as being "destroyed as spoiled through being sunbleached, or by decay"). This left 47 specimens (28%) in the Museum collections (see Appendix I and II), and intriguingly this included such rarities such as the Squacco Heron *A. ralloides* and Purple Heron *A. purpurea*. The Musgraves retained virtually all the mammals (apart from the Polecat *Mustela putorius* Linnaeus, 1758 and Pine Marten *M. martes*), though, for unknown reasons these were also destroyed.

Of the 154 bird specimens, 61 (40%) were definitely obtained in Lakeland, 27 (18%) from Caithness and 8 (5%) from elsewhere. For the remaining 58 (38%) bird specimens no details of locality have survived, but, as the 'Preface' to the catalogue notes, the bulk of the material was taken on the Musgrave's estate and we conclude that much of the material of unknown provenance was likely to have been taken locally. Most species (69% birds, 70% mammals) are represented by only one specimen. Therefore, only the remaining approximately 30% of species are represented by two to four specimens (duplicates). Only two species, Ptarmigan *Lagopus muta* (Montin,1776) and Otter *Lutra lutra* (Linnaeus, 1758), are represented by four specimens. Amongst the birds, the duplicates are where male and female plumage differs, Sparrowhawk *Accipiter nisus* (Linnaeus, 1758) being a typical example, or in which breeding and winter plumages differ, as in the Ptarmigan *L. muta*.

The sex is known (documented) for 61 of the 154 bird specimens. Overall, there are more male specimens (38) than female (23), which represent 33 and 21 species respectively. The 'wildfowl' especially include many male representatives, for instance, there are seven 'duck' (Anatidae) species only represented by males. In the case of the Ruff *Calidris pugnax* (Linnaeus, 1758), all three specimens are male. The picture is more complex for 'birds of prey'. There are only male examples of some species including Golden Eagle *Aquila chrysaetos* (Linnaeus, 1758), White-tailed Eagle *Haliaeetus albicilla* (Linnaeus, 1758) and Hobby *Falco subbuteo* Linnaeus, 1758, but for the Peregrine *Falco peregrinus* Tunstall, 1771 and Merlin *Falco columbarius* Linnaeus, 1758, female specimens out-number those of males by 2 to 1, and the only Goshawk *Accipiter gentilis* (Linnaeus, 1758) specimen, for which sex has been documented, is female (Fig. 2). Thus although there is an overall bias towards males in the collection, this varies between taxonomic groups.

Figure 2. Skin of a second winter, female Goshawk A. gentilis*, taken at Berriedale, Caithness in the 19th century; originally part of the Edenhall Collection and now part of the Tullie House Museum Collection (Accession No. CALMG 1927.42.12). (© Tullie House Museum and Art Gallery, image taken by Robin Sellers).*

Table 1 shows the composition of the collection, using the sort of categories Victorian sportsmen might have recognised, rather than according to formal taxonomic groupings (although there are clear similarities between the two). Birds of prey, both diurnal and nocturnal, are well represented, comprising up to 25% of the collection in terms of the number of specimens, with all the species on the Cumbria county list being included except Black Kite *Milvus migrans* (Boddaert, 1783) (*cf.* Sellers, 2015), though not necessarily by locally taken examples. Much the same is true of the bitterns, egrets and herons (order Pelecaniformes, family Ardeidae), with eight of the nine species recorded in Cumbria being found in the Edenhall Collection, the exception being the Great White Egret *Ardea alba* Linnaeus, 1758. Quarry species including gamebirds, wildfowl and waders are reasonably well represented, and make up almost half of the collection in terms of the number of specimens. However, there are some curious omissions – no Grey Partridges *Perdix perdix* (Linnaeus, 1758), Pheasants *Phasianus colchicus* Linnaeus, 1758 or Mallard *Anas platyrhynchos* Linnaeus, 1758, for instance. Divers and grebes are also almost fully represented, as are auks, but other seabirds less well, with just two species of gull, one skua and no terns. Passerines, which constituted around half of all bird species in Lakeland in the nineteenth century, have just eight representatives, whilst there are just four small birds (taken to be birds with weights <30 g), namely Nuthatch *Sitta europaea* Linnaeus, 1758, Crossbill *Loxia curvirostra* Linnaeus, 1758, Two-barred Crossbill *L. leucoptera* and Snow Bunting *Plectrophenax nivalis* (Linnaeus, 1758). A further four species belong to three other orders (the 'near passerines'), all poorly represented in Lakeland.

Rarities in the collection

The entire collection included a number of rare birds (following, for example, Dymond *et al.,* 1989). These include either vagrants (birds outside their normal breeding or wintering ranges, or away from their usual migration routes) or species with very small local populations. The catalogue draws attention to three, Purple Heron *A. purpurea* and Squacco Heron *A. ralloides*, both of which were the first of their kind to be taken in Lakeland, and Rough-legged Buzzard *Buteo lagopus* (Pontoppidan, 1763), which in the nineteenth century was probably better characterised as an occasional winter visitor and passage migrant in both Lakeland and Caithness rather than a true vagrant (comments on status based on Macpherson (1892) for Lakeland, and Harvie-Brown and Buckley (1887) for Caithness).

Grouping	Taxonomic Order	Percentage of bird specimens in entire collection (n=154)	Percentage of bird species in entire collection (n=111)
Wildfowl	Anseriformes	18	17
Gamebirds	Galliformes	7	5
Divers and grebes	Gaviiformes, Podicipediformes	7	5
Seabirds	Procellariiformes, Suliformes, Charadriiformes (families Laridae, Stercoridae and Alcidae)	9	9
Herons & rails	Pelecaniformes, Gruiformes	8	11
Birds of Prey	Accipitriformes, Strigiformes, Falconiformes	25	23
Waders	Charadriiformes (families Haematopodidae, Recurvirostridae and Charadriidae)	16	19
Near passerines	Coraciiformes, Bucerotiformes, Piciformes	3	4
Passerines	Passeriformes	7	7

Table 1. Composition of principal groupings of birds in the Edenhall Collection.

Other rarities included the following:

from Lakeland: Osprey *Pandion haliaetus* Osprey *Pandion haliaetus* (Linnaeus, 1758), Honey-buzzard *P. apivorus*, Great Northern Diver *Gavia immer* (Brünnich, 1764), Slavonian Grebe *Podiceps auritus* (Linnaeus, 1758), Spotted Crake *Porzana porzana* (Linnaeus, 1766), Gyr Falcon *F. rusticolus*, Goshawk *A. gentilis*, Marsh Harrier *Circus aeruginosus* (Linnaeus, 1758) (which appears to have been not uncommon as a breeding bird in Lakeland at the beginning of the nineteenth century but was considered a rarity by the century's end), Montagu's Harrier *Circus pygargus* (Linnaeus, 1758) and Two-barred Crossbill *L. leucoptera*.

from Caithness: Goshawk *A. gentilis*.

Provenance unknown: Harlequin Duck *Histrionicus histrionicus* (Linnaeus, 1758), Little Bittern *Ixobrychus minutus* (Linnaeus, 1766), Night-heron *Nycticorax nycticorax* (Linnaeus, 1758), Cattle Egret *Bubulcus ibis* (Linnaeus, 1758), Little Egret *Egretta garzetta* (Linnaeus, 1766), Red Kite *Milvus milvus* (Linnaeus, 1758), Great Snipe *Gallinago media* (Latham, 1787), Wood Sandpiper *Tringa glareola* Linnaeus, 1758, Little Auk *Alle alle* (Linnaeus, 1758), Scops Owl *Otus scops* (Linnaeus, 1758) and Tengmalm's Owl *Aegolius funereus* (Linnaeus, 1758).

The Goshawk, *A. gentilis* from Caithness (Figure 2) is of particular significance, being only the third fully authenticated nineteenth century record of that species from the area. It was a second year female with unusually long wings and appears to have been a bird from the north of the species' European range, that is, from Scandinavia (further details in Sellers, 2018a).

Overall 23 (21%) of the bird species in the collection were vagrants and as such would have been regarded as rarities in the nineteenth century, and, with the exception of the Little Egret *E. garzetta*, which colonised Britain in the 1990s (Balmer *et al.*, 2013), are still regarded as such. A substantial proportion of the remaining species had either small local breeding or wintering populations (for present purposes taken to be respectively <150 breeding pairs or <300 birds) or to have occurred in Lakeland on passage in limited numbers (<300 birds present at any one time). These potentially 'at risk' species (see Appendix I) with their frequency of occurrence is shown in Figure 3. Around half (57 of 111 or 51%) of the bird species represented were those most likely to have been 'at risk' of being affected by collecting.

The collection may formerly have included several additional specimens, for a receipt dated 27th December 1850 exists for several specimens preserved for Sir George Musgrave by Philip Turner, the taxidermist in Penrith (Sellers, 2018b). They include the following not mentioned in the catalogue: an Eider *Somateria mollissima* (Linnaeus, 1758), a Ruff *C. pugnax* (three are listed, but the receipt refers to four specimens), a 'globe of foreign birds', a Rabbit *Oryctolagus cuniculus* (Linnaeus, 1758) and a 'chamelion', probably the Common Chameleon *Chamaeleo chamaeleon* (Linnaeus, 1758). What happened to these additional specimens is unknown, but it seems likely that they were either exchanged with other collectors, given away as gifts, or, having being subject to decay, were destroyed. This applies also to four of the seven large ardeids shown in Figure 1 (tentatively identified as Grey Herons *A. cinerea*) not mentioned in the catalogue.

