Journal of Natural Science Collections

ISSN 2053-1133

Volume 6 | 2018

NatSCA

Natural Sciences Collections Association

Index

Editorial

Rachel Jennings

Dear reader,

Welcome to Volume 6 of the Journal of Natural Science Collections. I apologise that it reaches you rather later than usual – due to various personal circumstances, I have not had as much time and energy to put into the Journal as I would like. I have now decided to step down as Editor, so this volume will be my last. I have thoroughly enjoyed working on the Journal, and I want to sincerely thank every author, reviewer, and Editorial Board member for making it the success that it is.

The articles in this Volume cover a wide range of subjects. First, **Das and Lowe** discuss scientific racism and decolonial approaches to interpreting natural history collections. This paper is based on their talk, '*Nature Read in Black and White*', presented at the 2017 NatSCA Conference.

The next three articles broadly cover the topic of digitisation and making collections accessible: **Ablett et al.** describe the '*Mollusca Types in Great Britain*' database, which brings together collections from regional museums across Britain; **Gardiner** discusses the history – and future – of the Cambridge University Herbarium; **Arzuza Buelvas** introduces the Murphy spider collection at Manchester Museum and its importance as a research collection.

Next, **Steele** describes a collaborative project between the University Museum of Zoology, Cambridge, and four NERC-funded projects in Southeast Asia to communicate conservation biology and ecology to different audiences.

The next two papers focus on collections moves and conservation: **Flanagan, White and Viscardi** describe a pest management protocol for microscope slide collections, with considerations for collections management; **Herrero, Chandler and Viscardi** discuss a difficult entomology collection move and concerns for pest control involving very low temperatures.

Jackson and Larkin segue us from conservation into exhibition planning: they describe the collection, conservation, and mounting of a fin whale skeleton from the Cumbria coast for display at Tullie House. **Nunn and Smith** then discuss the use of puppetry for marketing and engagement activities relating to the 2017 '*Dinosaurs of China*' exhibition at Wollaton Hall.

I hope that you find this collection of articles interesting, inspiring, and useful - there is a lot of practical advice in these papers that can be applied to other museums and collections.

View from the Chair

Paolo Viscardi

Another year of Brexit discussions with no deal being agreed has meant continued uncertainty for the museums sector in the UK and parts of Europe. NatSCA has been representing our membership in discussions with the Department for Environment, Food & Rural Affairs (Defra) about CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) and the impact of a no-deal Brexit on movement of natural history specimens across the UK borders, and we are sharing updates as they emerge. The long and short of it is that permits will be required to move specimens that fall under Annexes A and B and notifications for some species in Annex C, unless you are a registered Scientific Institution (registration currently costing £221 and taking up to 3 months to process). Of course, this may change in the event of a deal. We are also in ongoing discussion with the Home Office about licensing of collections containing substances controlled by the Misuse of Drugs Regulations 2001. While on the subject of legislation, we addressed the General Data Protection Regulation (GDPR) that came into effect on 25th May 2018 by conducting a review of our data management and publishing a new Privacy Policy that outlines how we use any personal data we collect: www.natsca.org/privacy-policy.

In the wider museum sector, we have been involved in steering the emerging Subject Specialist Network Consortium. This forum is shaping up to be the largest network of collections expertise and offers an opportunity for SSNs to share information and coordinate efforts to address issues such as training and collections at risk, which we continue to monitor and respond to. NatSCA has also been representing natural sciences collections at the Museums Association (MA) conference in a session on '*Collections 2030*', and at the Linnean Society Plenary meeting on the theme '*How are we communicating the Importance of Taxonomy and Systematics?*'.

At our own 2018 conference and AGM held at Leeds City Museum, we adopted the theme of '*The museum ecosystem: exploring how different subject specialisms can work more closely together*'. This focus on collaboration has been an important part of NatSCA's strategy over the past few years, as we respond to changes to staffing approaches in the sector and witness ongoing attrition of subject specialist posts in favour of more generalist collections manager roles. Working together helps raise awareness of, and demonstrate engagement with, wider museum practice. We hope that this supports our members' professional development and employability in a changing sector, while also demonstrating that workers in natural sciences are forward-looking and open minded - bearing little resemblance to the caricature of disconnected hobbyists that has damaged our standing in the sector in the past. At the AGM in Leeds we were delighted to welcome two new members to the committee, Jennifer Gallichan and Yvette Harvey. We're happy to have some new blood to keep things fresh and bring new perspectives. Please think about putting yourself forward for election to the committee if you want to get involved - nomination forms are on the website at www.natsca.org/nominations.