The much smaller number of mammals in the collection includes at least three species (Otter *L. lutra*, Pine Marten *M. martes* and Polecat *M. putorius*, *cf.* Appendix II) with small and potentially vulnerable populations; all three subsequently went extinct in Lakeland, but are slowly making a comeback with more enlightened attitudes to nature conservation. Although little quantitative data is available, it is likely that Red Squirrels *Sciurus vulgaris* Linnaeus, 1758 were quite widespread in Lakeland in the past but in decline (Macpherson, 1892). A fifth species, the Wildcat *Felis sylvestris* Schreber, 1777, may once have occurred in Lakeland but had been eradicated before the Musgraves began collecting (Macpherson, 1892); the example in their collection had been acquired from Scotland.

The Musgraves do not appear to have made any attempt to publish the particulars of the more unusual birds they had collected (their name does not appear in a bibliography of Cumbrian ornithology, for instance, *cf.* Sellers *et al.*, 2017). Details of a number of the rarities listed above did, nevertheless, become known to the leading British naturalists of the day. The Squacco Heron *A. ralloides* is referred to by Yarrell (1856) in his *A History of British Birds* and he records that he obtained his information about it from T. C. Heysham, the leading Lakeland ornithologist of the period, and who in turn had learned about it from 'a communication between Sir George Musgrave and Mr Jesse', though who Mr Jesse was is not known. Gould (1873b), writing almost a generation later, also makes reference to this bird, but he had obtained his information direct from Sir George's son, R. C. Musgrave, in 1865, presumably having become aware of the connection through Yarrell's book. The suspicion is that the Musgraves

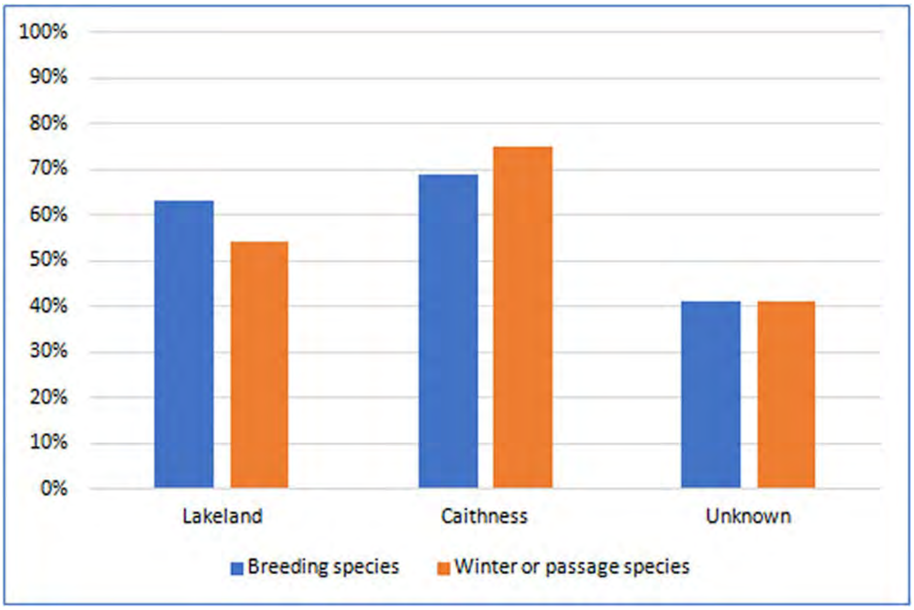

Figure 3 Frequency of occurrence of bird species potentially at risk in relation to where collected.

were unsure of the identification of this bird (it was the first to be found in Lakeland, and one of the first in Britain) and that they had made representation to 'Mr Jesse', and perhaps others, to help determine or confirm just what species it was. The Purple Heron *A. purpurea* seems to have come to light in correspondence between Gould and R. C. Musgrave sometime before 1870, most likely following the initial contact over the Squacco Heron *A. ralloides* (Gould,1873a). The Gyr Falcon (*F. rusticolus*) in the collection had originally been taken by a poacher (this is evident from the letter tucked into the catalogue) and had been preserved by Thomas Hope, another taxidermist in nearby Penrith (and father of L. E. Hope, the Director at the then Carlisle Museum). It was purchased from Hope Senior by Sir George Musgrave, a fact reported by H. Harrison (1866) in a letter to *The Zoologist* in which he notes that he had himself tried to purchase the bird, only to discover that it had already been sold. He does not say how he had become aware of the bird. Details of most of the other rarities did not appear in print until the publication of Macpherson's *A Vertebrate Fauna of Lakeland* in 1892.

Discussion

Quite what induced Sir George Musgrave to begin collecting birds and mammals is not on record, but it was something that many of his contemporaries among the landed gentry and well-to-do did. He used the material he acquired to decorate his home at Edenhall, a practice which his sons continued. These cases of taxidermy birds and mammals were, in part, marks of his status, wealth (the costs of having animals preserved by professional taxidermists were considerable, for example see Morris, 2010), his prowess as a sportsman, mementoes of time spent in the field or activities on the Edenhall Estate and, no doubt, reflected a broad interest in natural history. If the collection was acquired in this spirit, it is not surprising that the majority of species are represented by only one specimen, and that where there were duplicates, this mainly reflected variation in plumages (discussed above).

The overall bias towards males in birds, described above, may reflect historical active selection, in the case of some taxa, including Anatidae, where the male plumages are more colourful. However, some of this collecting bias may have been non-deliberate: in a large study of 2 million bird and mammal specimen records from 5 large international museums, Cooper *et al.,* (2019) concluded that although some of the bias in collections towards males was a result of deliberate selection, much of it was also non-deliberate and influenced by factors relating to characteristics of individual species and how they were trapped.

The collection is also notable for the inclusion of certain rarities such as the Purple Heron *Ardea purpurea* and Squacco Heron *Ardeola ralloides*, which were the first of their kind to be obtained in Lakeland (Macpherson, 1892), which likely influenced the Musgraves' interest in these birds; that properly set up they can make for a spectacular display may have been a factor too. Common birds and especially small ones were underrepresented, possibly because everyday species were of no great interest, or perhaps because the Musgraves were far more interested in non-passerines generally. There is no published information on other collections of similar size, but the composition of the Musgraves' collection is broadly similar to the material that passed through taxidermists' hands, exemplified by the records for Raine Bros, the Carlisle taxidermists (Sellers, 2017).

Where collection data is provided in the catalogue (see above), all but one of the specimens had been shot, caught in traps or "killed" (by unknown methods), and the question arises whether these activities had any effect on the populations of the species concerned. The numbers taken by the Musgraves were small and by themselves were unlikely to have had any detectable effect on local populations. However, it is the combined effect of many sportsmen, collectors and gamekeepers on wildlife over long periods that may have had a detrimental effect on the viability of certain bird populations. There were at least twenty collectors with a serious interest in birds or mammals active in Lakeland in the nineteenth and early twentieth centuries (Shrubb, 2013). There were many incidental natural history collectors, as well as people taking wild animals to decorate or adorn such things as fire screens (feathers), mammal heads on shields (*de rigueur* for sportsmen), bell-pulls (Foxes' tails were very popular) and so on (see, for instance, Sellers, 2017). Gamekeepers were probably the group that did the most damage to wildlife, particularly to birds of prey. There appear to be no known records of their activities in Lakeland, but looking at other regions, they had a very considerable impact on wildlife populations, some effects of which are still felt today (*e.g.* Bourne, 2006; Lovegrove, 2007). How much impact the combined efforts of collectors, sportsmen and gamekeepers has had on the fauna of Lakeland is difficult to determine, but the relatively high percentage of species in the 'most at risk' category hints that it might not have been negligible. The presence of a variety of rarities comes as no surprise, but as these would have been birds outside their normal breeding or wintering ranges or away from their usual migration routes, their taking is unlikely to have had any discernible effect on their populations. This combined practice could, however, have effectively forestalled any possibility of such species becoming established in Lakeland, although there are, indeed, many factors influencing the establishment of a viable population.

Acknowledgements
Tullie House Museum and Art Gallery is acknowledged for permitting access to the zoological collections (which was done via the first author when he was in post as a Curator). Tullie House are also acknowledged for permission to reproduce the image in Figure 2 and we thank Assistant Curator, Claire Sleightholm for additional collections data. We also thank the anonymous reviewers and Journal Editor for helpful comments in the preparation of this manuscript, David and Judith Clarke for drawing the existence of the photograph illustrated in Figure 1 to our attention, and to Dr Sydney Chapman of Penrith and Eden Museum (Eden District Council) for permission to reproduce this photograph.

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Appendix I. Bird species in the Edenhall Collection.

Column A: status in the 19th century, based on Harvie-Brown & Buckley (1887) for Caithness, and on Macpherson (1892) for Lakeland and the other two categories. Status categories as follows: P, passage migrant; R, resident breeder (present throughout the year); S, breeding summer visitor; V, vagrant, W, winter visitor and X, not on British List.

Column B: Small local population, categorised as follows:

** small local breeding population (<150 pairs).

* small numbers occurring locally in winter or on passage (<300 birds).

**/* small local breeding and wintering population (<300 birds).

Column C: number of specimens in the Edenhall Collection; N, preserved with nest and eggs; Y, preserved with young (not included in the number of specimens). Note that some species are represented in two or more of the four groups listed here.

Column D: Specimens retained for the Tullie House Collection marked TH; all others either destroyed or retained by the Musgraves.

Purchased from H. Shaw of Shrewsbury.

	A	*B*	*C*	D
Species taken in Lakeland (61 specimens of 50 species)				
Barnacle Goose *Branta leucopsis* (Bechstein, 1803)	W P	*	1	
White-fronted Goose *Anser albifrons* (Scopoli, 1769)	W P	*	1	
Bewick's Swan *Cygnus columbianus* (Ord, 1815)	P	*	1	
Whooper Swan *Cygnus cygnus* (Linnaeus, 1758)	P	*	2	
Shoveler *Spatula clypeata* (Linnaeus, 1758)	R W	**/*	1	TH
Gadwall *Mareca strepera* (Linnaeus, 1758)	R W	**/*	1	TH
Teal *Anas crecca* Linnaeus, 1758	R W	**	1	
Pochard *Aythya ferina* (Linnaeus, 1758)	R W	**	1	
Tufted Duck *Aythya fuligula* (Linnaeus, 1758)	R W	**	1	
Goldeneye *Bucephala clangula* (Linnaeus, 1758)	W P		2	
Goosander *Mergus merganser* Linnaeus, 1758	W		2	
Black Grouse *Lyrurus tetrix* (Linnaeus, 1758)	R	**/*	2	TH(2)
Red Grouse *Lagopus lagopus* (Latham, 1787)	R		1	
Red-throated Diver *Gavia stellata* (Pontoppidan, 1763)	W	*	2	TH(1)
Great Northern Diver *Gavia immer* (Brünnich, 1764)	V		1	
Little Grebe *Tachybaptus ruficollis* (Pallas, 1764)	R W	**	1	
Great Crested Grebe *Podiceps cristatus* (Linnaeus, 1758)	R W	**	1	
Slavonian Grebe *Podiceps auritus* (Linnaeus, 1758)	V		2	
Bittern *Botaurus stellaris* (Linnaeus, 1758)	W	*	1	
Squacco Heron *Ardeola ralloides* (Scopoli, 1769)	V		1	TH
Grey Heron *Ardea cinerea* Linnaeus, 1758	R		1	
Purple Heron *Ardea purpurea* (Linnaeus, 1766)	V		1	TH
Osprey *Pandion haliaetus* (Linnaeus, 1758)	P	*	1	TH
Honey-buzzard *Pernis apivorus* (Linnaeus, 1758)	S	**	1	TH
Sparrowhawk *Accipiter nisus* (Linnaeus, 1758)	R		2	
Goshawk *Accipiter gentilis* (Linnaeus, 1758)	R	**/*	1	TH
Marsh Harrier *Circus aeruginosus* (Linnaeus, 1758)	S	**	1	
Montagu's Harrier *Circus pygargus* (Linnaeus, 1758)	V		1	
Rough-legged Buzzard *Buteo lagopus* (Pontoppidan, 1763)	W P	*	2	TH(1)
Buzzard *Buteo buteo* (Linnaeus, 1758)	R		1	
Water Rail *Rallus aquaticus* Linnaeus, 1758	R W	**/*	1	
Corncrake *Crex crex* (Linnaeus, 1758)	S		1	
Spotted Crake *Porzana porzana* (Linnaeus, 1766)	S	**	1	TH
Coot *Fulica atra* Linnaeus, 1758	R W		1	
Woodcock *Scolopax rusticola* Linnaeus, 1758	R W		1	TH
Green Sandpiper *Tringa ochropus* Linnaeus, 1758	P	*	1	
Barn Owl *Tyto alba* (Scopoli, 1769)	R		1	
Tawny Owl *Strix aluco* Linnaeus, 1758	R		1	
Long-eared Owl *Asio otus* (Linnaeus, 1758)	R W	**/*	1	
Short-eared Owl *Asio flammeus* (Pontoppidan, 1763)	R W	**/*	1	

	A	*B*	*C*	D
Kingfisher *Alcedo atthis* (Linnaeus, 1758)	R		1	
Kestrel *Falco tinnunculus* Linnaeus, 1758	R		1	
Merlin *Falco columbarius* Linnaeus, 1758	R W P	**/*	1	
Hobby *Falco subbuteo* Linnaeus, 1758	S	**	1	TH
Gyr Falcon *Falco rusticolus* Linnaeus, 1758	V		1	TH
Peregrine *Falco peregrinus* Tunstall, 1771	R W P	**/*	2	TH(2)
Hooded Crow *Corvus cornix* (Linnaeus, 1758)	V		1	
Waxwing *Bombycilla garrulus* (Linnaeus, 1758)	W P	*	1	
Crossbill *Loxia curvirostra* Linnaeus, 1758	R W	**/*	2	
Two-barred Crossbill *Loxia leucoptera* Gmelin, 1789	V		2	TH(2)
Species taken in Caithness (27 specimens of 20 species)				
Greylag Goose *Anser anser* (Linnaeus, 1758)	R	**/*	1	
Wigeon *Mareca penelope* (Linnaeus, 1758)	R W	**	2(+N)	TH(1)
Common Scoter *Melanitta nigra* (Linnaeus, 1758)	S	**	2(+N)	TH(2+N)
Ptarmigan *Lagopus muta* (Montin, 1776)	R	**/*	4	TH(3)
Red-breasted Merganser *Mergus serrator* Linnaeus, 1758	S	**	2	
Red-throated Diver *Gavia stellata* (Pontopiddan, 1763)	S	**	1	TH
Great Northern Diver *Gavia immer* (Brünnich, 1764)	V		1	TH
Cormorant *Phalacrocorax carbo* (Linnaeus, 1758)	R		2	
Goshawk *Accipiter gentilis* (Linnaeus, 1758)	V		1	TH
Rough-legged Buzzard *Buteo lagopus* (Pontoppidan, 1763)	W P		*	1
Dunlin *Calidris alpina* (Linnaeus, 1758)	S		1	
Redshank *Tringa totanus* (Linnaeus, 1758)	S		1(+Y)	
Greenshank *Tringa nebularia* (Gunnerus, 1767)	S	**	1	
Black-headed Gull *Chroicocephalus ridibundus* (Linnaeus, 1766)	S		1(+Y)	
Herring Gull *Larus argentatus* Pontoppidan, 1763	S		1	
Arctic Skua *Stercorarius parasiticus* (Linnaeus, 1758)	S	**	1	TH
Snowy Owl *Bubo scandiacus* (Linnaeus, 1758)	V		1	TH
Merlin *Falco columbarius* Linnaeus, 1758	R	**/*	1	
Peregrine *Falco peregrinus* Tunstall, 1771	R	**/*	1	TH
Raven *Corvus corax* Linnaeus, 1758	R	**/*	1	TH
Species taken elsewhere (8 specimens of 7 species)				
Great Northern Diver *Gavia immer* (Brünnich, 1764)	V		1	
Gannet *Morus bassanus* (Linnaeus, 1758)	S		1	
Golden Eagle *Aquila chrysaetos* (Linnaeus, 1758)	R	**/*	1	
Montagu's Harrier *Circus pygargus* (Linnaeus, 1758)	S	**	1	
White-tailed Eagle *Haliaeetus albicilla* (Linnaeus, 1758)	R	**/*	2	
Curlew *Numenius arquata* (Linnaeus, 1758)	R S		1	
Common Guillemot *Uria aalge* (Pontoppidan, 1763)	S		1	
Species for which location taken unknown, but most probably from Lakeland (58 specimens of 47 species)				
Shelduck *Tadorna tadorna* (Linnaeus, 1758)	R		2(+Y)	
Tufted Duck *Aythya fuligula* (Linnaeus, 1758)	R W	**	1	
Harlequin Duck *Histrionicus histrionicus* (Linnaeus, 1758)	V		1	TH
Long-tailed Duck *Clangula hyemalis* (Linnaeus, 1758)	W		1	TH
Smew *Mergellus albellus* (Linnaeus, 1758)	W	*	2	
Capercaillie *Tetrao urogallus* Linnaeus, 1758	R	**/*	2	
Quail *Coturnix coturnix* (Linnaeus, 1758)	S	**	2	TH(2)
Black-throated Diver *Gavia arctica* (Linnaeus, 1758)	S	**	1	
Storm Petrel *Hydrobates pelagicus* (Linnaeus, 1758)	S		1	
Little Bittern *Ixobrychus minutus* (Linnaeus, 1766)	V		1	
Night-heron *Nycticorax nycticorax* (Linnaeus, 1758)	V		2	
Cattle Egret *Bubulcus ibis* (Linnaeus, 1758)	V		1[e]	
Little Egret *Egretta garzetta* (Linnaeus, 1766)	V		1[e]	
Gannet *Morus bassanus* (Linnaeus, 1758)	S		1	