While we can learn from our colleagues in other disciplines, we also have a lot to share. During the 2018 membership year, Clare Brown and Donna Young organised a '*Skeleton Preparation Workshop*' in partnership with Historic England and a '*Finding Funds*' workshop at the World Museum, Liverpool. We also ran a '*Caring for Natural Science Collections*' one-day conference at the Oxford University Museum of Natural History, which was made possible by NatSCA's Conservation Group, steered by our Conservation Representative Lucie Mascord.

We had an improved uptake of bursaries on previous years after raising the amount available per person to £250, to help cover increasing costs of accommodation and travel. Our call for projects for the Bill Pettit award was pushed back to 8th March 2019 while we waited for a decision about project funding from Arts Council England. Unfortunately, we were unsuccessful in that bid despite a huge amount of work by our committee members Isla Gladstone and Holly Morgenroth to get the proposal prepared and submitted. The work Isla put in was particularly notable as she was on maternity leave at the time, and we would like to offer her our congratulations on the birth of her second child alongside our thanks. I would also like to thank Emma-Louise Nicholls who served on the committee as a co-opted member representing GCG while Isla was on maternity leave. Emma has also been doing a fantastic job of running the NatSCA blog for several years and we are sad to be losing her while she focuses on GCG and her role at the Horniman.

I would also like to wish a fond farewell to Paul Brown, who is stepping down after over a decade on the NatSCA committee. Paul has filled the role of Chair, Secretary, and - most recently - Archivist, and was instrumental in shaping NatSCA as it emerged from the union of the Biological Curator's Group and Natural Sciences Conservation Group in 2003. We're fortunate to be keeping that font of knowledge close at hand as Paul has kindly offered to continue in his Archivist role in a voluntary capacity. Paul, you will be missed on committee and I offer you our sincere thanks.

Finally, I would like to thank our volunteers that aren't on the committee, but who play a vital role in keeping things running. That includes all the members of our Conservation Group and Editorial Board, as well as individuals who help the committee, namely Glenn Roadley, Lily Nadine Wilks, Sam Barnett, and the indispensable Justine Aw. Of course, the committee are volunteers too and I thank them all for their effort in making NatSCA work, and as ever I reserve special thanks for Holly for keeping us on an even financial keel.

Nature Read in Black and White: decolonial approaches to interpreting natural history collections

Subhadra Das[1]* and Miranda Lowe[2]

Address: [1] *UCL Collections (Science), 223 Wilkins Building, UCL, Gower Street, London, WC1E 6BT, UK*

[2] *Natural History Museum , Dept of Life Sciences , Invertebrates Division, Cromwell Road , London, SW7 5BD, UK*

**Corresponding author: subhadra.das@ucl.ac.uk*

Received: 28/08/2018

Accepted: 21/11/2018

Citation: Das, S. and Lowe, M., 2018. Nature Read in Black and White: decolonial approaches to interpreting natural history collections. *Journal of Natural Science Collections,* 6, pp.4-14.

Abstract

Narratives about the history of collecting are commonly absent from the interpretation of natural history collections. In this paper, we argue this absence – particularly in relation to colonial histories – perpetuates structural racism within modern society by whitewashing a history where science, racism, and colonial power were inherently entwined. This misrepresentation of the past is problematic because it alienates non-white audiences. Using examples from a single natural history collection – the Natural History Museum, London (NHM) – we will demonstrate how an existing collection retains these colonial ideologies and narratives, and, as such, can be used at the centre of decolonial approaches to interpreting natural history collections. We propose that publicly acknowledging difficult pasts is an important first step in creating less racist museum interpretation in natural history museums.