	A	B	C	D
Hen Harrier *Circus cyaneus* (Linnaeus, 1766)	S	**/*	2(1[e])	TH (2)
Red Kite *Milvus milvus* (Linnaeus, 1758)	R	**/*	2[e]	TH (2)
Oystercatcher *Haematopus ostralegus* Linnaeus, 1758	R S		1	
Black-winged Stilt *Himantopus himantopus* (Linnaeus, 1758)	V		1	
Avocet *Recurvirostra avosetta* Linnaeus, 1758	V		1	
Lapwing *Vanellus vanellus* (Linnaeus, 1758)	R S		1	
Golden Plover *Pluvialis apricaria* (Linnaeus, 1758)	R S		1	
Grey Plover *Pluvialis squatarola* (Linnaeus, 1758)	P	*	1	TH
Ringed Plover *Charadrius hiaticula* Linnaeus, 1758	R W P		1	
Dotterel *Charadrius morinellus* Linnaeus, 1758	S	**	1	
Turnstone *Arenaria interpres* (Linnaeus, 1758)	W P		1	
Ruff *Calidris pugnax* (Linnaeus, 1758)	W P	*	3	
Curlew Sandpiper *Calidris ferruginea* (Pontoppidan, 1763)	P	*	1[e]	
Jack Snipe *Lymnocryptes minimus* (Brünnich, 1764)	W P		1	
Great Snipe *Gallinago media* (Latham, 1787)	W	*	1	
Snipe *Gallinago gallinago* (Linnaeus, 1758)	R S W P		1	
Green Sandpiper *Tringa ochropus* Linnaeus, 1758	P	*	1	
Wood Sandpiper *Tringa glareola* Linnaeus, 1758	P	*	1[e]	
Little Auk *Alle alle* (Linnaeus, 1758)	V		2	
Common Guillemot *Uria aalge* (Pontoppidan, 1763)	S P		1	
Razorbill *Alca torda* Linnaeus, 1758	S P		1	
Puffin *Fratercula arctica* (Linnaeus, 1758)	S P		1	
Scops Owl *Otus scops* (Linnaeus, 1758)	V		2	TH(1)
Little Owl *Athene noctua* (Scopoli, 1769)	R	**/*		
Tengmalm's Owl *Aegolius funereus* (Linnaeus, 1758)	V		1	
Eagle Owl *Bubo bubo* (Linnaeus, 1758)	X		1	TH
Roller *Coracias garrulus* Linnaeus, 1758	V		1	TH
Hoopoe *Upupa epops* Linnaeus, 1758	V		1	TH
Great Spotted Woodpecker *Dendrocopos major* (Linnaeus, 1758)	R		1	
Merlin *Falco columbarius* Linnaeus, 1758	R W P	**/*	1	
Nuthatch *Sitta europaea* Linnaeus, 1758	R		1	
Snow Bunting *Plectrophenax nivalis* (Linnaeus, 1758)	W		1	

Appendix II. Mammal species in the Edenhall Collection (15 specimens of 10 species)

(Columns and symbols as Appendix I; X, extinct in Lakeland; †, species with populations that declined sharply in the 19th and early 20th centuries, and subsequently went extinct; ‡, species with populations that were probably declining in the 19th century)

Red Squirrel *Sciurus vulgaris* Linnaeus, 1758	R	‡	1	
Fox *Vulpes vulpes* (Linnaeus, 1758)	R		2(+Y)	
Otter *Lutra lutra* (Linnaeus, 1758)	R	†‡	4(+Y)	
Badger *Meles meles* (Linnaeus, 1758)	R		1	
Pine Marten *Martes martes* (Linnaeus, 1758)	R	†	1	TH
Stoat *Mustela erminea* Linnaeus1758	R		1	
Weasel *Mustela nivalis* Linnaeus, 1766	R		1	
Polecat *Mustela putorius* Linnaeus, 1758	R	†	1	TH
Wildcat *Felis silvestris* Schreber, 1777	X		1	
Red Deer *Cervus elaphus* Linnaeus, 1758	R		2	

The specimens were obtained as follows:

Lakeland: Otter (4), Polecat (1) and Red Deer (2).

Elsewhere in Britain: Wildcat (1).

Where taken unknown (but probably Lakeland): Red Squirrel (1), Fox (1), Badger (1), Pine Marten (1), Stoat (1) and Weasel (1).

Freedman, J., and Gelsthorpe, D. 2021. JoNSC. 8. pp.66-72.

The rediscovered collection of *Myotragus balearicus* Bate, 1909 (Artiodactyla, Bovidae) at Manchester Museum

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Received: 18th Aug 2019

Accepted: 28th Jan 2021

Citation: Freedman, J., and Gelsthorpe, D. 2021. *The rediscovered collection of* Myotragus balearicus *(Bate, 1909) (Artiodactyla, Bovidae) at Manchester Museum. Journal of Natural Science Collections.* **8.** pp.66-72.

Abstract

New discoveries within collections with significant research value are being made each year. New scientific information and historical context is uncovered revealing rich collections stories for researchers and the public. This paper details a recently rediscovered collection of over 60 specimens of the Late Pleistocene mammal *Myotragus balearicus* Bate, 1909 at Manchester Museum, along with a very brief overview of the species and its discoverer, Dorothea Bate. Whilst the small collection may hold some research potential, there is a great opportunity to use the collection for university students and members of the public to learn more about the history of science, early female palaeontologists, and island evolution and extinction.

Keywords: *Myotragus balearicus*; island evolution; Dorothea Bate; Manchester Museum; museum collections.

Introduction

Museum collections contain a wealth of undiscovered stories for the public and opportunities for scientific advancement. Despite the ongoing curation of natural history collections, there are still many specimens in museums that remain unknown by curators and the research community.

In recent years, there have been numerous examples of specimens that have been 'rediscovered'. A number of ichthyosaur specimens in museums have recently been examined in detail, all for the first time since their acquisition. One specimen long thought to be an ichthyosaur cast, turned out to be a real fossil and a new species: *Ichthyosaurus anningae* Lomax and Massare, 2015 (Larkin and Lomax, 2015; Lomax and Massare, 2015).

Re-examination of ichthyosaur specimens has led to the identification of several other new species (for examples see Lomax, 2016; Lomax and Massare. 2016; Lomax, Massare, and Rashmiben, 2017; Lomax and Massare, 2018), as well as correctly identifying species that have been mis-identified (Massare and Lomax, 2013; Lomax, Evans and Carpenter, 2017).

The holotypes of the ice age cave hyena *Crocuta crocuta spelaea* Goldfuss, 1823 and the cave lion *Panthera leo spelaea* Goldfuss, 1810 from the Zoolithen Cave at Geilenreuth, Germany, were thought to be lost. Research by Diedrich (2008) has found these specimens, safely stored in two different museums: the cave hyena holotype in the collections at the Goldfuss Museum of the Reinische Friedrich Wilhelms-Universität Bonn, Germany, and the cave lion holotype at the Museum fűr Naturkunde, Humboldt-Universität, Berlin. The holotype specimen of the cave bear *Ursus spelaeus* Rosenműller, 1794 from the same site was also thought to be lost, but was rediscovered in the collections at the Museum fűr Naturkunde, Berlin (Diedrich, 2009).

These are just a few examples of specimens that have been rediscovered or re-examined, demonstrating the importance of knowing what is held in museum collections. A large collection of rare sub-fossils (sensu Butler, 1994) were recently 'rediscovered' at Manchester Museum. This paper outlines the collection in detail, along with a very brief overview of the species, and the potential significance of the collection. One of the aims of this paper is to highlight this collection to the wider scientific and history of science research community, contribute to the known dataset for this species and add to the stories associated with the collection.

Myotragus discovery

M. balearicus was discovered by Dorothea Bate (1878-1951) in three coastal cave sites on the large Mediterranean Island of Mallorca (also called Majorca): Font de sa Cala (Cova de na Barxa, the holotype deposit for *M. balearicus*), near Capdepera; Cova des Coloms at Cap Farrutx, Artà; and near Cap Menorca, Alcúdia (Bate, 1914). One *Myotragus* bone was found at Cala Figuereta, near Santanyí (Bate, 1914), but the whereabouts of this specimen is presently unknown. This species was not just restricted to Mallorca, with a number of fossils found at the close by island of Menorca (Bate, 1914), and specimens have also been discovered on the two small islands just off Mallorca, Cabrera and sa Dragonera (Bover and Alcover, 2003).

Bate was one of the earliest women to be employed as scientific staff at the British Museum (Natural History) (now the Natural History Museum, London) in 1898, and worked there for 50 years, mostly as a volunteer before made a permanent member of staff at the age of 69 at Tring in Hertfordshire (Shindler, 2005). Although initially undertaking a variety of work with bird skins and preparing a large diversity of fossils, she began to explore the Mediterranean islands in search of fossils, initially at her own expense (Shindler, 2005). Bate made significant finds on several these islands, and substantial contributions in Late Pleistocene to Early Holocene island fauna (Shindler, 2004).

Overview of *M. balearicus*

Myotragus arrived on Mallorca around 5 and a half million years ago (Bover *et al.*, 2014), when the Mediterranean Sea was almost completely dry, and the Mediterranean islands were connected to the mainland through exposed land bridges (Clauzon *et al.*, 1996; Manzi *et al.*, 2013). Flooding of the Mediterranean through the Gulf of Gibraltar severed contact from mainland populations, where it evolved in isolation (Bover *et al.*, 2014; Mas *et al.*, 2018).

It was a small animal, measuring just 50cm high at the shoulder (Figure 1) (Bover and Alcover, 1999; van der Geer, Lyras and de Vos, 2010). The small skull had two small, slightly curved horns growing

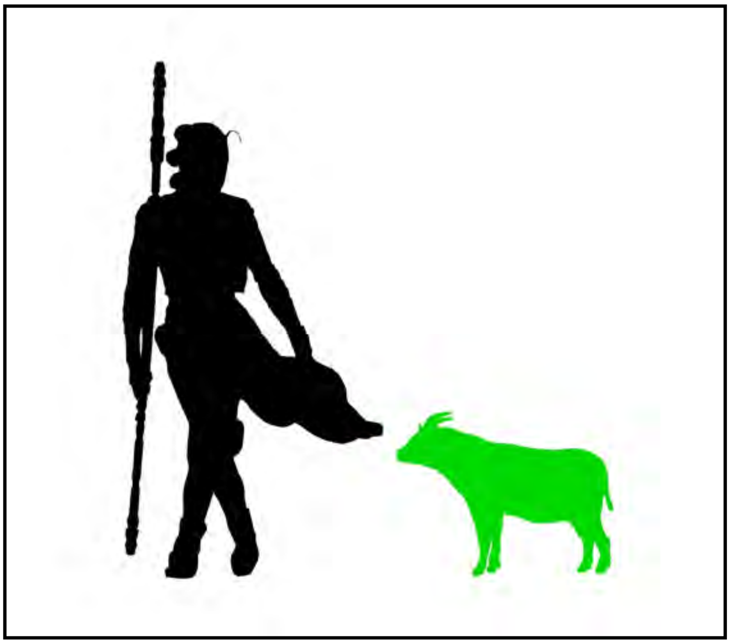

Figure 1. The enigmatic Myotragus balearicus *compared to a human 182cm tall. Measuring just 50cm at the shoulders,* M. balearicus *underwent dramatic reduction in size as a response to island evolution.*

backwards from the frontal bone (Figure 3A, C, D) (Bate, 1914). The lower jaw had two large continuously growing incisors (Figure 3B), similar to that seen in rodents (Bate, 1909), but it also very unusual for an Artiodactyla and not found in any extant species, and as with other caprines there are no incisors on the upper jaw. *Myotragus* most likely ate everything that it could, including tougher plants (Jordana and Köhler, 2011; Jordana *et al.*, 2013), with the continuously growing incisors beneficial to this varied vegetation diet. Whilst orbital sockets in all other caprines are located on the side of the heads, in *Myotragus* they are facing forwards like those of carnivores.

The post-cranial skeleton demonstrates more anatomical peculiarities, which Andrews (1915), Bover & Alcover (1999), Bover, Fornós and Alcover (2005), Spoor (1988a), Spoor (1988b) describes in detail. The humerus (Figure 3G) and femur are both reduced in size, being very short and thick. All limb bones are short and robust, with the radius and ulna not as robust as the femur and humerus. The metacarpus, metatarsus and phalanges are all short and very thick. The smaller body size in *Myotragus* shows the limb bones developing extreme shortening and increased robustness, which are likely a result of a predator-free environment, with this species losing the need for speed (Spoor, 1988a; Spoor, 1988b).

It was very successful and adapted uniquely to life on the islands without predators. Its overall body size was much reduced (Figure 1), which, following Foster's rule, has been seen in many species of herbivores that have been isolated on islands (Foster, 1964). Other examples include dwarf elephants on Cyprus (Bate, 1903), dwarf hippos on Crete (Evans, 1925), the Cretan dwarf mammoth (Bate, 1907; Herridge and Lister, 2012), and even within our own Genus, with *Homo floresiensis* Brown *et al.* 2004 (Brown *et al.*, 2004). Isolation from populations on the mainland, a lack of predators, a smaller land mass, and more available food led to relatively rapid and extreme evolution of mammals on islands (Foster, 1964).

Myotragus became extinct around 4,035 years ago (Bover *et al.*, 2016). The cause of its extinction has been hotly debated. Climate changes on the islands of Mallorca and Menorca have been suggested to be the main driver (Lull *et al.*, 1999; Jalut, *et al.*, 2000; Pérez-Obiol *et al.*, 2000; Pérez-Obiol *et al.*, 2001), however there are some researchers whom favour humans as the main cause of their extinction (Ramis and Bover, 2001; Bover and Alcover, 2003; Bover *et al.*, 2016). There is currently no evidence to suggest that *Myotragus* and humans overlapped, and the exact cause of the extinction of *M. balearicus* is unknown (Ramis and Bover, 2001; Bover and Ramis, 2005).

The collection of *Myotragus balearicus* at Manchester Museum

Manchester Museum is one of the largest university museums in the UK with over 4.5 million specimens dating back to 1820s. The collection includes natural history, archaeology, ethnography and Egyptology.

A collection of 60 bones of *Myotragus balearicus* were recently discovered in the collections store room. The collection was purchased from Dorothea Bate for £10, brokered by Dr Charles Andrews of the British Museum (Natural History) in October 1914 (Figure 2). Dr Andrews was a curator in the Department of Geology, who worked with fossil mammals from around the world (Woodward, 1924), and published a detailed monograph of *M. balearicus* (Andrews, 1915). The type specimens of *M. balearicus* are held at the Natural History Museum, London.

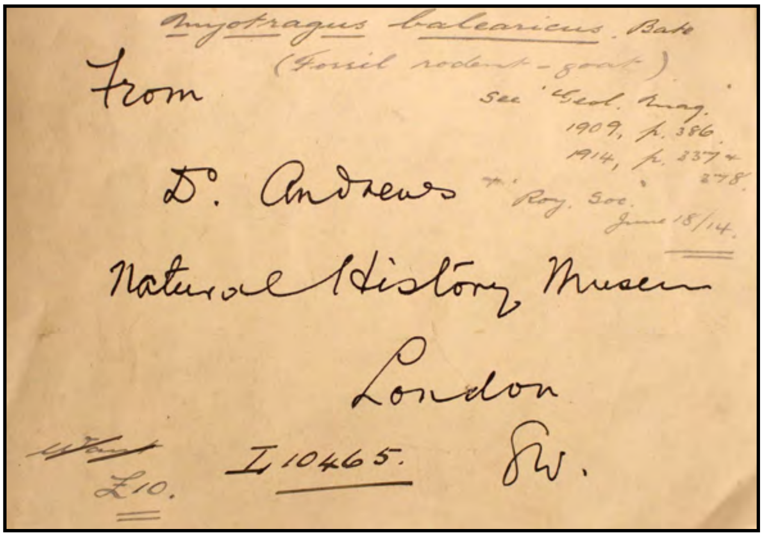

Figure 2: The accompanying label with the Myotragus collection at Manchester Museum. The label has been annotated by an unknown person with the publication details and the £10 price with 'Want' crossed through (possibly implying they were sent on approval). Image Manchester Museum.

Figure 3: A selection of Myotragus balearicus *specimens held in the collections at Manchester Museum, all previously unfigured. (A) Skull with fine grained cave earth still attached (L10465.1); (B) Left mandible (L10465.9); (C) Horn-core (L10465.5); (D) Horn-core (L10465.7); (E) 7 incisors from the lower jaw (L10465.22); (F) Right tibia (L10465.41); (G) Left humerus (L10465.31). Scale bar = 1cm. Images Manchester Museum.*

The specimens were accessioned in October 1914 soon after they were purchased for the Museum. The accession register records the following information:

> 'L. 10465, Oct, *Myotragus balearicus,* Majorca, Purchased £10 from Miss Bate'

Although there is no field locality information with the collection, the good preservation and lack of stalagmite coating on this collection is also noted in the fossils described by Bate (1914). The fossils are most likely from three possible sites in the Jurassic Limestone: Fuente de la Cala (Cova de na Barxa, the holotype deposit for *M. balearicus*), near Capdepera Mallorca, Cuevas de los Colombos, Cap French, or a cave near Cavo de Menorca, Alcudia. Future work on the isotopic signatures on this collection may provide more information about the site they were discovered.

The bones are exceptionally well preserved, but often incomplete with breakages (Figure 3). The fragmented skull (L.10465.1, Figure 3A) has cave-earth embedded in the back of the skull, which is fine grained and pink-brown in colour. The cave earth contains a number of broken bone fragments, indicating that the bones in this collection may have been broken prior to, or after deposition, rather than during excavation. The collection includes most of the skeletal elements of *M. balearicus*, representing at least five individuals (Table 1).

Significance and potential of the collection

Specimens of *M. balearicus* have been used for research from the collections in at least the Natural History Museum, London, the Institut Mediterrani d'Estudis Avançats, Mallorca, the Societat d'Història Natural de les Balears, Mallorca, the Deia Archaeological Museum, Mallorca, the Museum Belear de Ciéncies Naturals, Mallorca, the Institute of Earth Sciences, Utrecht, the American Museum of Natural History, New York, and the National Museum of Natural History, Smithsonian Institution, Washington D.C. (for example: Spoor, 1988a; Spoor, 1988b; Waldren, 1999; Lalueza-Fox *et al.*, 2002; Bover, Quintana and Alcover, 2010; Jordana *et al.*, 2013). These collections have allowed detailed work to be carried out in an attempt to answer many questions about the natural history of this species, and island evolution in general. Whilst this collection at Manchester Museum is not a significantly large compared to these other institutions, this collection offers some new research potential and is another piece of the jigsaw illustrating the work of Dorothea Bate.

There is nothing to suggest these specimens have been examined by researchers since their sale to Manchester Museum in 1914. They have not been previously published and are not included in the catalogue of type and figured specimens (Jackson, 1952). The specimens have been overlooked for over 100 years. Their association with the pioneering female scientist, Dorethea Bate means they are of historical, if not scientific, significance.