Keywords: Structural racism; decolonial approaches; history of science; natural history; curation; museum interpretation; museum ethics; acknowledgement; social justice

Introduction

On December 4, 2016, in a Twitter thread of 100 unpopular opinions about museums, Danny Birchall, Digital Manager at the Wellcome Collection, tweeted, "52/Natural history museums are more racist that anyone will admit" (Birchall, 2016). To the authors of this paper, Birchall's was an affirming statement, reflecting our own experiences as people of colour working with natural history and historical science collections, in a national museum and at a university. It also posed an intriguing challenge: how can we describe the racism inherent in museum practice relating to natural history collections and, more importantly, what can we do to change this?

The greater part of this paper is dedicated to exploring and answering the first question: how are natural history museums (i.e. cultural institutions which hold, curate and interpret collections of plant, animal, and human remains, and geological specimens and fossils) implicated in perpetuating racism? To do this we will recount the history of natural history – the Enlightenment science which became biology and genetics as we know them today, having previously included what we now call social sciences, such as anthropology and archaeology. We will then consider decolonial approaches to understanding this history, particularly the role museums played in the colonial project and the implications this has for contemporary museum practice. With this in mind, we will consider how natural history and other science collections communicate with public audiences and how these messages can be perceived. Using examples from a single natural history collection – the Natural History Museum, London (NHM) – we will demonstrate the potential which exists for decolonial approaches to interpreting natural history collections.

Having explored these issues, we will conclude by addressing the second question, and outlining how staff working in contemporary natural history collections can actively counteract racism by considering, embracing and implementing a decolonial approach.

A brief history of scientific racism from the Enlightenment to WWII

Scientific racism has its roots in the Enlightenment, a period of European history when scientific epistemologies began to overtake religious ones for ways of understanding the natural world. According to Fredericksen, "The scientific thought of the Enlightenment was a pre-condition for the growth of modern racism based on physical typology" (Fredericksen, 2002: p.56). Taxonomy was a key aspect of Enlightenment science, particularly when it came to the natural world. (While contemporary definitions draw a distinction between typology and taxonomy, it is important to note this distinction was not apparent in early Enlightenment science. In the context of this paper, it is also worth pointing out that taxonomy is considered a science, with typology limited to the social sciences, arguably a continuation of a colonial approach.) The 'father of modern taxonomy', Carl Linnaeus, included humans amongst the animal species, and also divided them into categories based on physical appearance and behaviour. While these were not ranked, Linnaeus' prejudices are clear: e.g. Europeans were "acute, inventive... Governed by laws", while Africans were "crafty, indolent, negligent... Governed by caprice" (quoted in Fredericksen, 2002: p.56). Johann Friedrich Blumenbach, considered the father of physical anthropology, went further by developing an authoritative classification of humankind in his book *On the Natural Varieties of Mankind* in 1776. Blumenbach distinguished five types of human based on the geographical distribution of peoples known at the time: Caucasians, Mongolians, Ethiopians, Americans, and Malays. While Blumenbach considered these types composed a single species, and that they were abstractions or ideals, with most people falling in between types, he nonetheless considered Caucasians (named for the people he considered to be the most beautiful, Circassian Georgians) to be the source type from which the others had developed or degenerated (Fredericksen, 2002: p.57).

Combined with Johan Caspar Lavater's principle of physiognomy – that physical traits relate directly to what we now consider to be abstract traits such as emotion, character and intelligence – this quantitative approach to measuring human bodies and abilities gained academic traction over the course of the 19th century, with increasing divisions between the 'races' and their (wrongly) ascribed traits. While the work of physical anthropologists like Paul Broca and Samuel Morton – both of whom ranked 'races' according to skull size – are well documented (and discredited; see Gould, 1981), the role of biologists are less commonly spoken about. Like Blumenbach, Thomas Henry Huxley — famously 'Darwin's Bulldog' — also defined five 'races' of human: Australoid, Negroid, Xanthrochoi (light-skinned Europeans), Melanochroi (dark-skinned Europeans and light-skinned Africans and Asians) and Mongoloids. Biologist and Director of the Natural History Departments of the British Museum in South Kensington (later the Natural History Museum) Professor William F. Flower developed callipers to ensure greater accuracy and consistency of skull measurements, as well as highlighting the effects of climate and environment on developing so-called racial traits, including intelligence and morals (Challis, 2016: p.2). By the turn of the 20th century, the idea of physically distinct 'races' with measurable, fixed characteristics was firmly entrenched.