Element	Number of bones	Accession number
Skull and fragments	8	L.10465.1, L.10465.2, L.10465.3, L.10465.4, L.10465.19, L.10465.20, L.10465.21, L.10465.23
Horn-cores	4	L.10465.5, L.10465.6, L.10465.7, L.10465.8
Left jaw	1	L.10465.9
Right jaw	4	L.10465.10, L.10465.11, L.10465.12, L.10465.13
Thoratic vertebrae	18	L.10465.14, L.10465.15
Lumbar vertebra	3	L.10465.16, L.10465.17, L.10465.18
Incisors	6	L.10465.22
Molars	1	L.10465.22
Metacarpals	6	L.10465.24, L.10465.25, L.10465.26, L.10465.28, L.10465.33, L.10465.34
Right femur	1	L.10465.38
Proximal right femur	3	L.10465.27, L.10465.35, L.10465.38
Proximal femur	1	L.10465.44
Distal left femur	1	L.10465.36
Left radius-ulna	1	L.10465.39
Distal right radius-ulna	1	L.10465.45
Right ulna	2	L.10465.40, L.10465.41
Left ulna	2	L.10465.42, L.10465.29
Proximal right radius and ulna	1	L.10465.55
Proximal right radius	1	L.10465.30
Left humerus	1	L.10465.31
Distal left humerus	1	L.10465.43
Right humerus	1	L.10465.37
Distal phalanx	5	L.10465.56, L.10465.57, L.10465.58, L.10465.59, L.10465.60
Tarsal	16	L.10465.46
Rib	1	L.10465.61
Sacrum	3	L.10465.48, L.10465.49, L.30465.50
Scapula	4	L.10465.51, L.10465.52, L.10465.53, L.10465.54
Bone fragments	11	L.10465.47

Table 1: The complete list of skeletal elements of Myotragus balearicus *held at Manchester Museum.*

This collection has a lot of untapped potential for use in education and display for students and for visitors. Connecting real objects with people in new ways is a powerful way to tell stories and give an insight into the passions of their collectors. The bones have recently been used in teaching undergraduate biology students about dwarfism in island species, prior to their fieldwork in Mallorca. These specimens open the door to illustrate a range of different topics, including: the history of science, female palaeontologists, island evolution and extinction. The Natural History Museum, London, which holds the type material for *M. balearicus*, is currently the only museum to display this genus in the UK, and this rediscovered collection offers many possibilities of reaching numerous new audiences.

Acknowledgements
The authors would like to thank Dean Lomax and Ross Barnett for providing examples of 'rediscovered' collections within museums, and Roula Pappa, Curator of Pleistocene Mammals, at the Natural History Museum, London. Thank you to the reviewers who provided constructive comments to improve this paper.

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NatSCA 2020 AGM and Minutes

Thursday 14th May 2020, 1.30pm
Zoom hosted by Manchester University

Attendees: Jack Ashby (JA), Clare Brown (CB), Amanda Callaghan (AC), Jan Freedman (JF), Jennifer Gallichan (JG), David Gelsthorpe (DG), Isla Gladstone (IG), Yvette Harvey (YV), Lucie Mascord (LM), Holly Morgenroth (HM), Maggie Reilly (MR), Glenn Roadley (GR), Paolo Viscardi (PV), Donna Young (DY).

1. Apologies for absence

Kirsty Lloyd (KL)

2. Minutes of AGM Thursday 26th-27th of April, 2018.

The meeting was held at the National Museum of Ireland as published in *Journal of Natural Science Collections* **7:** 98-102. There were no objections from membership with the exception of one amendment required: Kirsty Lloyd was proposed by Paolo Viscardi. These will be amended accordingly and will be signed by the chair and secretary at the committee's next meeting.

Proposed: Jan Freedman Seconded: Laura McCoy

3. Secretary's report - Yvette Harvey

Meeting attendance for the NatSCA committee members:

National Museums of Ireland, Dublin 2.v.2019	**World Museum, Liverpool 8.vii.2019**	**ZSL London 18.x.2019**	**Board Room, NHM London 10.i.2020**	**ZOOM 27.iii.2020**
Jack Ashby	Jack Ashby	Jack Ashby	Jack Ashby	Jack Ashby
Clare Brown	Clare Brown	Clare Brown	Clare Brown	Amanda Callaghan
Jennifer Gallichan	Jan Freedman	Amanda Callaghan	Amanda Callaghan	Jan Freedman
Isla Gladstone	Jennifer Gallichan	Jan Freedman	Jennifer Gallichan	Jennifer Gallichan
Yvette Harvey	David Gelsthorpe	Jennifer Gallichan	David Gelsthorpe	David Gelsthorpe
Rachel Jennings	Yvette Harvey	David Gelsthorpe	Isla Gladstone	Isla Gladstone
Miranda Lowe	Kirsty Lloyd	Isla Gladstone	Yvette Harvey	Yvette Harvey
Roberto Portela Miguez	Lucie Mascord	Yvette Harvey	Kirsty Lloyd	Lucie Mascord
Maggie Reilly	Holly Morgenroth	Kirsty Lloyd	Maggie Reilly	Holly Morgenroth
Paolo Viscardi	Glenn Roadley	Holly Morgenroth	Glenn Roadley	Maggie Reilly
	Paolo Viscardi	Maggie Reilly	Paolo Viscardi	Glenn Roadley
	Donna Young	Glenn Roadley	Donna Young	Paolo Viscardi
		Paolo Viscardi		Donna Young
		Donna Young		

The committee thanks the organisations that have provided venues for our meetings in Dublin, Liverpool, London and ZOOM.

4. Treasurer's report - Holly Morgenroth

2019-2020 end of year:

Accounts summary 01.02.2019 - 31.01.2020

Income	2019-2020		2018-19
Institutional Subscriptions			
Previous Years	239		160
Current Year (bank)	1,942		1,708
Current Year (PP)	39		
Future Years	-		40
		2,220	**1,907**
Personal Subscriptions			
Previous Years	180		55
Current Year	3,817		4,646
Current Year (PP)	68		
Future Years	60		167
		4,125	**4,869**
Workshop Income			
Entomology	1,645		
Data	780		
Funding	2,144		
		4,569	**4,349**
Conference Income			
2019	10,992		
2018	22		
		11,014	**9,015**
Grant Income			
Other			
Misc.	94		
Bank interest	45		27
		139	**77**
TOTAL INCOME		**22,067**	**20,217**

Expenditure	2019-2020		2018-19
Running costs			
Committee Expenses	- 4,244		- 2,254
Website	- 459		- 360
Stationery	- 5		
Postage	-		
Data Protection	- 35		- 35
		- 4,743	**- 2,289**
Workshops			
Conservation	- 209		
Entomology	- 1,075		
Data	- 582		
Funding	- 786		
		- 2,652	**- 2,353**
Conference			
2019	- 8,302		
		- 8,302	**- 7,241**
Publications & Information Provision			
2018 Journal print & postage	- 1,916		
2019 Journal print & postage	- 20		
		- 1,936	**- 2,750**
Charitable			
2019 Bill Pettit Fund	- 1,105		
Bursaries	- 500		
Sector support	- 100		
		- 1,705	**- 1,200**
Other			
			- 667
TOTAL EXPENDITURE		**- 19,339**	**- 16,500**
Excess Income over Expenditure		2,728	

OUTSTANDING EXPENDITURE		
Bill P	£ 2,000	
Journal	£ 1,748	
		£ 3,748
EXPECTED INCOME		
Entomology	£ 75	
Subs	£ 20	
		£ 95
Adjusted balance estimate 31.01.2020		£40,188

Cash Flow Statement			
01.02.2019	Current a/c	£ 18,683	
	Deposit a/c	£ 22,430	
	Paypal a/c		
			£41,113
31.01.2020	Current a/c	£ 21,259	
	Deposit a/c	£ 22,475	
	Paypal a/c	£ 107	
			£43,842
NB Adjusted balance			£40,188
			-£ 925

Narrative of the accounts

- Subscription income overall has decreased slightly compared to last year due to a decrease in personal membership but a slight increase in income from institutional members.

- Workshop income and expenditure is comparable to last year but we saw an increase in conference income – thank you to all of you who joined us in Dublin especially first time attendees (many from Ireland).

- There was a big increase in committee expenses (almost double the previous year). This is partly due to increased cost of public transport and having a more dispersed committee – previously about a third of the committee were very close to London. In addition to NatSCA committee meetings committee members have attended meetings of other SSNs and sector bodies to advocate on behalf of NatSCA and its membership. However, included in this figure is overnight accommodation for a two-day committee meeting. Such meetings are rare but it was deemed necessary last year due to NatSCA's change of status to a CIO – the application and its implications (e.g. development of new policies and procedures) involved a phenomenal amount of work.

- Slight decrease in cost of publishing the journal – a number of members now prefer a pdf rather than hard copy.

- NatSCA continues to support its members with bursaries and with the Bill Pettit Memorial Award. The award was increased in 2019 to £3,000. NatSCA also gave £100 to support the activities of the SSN Consortium.

- NatSCA's financial activity never fits neatly into a financial year. Once all pending income and expenditure is taken into account, the Charity made a slight loss of £925. But in reality (due to late payments from the previous year, the charity's finances remain stable.

- Just as an additional note, due to Covid19 the accounts for the current financial year will look very different. However, the charity's reserves will allow us to continue supporting members via Bill Pettit and other routes.