Museums were integral to entrenching these scientifically racist ideas, functioning as repositories for the objects and specimens collected on scientific expeditions carried out around the globe, and, simultaneously, legitimising this collecting in the context of scientific thought.

Towards the end of the 16th century, there was a shift in the paradigm of museum displays from enjoyment to education. This was accompanied by exhibition strategies that used collections as a means to display and advance new theories. These 'encyclopaedic' collections were representative of, and key to, the process of advancing scientific thought (Moser, 2006:

pp.11-12). An important example is the museum of Ole Worm in Copenhagen. Worm was one of the first to collect ethnographic objects. Depending on the type of object, these were often classed as natural objects (rather than objects resulting from human action) (Moser, 2006: p.43). While embodying the growing interest in and study of human culture, this method of display was also a way of objectifying these peoples and defining them as 'other', inherently different and separate from Western civilization (Arnold, 2006: p.239). The 'othering' of non-Western civilizations, combined with a further transformation of collections from private viewing rooms to public galleries, had an influence beyond the academic: it was fundamental to colonial ambition (see Bennett, 2004). Barringer, using the example of the South Kensington Museum (now, aptly, the Victoria and Albert Museum), states, "The acquisition of colonial objects from areas of the world in the which Britain had colonial or proto-colonial political and military interests, and the ordering and displaying of them by a museum which was a department of the British state, formed… a three-dimensional imperial archive" (Barringer, 1998: p.11).

Museums holding national collections, most notably the British Museum, are usually associated with this type of collecting, but scientific collections in general and natural history collections in particular also played an important role in colonial collecting. In his book *Bone Rooms: from Scientific Racism to Human Prehistory*, Redman describes how natural history museums in the United States were repositories for the competitive collecting of Native American human remains, collected to further race science and racial theory (Redman, 2016). In addition to acting as repositories, museums – and other academic institutions, such as universities – were instrumental in legitimising scientific study. Craniological collections in 19th-century museums, whereby the superiority of white Europeans over non-white peoples across the rest of the globe was established, not only increased knowledge of craniology, they legitimised the process of scientific thought at the same time (Dias, 1998). Much of this ideological role of natural history museums has yet to be properly explored. The Mobile Museum project, based at The Royal Botanical Gardens, Kew, is currently in the process of researching the provenance and purpose of their economic botany collections – plant specimens and the wide range of objects made from plants – which were collected from around the British Empire and then distributed to schools across the British Isles (Cornish and Wilkey, 2018).

Mainstream science and public perceptions of that science changed fundamentally in the middle of the 20th century when the Nazi's application of eugenic (race science) principles in 'The Final Solution' became known to the world. The systematic slaughter of thousands of Roma, communists, Poles, Slavs, the mentally and physically disabled, homosexuals, political dissidents, and six million Jews was enough to discredit scientific essentialist ways of thinking (Fredericksen, 2002: pp.128-9).

Decolonial thinking and natural history collections

It is important to consider the context in which the work of scientific racism was done. To do this, we take a decolonial position, which frames contemporary thought – including scientific thought – in the context of colonialism. We define 'science' following Marks, as "the production of authoritative knowledge in the modern world" (Marks, 2017: p.59). The use of the term 'production' here is important as it is active, as opposed to 'discovery', which has the connotation of being passive.

The history of Enlightenment science, including the natural sciences, is inseparably entwined with the history of European colonialism. One of the most historically important scientific expeditions set out to measure the transit of Venus in 1768. Having accomplished this part of its mission in Tahiti in 1769, the expedition returned to England in 1771, having visited the Pacific Islands, Australia, and New Zealand, and having collected vast quantities of astronomical, geographical, meteorological, botanical, zoological, and anthropological information and specimens. The expedition's commander, Captain James Cook (1728 – 1779), in addition to being a geographer, was also a naval officer. The expedition was funded by the Royal Society and sailed aboard *HMS Endeavour*, a Royal Navy vessel which also carried trained soldiers, marines, gunpowder and other weaponry. Cook was hardly the only one to command such a voyage, the motives of which were as much imperial as they were scientific. When he invaded Egypt in 1798, Napoléon Bonaparte (1769 – 1821) took 165 academics with him. The entanglement of science and Empire continued well into the 19th century. In 1831, when Charles Darwin (1809 – 1882) sailed on *HMS Beagle*, the mission of the expedition he was accompanying was to better map the South American coastline and Falkland and Galápagos Islands so as to enable greater British control of those areas (Desmond and Moore, 2009). Wherever these colonialist scientific expeditions went, subjugation of native people, slavery, and genocide were the result. The history of Enlightenment science and European colonialism are so inexorably entangled that they may be considered one and the same (Harari, 2014: pp.275-304).

Some of this overt, colonial scientific racism remains on display in contemporary natural history museums and is the focus of much contemporary decolonial critique. For example, the #DecolonizeThisPlace movement is calling for the reinterpretation and re-presentation of the Human Origins and Cultural Halls in the American Museum of Natural History (AMNH). These activists maintain that the continued, decontextualised inclusion of anthropological displays (dressed mannequins and dioramas) which do not include white people, in the context of a natural history museum, to be overtly racist. The movement also calls for a statue of Theodore Roosevelt outside the AMNH to be removed. The statue depicts Roosevelt astride a horse with a Native American and enslaved African walking either side of him. There is no room, say #DecolonizeThisPlace, for depictions of the non-white peoples of the United States as subjugates to its white inhabitants and government (#DecolonizeThisPlace, 2016).

While it is vital to confront overt racism in public institutions, it is also important to confront covert, less obvious forms of racism in these institutions using decolonial approaches. The distinctions made historically between white and non-white peoples were not solely based on physical differences, they were extended to aspects of behaviour, character, intelligence, and, by extension, culture. As such, colonial ways of thinking survive in contemporary society. In his pivotal book *Orientalism*, Said examines how European portrayals of 'The Orient' — North Africa, the Middle East and Southern Asia — were consistently reductive. They rendered the peoples of those parts of the world — and, crucially, their ways of thinking — as other, inferior and stereotypical (Said, 1978). Decolonial student movements, such as Rhodes Must Fall Oxford (Rhodes Must Fall Oxford, 2019) and #WhyIsMyCurriculumWhite, are critical of the overarching structures of knowledge which frame Western thought as objective and apolitical. A white curriculum, they say, denies the existence and importance of other peoples and cultures from other parts of the world and serves to keep a colonialist ideology of knowledge in place (UCL, 2014).
With these approaches to literature and university syllabi in mind, what can people working in natural history museums do to change the existing colonial frame?

Racism in the gaps

In light of its colonialist history, there is a need to critique Western science and the ways in which it is presented, including natural sciences like biology and genetics, with a decolonial framework in mind. (This is not a critique of rationalist approaches to studying and understanding the world, but a deconstruction of the uncritical production of scientific knowledge which is then presented as objective fact.) In the scientific context, a key expression of continuing colonial thought is the denial of the colonialist history of science described above. "After World War II", according to Marks, "the scientific study of human heredity had to be thoroughly reinvented… That reinvention partly involved writing the eugenics movement [historically the most recent branch of scientific racism] out of its history" (Marks, 2017: p.97). Science museums, including museums with natural history collections, have positioned themselves at the 'hard science' end of the spectrum (as opposed to 'social' sciences like anthropology and archaeology. Historically these subjects were part of the natural sciences, along with biological sciences like comparative anatomy). A key part of this positioning involves distancing the practice of science from its history, focussing solely on the delight in discovering more and more about the natural world, and also advocating what we as humans can do to protect it.

The concept of 'race' is rarely discussed in a natural history museum context today (an exception being the exhibition *RACE: Are we so different?* funded by the American Anthropological Association (2016)). Nowadays, many mainstream scientists, particularly biologists and geneticists, are quick to point out that there is no scientific basis for understanding 'race' as defined by historical biologists. Public scientists and science communicators explain in detail how, in the last few decades, the science of genetics has disproved the scientific theory of 'race' (for example, see Rutherford, 2016). While their work is commendable in the context of combatting overt racism, we maintain that a blanket statement by scientists that there is no scientific basis for 'race' *in the consistent absence of any historical context about the scientific history of racism*, is problematic and has the potential to perpetuate covert, structural racism. If there is no such thing as 'race', why are we talking about it in the first place?