CHARITY COMMISSION FOR ENGLAND AND WALES	Natural Sciences Collections Association			1098156	CC16a
	Receipts and payments accounts				
	For the period from	Period start date 01.02.2019	To	Period end date 31.01.2020	

Section A Receipts and payments

	Unrestricted funds	Restricted funds	Endowment funds	Total funds	Last year
	to the nearest £	to the nearest £	to the nearest £	to the nearest £	to the nearest £
A1 Receipts					
Institutional subscriptions	2,220	-	-	2,220	1,907
Personal subscriptions	4,125	-	-	4,125	4,869
Workshops	4,569	-	-	4,569	4,349
Conferences	11,014	-	-	11,014	9,015
Bank Interest	45	-	-	45	27
Misc	94	-	-	94	50
	-	-	-	-	-
	-	-	-	-	-
Sub total *(Gross income for AR)*	22,067	-	-	22,067	20,217
A2 Asset and investment sales, (see table).					
	-	-	-	-	
	-	-	-	-	-
Sub total	-	-	-	-	-
Total receipts	22,067	-	-	22,067	20,217
A3 Payments					
Running costs	4,743	-	-	4,743	2,649
Workshops	2,652	-	-	2,652	2,353
Conferences	8,302	-	-	8,302	7,241
Publications & Information provision	1,936	-	-	1,936	2,750
Bill Pettit Memorial Fund	1,105	-	-	1,105	1,200
Bursaries	500	-	-	500	307
Sector support	100	-	-	100	-
Sub total	19,338	-	-	19,338	16,500
A4 Asset and investment purchases, (see table)					
	-	-	-	-	
	-	-	-	-	
Sub total	-	-	-	-	-
Total payments	19,338	-	-	19,338	16,500
Net of receipts/(payments)	2,729	-	-	2,729	3,717
A5 Transfers between funds	-	-	-	-	-
A6 Cash funds last year end	41,113	-	-	41,113	28,136
Cash funds this year end	43,842	-	-	43,842	31,853

Section B Statement of assets and liabilities at the end of the period				
Categories	Details	Unrestricted funds	Restricted funds	Endowment funds
		to nearest £	to nearest £	to nearest £
B1 Cash funds		43,842	-	-
		-	-	-
		-	-	-
	Total cash funds	**43,842**	**-**	**-**
	(agree balances with receipts and payments account(s))	OK	OK	OK
		Unrestricted funds	Restricted funds	Endowment funds
	Details	to nearest £	to nearest £	to nearest £
B2 Other monetary assets	Late membership Subs	20	-	-
	Late event payment	75	-	-
		-	-	-
		-	-	-
		-	-	-
		-	-	-
	Details	Fund to which asset belongs	Cost (optional)	Current value (optional)
B3 Investment assets			-	-
			-	-
			-	-
			-	-
			-	-
	Details	Fund to which asset belongs	Cost (optional)	Current value (optional)
B4 Assets retained for the charity's own use			-	-
			-	-
			-	-
	Details	Fund to which liability relates	Amount due (optional)	When due (optional)
B5 Liabilities	Bill Petit 2019	unrestricted	2,000	
	Journal	unrestricted	1,748	
			-	
			-	
			-	
Signed by one or two trustees on behalf of all the trustees	Signature	Print Name		Date of approval

Accounts will be signed when agreed at AGM

Proposed: Kate Andrew Seconded: Vicky Ward

5. Membership Secretary's report - Maggie Reilly

For 2019 the membership statistics are as follows:

279 paid up members breaking down as 54 institutional members and 225 personal members.

74 unpaid subs breaking down as 5 unpaid institutional members (one still in process) and 69 unpaid personal members.

There were 49 new members since 2018.

There are 13 free of complementary mailings of the journal either for legal/copyright reasons or networking. These are – British Library LDO, British Library CRO, GCG, Smithsonian Institute Library Gifts and Exchanges, ACE, SPNHC, MA, Zoo Record plus five copies to ALDL.

The membership remains largely UK based at around 80% of total, however 18 different countries are represented in the 20% 'overseas' members.

Membership had been slowly increasing over the last few years and has stabilised out around the 280 mark which is a satisfactory level though we always seek to increase NatSCA's reach. The pattern of new members/unpaid subs in the last few years suggests we have people joining only for training and other events. Member discount means it is cash neutral to join. We would like to encourage such people to maintain their subs and continue to benefit from membership.

Several reminders that subs are due are sent out each year to the membership. Those members who pay via Paypal are sent their renewal link in February. Other reminders follow. Institutions are sent electronic invoices. The database is 'cleaned' every two years of those members whose subs have lapsed.

I would like to especially thank Justine Aw and Holly Morgenroth for help, advice, fixes and keeping the show on the road.

For journal distribution, mailing labels were supplied and sent to the printer/distributor. This year was the first year where members could elect to receive an electronic copy only – over 100 members did so. Volume 6 was uploaded to the website in March and as usual a new password sent out to all paid up members for 2018 and to the new members for 2019. In July, a full pdf download of the journal (as well as the individual articles download on the website) was also made available to paid up members.
Finally, on a personal note, as I am retiring from committee at this 2020 AGM, and this will be my last AGM report as membership secretary, I would like to say that it has been a privilege to be part of NatSCA from its inception, see it grow and serve the interests and needs of the natural sciences community. I will continue in a voluntary capacity to effect the handover to the new membership secretary and help with the CIO transition.

It has also been hugely interesting and a lot of fun working with the great people who have served over the years on committee – so, so long and thanks for all the fish! See you around!

6. Editor's Report - Jan Freedman

Firstly, apologies for the late print of Volume 7 of the *Journal of Natural Science Collections*. Some reviewers were a little slow at getting back, but I'm very pleased that this Volume is full of very interesting and high quality articles for the natural science community. From exhibitions to conservation and best practice, Volume 7 is very useful to those working in the sector.

I would really like to thank the Editorial Board, Rob Huxley, Matthew Parkes, Bethany Palumbo, David Notton, Paolo Viscardi, Donna Young, and Lucie Mascord, and all the peer reviewers for their work with articles. Their time and hard work has ensured the Journal articles are to the highest standard.

Two new Notes & Comments articles have been published in the last two months. These are online, free access articles that are not peer reviewed. They cover small projects, conference reviews, and ideas in natural science. I am aiming to publish one a month, and will share the articles as they come out through the NatSCA Jisc Mail.

I am working on the articles from the Conservation conference in October 2018 for a special online series of papers. These articles are being peer reviewed, and will be coming online soon.

Please continue to send ideas for articles to the editor (editor@natsca.org), for both the Notes and Comments and the *Journal of Natural Science Collections*.

I would like to thank the NatSCA committee for their support after I took over the Journal when the previous Editor stepped down. A big thank you to Maggie Reilly, for distributing labels for Volume 7 and organising passwords for the online access. I would also like to give a big thank you to Justine Aw, who uploads all the Journal articles, and all the Notes and Comments articles onto the NatSCA website (https://www.natsca.org/publications).

6. Chair's Report - Paolo Viscardi

I would like to start by offering my thanks to you all for making the effort to attend this Virtual AGM and offering thanks to Dave Gelsthorpe for hosting. I apologise if any technical issues arise for some of you – doing these things online isn't perfect and it means we don't get to enjoy each other's company, but it's important for NatSCA to be able to hold this meeting so that we can fulfil our requirements for the Charity Commission and complete our change to Charitable Incorporated Organisation status.

We were meant to be in Cardiff, and it's a real shame we couldn't make it, I want to say a big thank you to Jen Gallichan for all her effort to arrange that meeting – but we are hoping that NatSCA will be able to go ahead with what was planned next year instead, situation permitting.

This report is for the year closing February 2020, but I will provide updates on activity since then.

2019 was yet another uncertain year, with the implications of Brexit still being identified. NatSCA has been helping to support the natural science collections sector by liaising with Defra to help inform them of the needs of museums with scientific collections with regards to Brexit & CITES legislation.

To help address some of the other bigger picture issues surrounding the decline of subject specialist expertise in the museums sector we have been working with other Subject Specialist Networks (SSNs). A large part of this work involves us being on the steering group for the SSN Consortium. This is an important group, as it joins together the voices of around 40 SSNs similar to NatSCA, amplifying the message that museum collections need knowledge to unlock their potential. Through the Consortium we have an opportunity to engage more effectively with sector bodies, and we have already helped inform the Art Fund and Arts Council England about how the wider museums sector is supported by specialist groups and how they as funders can better support the work we do. This has resulted in a new funding strand from the Art Fund and we are in discussion with Arts Council England about how SSNs might be better supported to increase capacity for developing and delivering resources for our members.

Update on this – the Consortium has secured funding from the Art Fund to get properly established with appropriate governance and develop a strategy to further the aims of SSNs.

We met with representatives from ACE this morning, who were prioritising Covid-19 support, but were keen to engage with the SSN Consortium in the future to help get a better understanding of how they could work with and support the SSNs.

We had good uptake of our conference bursaries for last year, after increasing the award from a maximum of £100 to £250. Our 2019 Bill Pettit Memorial Award went to two projects. The Dorman Museum "Leo the Lion conservation project" (£1105) and the Victoria Gallery, Liverpool "Primate skeleton conservation project" (£1840). Both will have the results reported on our blog.

This year's Bill Pettit grant has recently been awarded to: "The Last Passenger" which is a project to conserve the SS Great Britain's Cormorant (£1424) and Curating digitising and displaying a unique historic odontological collection at the Gordon Museum (£2100).

Training delivered in 2019 included "Finding Funds for Fossils, Ferns and Flamingos: how to secure money for museum collections" run in partnership with the World Museum Liverpool; a "Care and Conservation of Insect Collections" workshop was run in partnership with The Oxford University Museum of Natural History, and "An introduction to mobilising your collection's biodiversity data" workshop in partnership with Bristol Culture and NMH London. This training ties in with our aim of facilitating the integration of the UK national dispersed collections with the European Distributed System of Scientific Collections (DiSSCo) programme. DiSSCo looks to become an increasingly important initiative for mobilising collections data and improving access to collections around the UK and Europe.

Earlier this year, before lockdown, we also ran a Natural Science Collections: The Basics course which was kindly hosted by the University of Cambridge Museum of Zoology. We did have other training courses being planned, plus our Conservation Working Group were planning a bone conservation workshop at this year's SPNHC conference that was due to be held in Edinburgh. Obviously these physical meetings and events won't be taking place now, but we will be looking at providing some online training and events.