It is clear that the absence of the story of 'race', particularly the history of scientific racism, is not lost on audiences visiting natural history museums. While a NatSCA-commissioned survey in 2013 showed that natural science galleries are an established favourite among museum visitors (Jenkins, Lisk, and Broadley, 2013), these numbers alone do not tell the whole story. In an anthropological study, Dawson has demonstrated that the consistent ignoring of the history of scientific racism is obvious to people of colour who visit natural history museums (Dawson, 2018). Dawson interviewed groups of people whose backgrounds are under-represented in science communication, i.e. UK residents from socio-economically disadvantaged backgrounds and from minority ethnic backgrounds, and concludes that they are excluded by current museum interpretation practices. One reason for this, she says, is "cultural imperialism — when the culture, views and practices of the socially dominant appear universal" (Dawson, 2018: p.10). Dawson goes on to give examples, including how "participants in the Somali and Sierra Leonean groups described how they resented the perception of Africa as burdened by disease and 'saved' by the West in stories about medicine" (Dawson, 2018: p.10). She includes an example from a natural history museum context, saying "...Maria from the Latin American group remarked that even in an exhibition about Colombian butterflies, the rich science-related cultural history of Colombians was erased" (Dawson, 2018: p.11).

In the case of natural history museums, we posit that covert racism exists in the gaps between the displays.

Referencing Mason and Sayner's (2019) delineation of museal silences, we argue that museums collude in society's silences about racism and colonialism (see also Fletcher, 2012, on 'imperialist amnesia') and produce silence through structures of knowledge. "Museums", say Mason and Saynor, "may consider they simply do not possess the material culture about a given topic because they are used to looking at their collections through a specific disciplinary lens" (Mason and Saynor, 2019: p.9). We argue that for natural history museums, this is the lens of decontextualized, ahistorical 'hard science'. Beyond unambiguous flagships like the statue of Theodore Roosevelt outside the AMNH, there are stories which are not being told in natural history museums because of the limitations of the 'hard science' lens, and audiences are capable of seeing through the silence.

Mason and Saynor go on to emphasise, "This situation comes about not through a deliberate suppression but because ways of seeing and classifying the world are culturally constructed and because cultural practices tend to reproduce the dominant narratives and silences of wider society" (Mason and Saynor, 2019: p.9). We argue that these dominant narratives can be changed. While it is understandable that addressing the racist past of a discipline is difficult and upsetting work, we argue that the absence of this work perpetuates racism – particularly by perpetuating stereotypes – in Western society today. This is very clear when looking at natural history museums from a decolonial point of view, and considering the experiences of non-white people who visit them. Museums were put in place to legitimise a racist ideology. By ignoring this history, they are continuing to do so.

Hidden figures

In spite of their colonial history, natural history museums are well-placed to relate decolonial narratives because the stories, work, and knowledge of non-white peoples remain manifest in natural history collections and museum spaces. Many naturalists, such as Sir Hans Sloane (1660 – 1753), travelled throughout the colonies to discover more about the natural world. In addition to describing the plants, animals, and geology of the Americas, their accounts included observations of slavery and the transatlantic slave trade. Many enslaved Africans and indigenous peoples of the Americas were also mentioned in these documents, but often not fully acknowledged for their input of skills and knowledge about local flora and fauna. These people were mainly unnamed, and the consistent omission of the scientific contributions of people of colour was central to the colonial project. The following examples, all from London's Natural History Museum (NHM), demonstrate the quantity and breadth of these publicly untold stories.

In their rush to see the displays at the NHM, most visitors moving through the grand Hintze Hall may not notice the ceiling is a work of art. Known as the 'Gilded Canopy' (Knapp and Press, 2005), the soaring vault is a golden cover adorned with 162 illustrated botanical panels showing plants from across the world. Many of the plants portrayed have medicinal uses, some are ornamental, and others – like cotton, tea and tobacco – were the plants that fuelled the British Empire's economy.