Last year's AGM and conference was on the theme of "Dead Interesting: Secrets of Collections Success" which was generously hosted by the National Museum of Ireland with additional tours kindly provided by the National Botanic Gardens of Ireland.

We were delighted to welcome Glenn Roadley, Amanda Callaghan, Kirsty Lloyd and Jen Gallichan, who were elected as trustees at the Dublin AGM and who have already proven to be valuable assets to the committee.

At the Dublin AGM the membership voted for a proposed change in NatSCA's status to a Charitable Incorporated Organisation (CIO), which will be enacted at this AGM. This is a step that many SSNs are undertaking since the CIO status was introduced by the Charities Commission in 2013, since it confers 'legal personality' allowing entry into contracts on behalf of the organisation rather than individual trustees, which means Committee members are no longer personally financially liable for issues that might arise.

This switching of status won't make much of a visible difference for members, but it has driven a lot of governance review within the Committee which will mean you can expect some more clarity around how we operate, including some new policies. It does also mean we have to change our bank accounts, so if you have standing orders or direct debits set up to pay your subs, you will need to update your set up.

Because of this sort of issue we are likely to run two bank accounts for a while, to facilitate the switch over, but from this moment we will longer be operating as the Natural Sciences Collections Association, Registered Charity no. 1098156 and we will be operating as the Natural Sciences Collections Association, Registered Charitable Incorporated Organisation no. 1186918.

The first action of NatSCA CIO is for the standing trustees of the old charity to step down and we will now undertake the appointment of trustees to the steering committee of the CIO, so I will take this opportunity to thank you for the pleasure of being chair of NatSCA for the last few years and I will hand over to Tivvy to lead the appointment of the committee for the new CIO.

7. Dissolution of NatSCA Registered Charity No. 1098156

See penultimate paragraph above.

From this moment NatSCA as a Registered Charity no longer exists.

8. Formation of NatSCA Reg Charitable Incorporated Organisation No. 1186918

See final paragraph above.

From this moment NatSCA is now a Charitable Incorporated Organisation (CIO).

9. Election of Committee - Yvette Harvey

Trustees form a steering committee with obligations to ensure NatSCA meets our mission to support the membership, ensure good governance and conform to Charity Commission regulations.

As we transition to CIO status, all the current committee are obliged to resign. For sustainability and continuity, we propose that those who were not due to reach the end of their terms at this AGM, will be re-elected 'en bloc'. Such committee members are indicated below. . They have been proposed and seconded in the normal manner, and the membership secretary confirmed that those proposed, those proposing and those seconding are all current personal members of NatSCA.

Nominee	Position	Proposed	Seconded
Amanda Callaghan	OM (Training)	Yvette Harvey	Glenn Roadley
David Gelsthorpe	OM (Bill Pettit Award)	Rachel Webster	Diana Arzuza
Glenn Roadley	OM (Web)	Lukas Large	Olivia Beavers
Holly Morgenroth	Treasurer	Harriet Wood	Tony Irwin
Jack Ashby	OM (Evaluation)	Mathew Lowe	Tannis Davidson
Kirsty Lloyd	OM (Collections At Risk)	Maggie Reilly	Glenn Roadley
Lucie Mascord	OM (Conservation)	Paolo Viscardi	Glenn Roadley
Yvette Harvey	Secretary	Roberto Portela Miguez	Wendy Atkinson

If there are no objections to the candidates, can we accept and elect the listed people en bloc onto committee until re-election in 2021, or 2022 in the case of Treasurer.

Proposed: Paolo Viscardi **Seconded:** Laura McCoy

Below are the nominees for NatSCA trustee positions standing for election at this AGM. The membership secretary has confirmed that those proposed, those proposing and those seconding are all current personal members of NatSCA. No term will exceed three years without re-election.

Nominee	Position	Proposed	Seconded
Isla Gladstone	Chair	Ray Barnett	Nigel Larkin

With the same number of nominees as positions for this post, there will be no competition. If there are no objections to the candidate, can we accept and elect the nominee onto committee?

Proposed: Paolo Viscardi **Seconded:** Lucie Mascord

Nominee	Position	Proposed	Seconded
Clare Brown	Membership Secretary	Laurin Gardiner	Rebecca Machin

With the same number of nominees as positions for this post, there will be no competition. If there are no objections to the candidate, can we accept and elect the nominee onto committee?

Proposed: Holly Morgenroth **Seconded:** Lesley Noe

Nominee	Position	Proposed	Seconded
Jan Freedman	Editor	David Waterhouse	Luanne Meehitiya

With the same number of nominees as positions for this post, there will be no competition. If there are no objections to the candidate, can we accept and elect the nominee onto committee?

Proposed: Amanda Callaghan **Seconded:** Jennifer Gallichan

Below are the names of nominated candidates standing for Ordinary Member positions on the committee:

Nominee	Position	Proposed	Seconded
Bethany Palumbo	Ordinary Member	Paolo Viscardi	Arianna Bernucci
Donna Young	Ordinary Member	Lauren Gardiner	Rachel Webster
Jennifer Gallichan	Ordinary Member	Kate Mortimer-Jones	Sally Whyman
Paolo Viscardi	Ordinary Member	Bethany Palumbo	Yvette Harvey
Tannis Davidson	Ordinary Member	Jack Ashby	Hannah Cornish

There were four vacancies for Ordinary Members and five nominees, requiring an election. An anonymous vote was taken supported by Google Forms, having verified membership via email addresses.

39 members voted. Results were compiled and Bethany Palumbo, Donna Young, Jennifer Gallichan and Paolo Viscardi were the successful candidates.

10. Chair's Welcome - Isla Gladstone

I would like to start by echoing Paolo Viscardi in thanking you all for joining us at this digital AGM today. The coronavirus pandemic is challenging in many different ways for individuals and our sector. Delivering this AGM helps put NatSCA in the best place possible for natural science collections and our community, and your support in this is appreciated.

I would also to share a couple of lines of thought with you as I step into my new role.

The first looks back to my own journey with NatSCA. My first interaction with the organisation was back in 2007 at the annual conference and AGM at Millennium Galleries Sheffield. I had just started my first museum job, as Curatorial Assistant at the Royal Cornwall Museum, which was rewarding but I admit I also felt a little isolated and overwhelmed. My overriding memory from that first meeting was of community, and the importance of being able to connect with others to share interests, challenges and support. I also remember a series of talks that challenged my thinking. Something that stuck in my mind was Trevor James from the National Biodiversity Network urging us to connect better to researchers and biological recording community and share our specimen biodiversity data. These things are still as important today as ever.

I also wanted to share my thinking today, which centres around the dual context of a changing sector ecology: with increasing loss of subject specialist posts, stretched roles and significant collections with no in-house subject expertise – but also of urgent need: for example the fundamental role natural science collections can have in research and engagement around environmental crises, and the urgent need to decolonise. How does NatSCA stay relevant and sustainable in this context, offering the best possible support and advocacy? For me this is about continuing to make sure our core programme is solid and responds to sector need; that we have the best data on natural science collections, the people who work with them, their needs and activity so we can give the best platform and advocacy; that we continue to collaborate at local and global level to bring wider capacity, exposure and expertise. I am looking forward to working with a fantastic group of trustees, yourselves and wider partners to achieve this.

11. Any other business

Adrian Doyle raised awareness of the next Pest Odyssey Network annual open meeting (online) on 8th July 2020, 2-5pm. The theme of the meeting is "Pest Off with Covid and Other Stories". The group are looking forward to the 2021 Pest Odyssey conference.

12. Vote of thanks - Isla Gladstone

I would like to offer deep gratitude to all of our NatSCA trustees and volunteers, who offer their time and expertise to help NatSCA achieve its mission.

A special thank you to Maggie Reilly, our fantastic membership secretary who has been a trustee of NatSCA since it was first established in 2003 with the merging of the Natural Sciences Conservation Group and the Biology Curators' Group. Maggie has been a huge asset to NatSCA, always supportive in bringing a longer-term perspective to help drive our work forward, alongside her significant membership role. Maggie has offered to continue to help NatSCA on a voluntary basis, for which we are very grateful.

Special thanks also to Paolo Viscardi, who has been NatSCA's Chair for the past seven years – first as maternity cover for Clare Brown, and then for two terms as elected Chair. Paolo has poured his energy and expertise into NatSCA, helping the committee's work to become more efficient, working on projects such as Natural History Near You and the recent establishment of the Subject Specialist Network Consortium, always raising his voice for natural science collections and willing to offer his support. I am personally grateful to Paolo for his support and handover of information as part of the transition to new Chair.

I would also like to specifically mention our volunteers: the Conservation Group which is led by trustee Lucie Mascord and includes Natalie Jones, Emilia Kingham, Julian Carter, Bethany Palumbo, Arianna Bernucci, Vicen Carrio, Nigel Larkin, Gill Comerford, Simon Moore and Vicky Purewal; the Editorial Board (Bethany Palumbo, David Notton, Matthew Parkes and Rob Huxley) and peer reviewers; and our operational support team who help us deliver events, projects, the conference and the essential work involved in the running of NatSCA (Justine Aw, Lily Wilks, Natalie Jones, Sam Barnett, Antoinette Madden and Erin McNulty).

Finally, I must mention our Treasurer Holly Morgenroth, whose hard work underlies everything we do.

13. Next AGM venue

National Museum Cardiff – May 2021**. To be confirmed.**

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NatSCA Committee

Published by the Natural Sciences Collections Association (2020)
ISSN (print): 2053-1133 ISSN (online): 2053-1141

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