One of these is the plant *Quassia amara* (Figure 1a), which Carl Linnaeus named after an enslaved Ghanaian, Kwasimukamba, or Graman Quassi (other spellings: Quacy, Kwasi and Quasi) (1692 – 1787) (Figure 1b), who was a healer and botanist. He was enslaved as a child and taken to Suriname, which was then a Dutch colony. Working as a scout and negotiator for the Dutch, he lost his right ear during the fighting against the Saramaka maroons, who branded him a traitor. The illustration reproduced here originally appeared in Captain John Gabriel Stedman's *The Narrative of a Five Years Expedition against the Revolted Negroes of Surinam* (1796). In 1774, Stedman witnessed the brutal oppression of slaves during a campaign against the maroons, which he described in his narrative. This illustration, by William Blake, was adopted by those who advocated the abolition of the slave trade.

Kwasi worked as a healer of some renown, eventually becoming so financially successful that he was able to buy his freedom. His success was due in part to his discovery, around 1730, that *Quassia amara* could be used to treat infections caused by intestinal parasites if drunk as a bitter tea. Kwasi's secret formula for this tea was purchased for a considerable sum by Daniel Rolander (1722/3 – 1793), one of the Linnaeus' students, who took it back with him to Europe in 1756. A specimen of the tree was later presented to Linnaeus in 1761 by Carl Gustaf Dahlberg (1721–1781), a Swedish plantation owner in Suriname. Linnaeus publicly named and described the genus, thus establishing it within European botany. Examples of those specimens can be seen within his collections at the Linnean Society, London (Linnean Society of London, n.d.). *Quassia* became a popular 'bitter', praised for its effectiveness in suppressing vomiting and removing fever, both in the Caribbean and in the whole of Europe. Experiments by European physicians showed it to be as potent as Peruvian bark but without the side effects, such as diarrhoea. Deemed safe and effective, *Quassia* – used in infusion, extract, or pills – was included in various European Pharmacopoeia. It continues to be used today in industrially-produced medicines for treating intestinal parasites.

Kwasi served during the next six decades as the colony's leading medicine man, with vast influence over all the inhabitants – black, white, and indigenous peoples – of Suriname. In other accounts from the period he is described as "one of the most

Figure 1. (a) Quassia amara, an image of the ceiling panel from the Hintze Hall at the Natural History Museum London and (b) 'The celebrated Graman Quacy,' an engraving by William Blake from John Gabriel Stedman's Narrative of a Five Years' Expedition Against the Revolted Negroes of Surinam.

extraordinary black men in Suriname, and perhaps the world" (Price and Price, 1988).

Unhappily for this notable case, there is no mention of Kwasi or his plant namesake in the new 2017 gallery interpretation of the Hintze Hall ceiling at the NHM. One story which does appear there is that of a Malay teenager called Ali, through his connection to Alfred Russel Wallace, the explorer, naturalist and biologist, and – along with Charles Darwin – the co-discoverer of evolution. In 1855, at the age of 15, Ali encountered Wallace in Sarawak and worked as his servant before becoming his local guide. Ali was also Wallace's specimen collector, and hunted and skinned birds which would eventually go on to be part of the NHM's collections. Wallace describes Ali's character in his autobiography, *My Life A record of events and opinions*, and how they cared for one another during periods of illness (Wallace, 1905). Ali contributed substantially to collecting a large proportion of the 125,600 specimens which were foundational to Wallace's work. Wallace could not have done this without his 'faithful companion' (van Wyhe and Drawhorn, 2015; van Wyhe and Rookmaaker, 2013).

Another example of the role of indigenous peoples and knowledge in European science is that of the work of Henry Smeathman (1742–1786), an entomologist who spent years working in Sierra Leone. Natural historians such as Daniel Solander, Joseph Banks, and John Fothergill sponsored Smeathman to go to Africa to collect natural history specimens in 1781. He was most successful at collecting insects, which his sponsors used in their own collections. Indigenous Africans helped Smeathman excavate termite mounds for his studies, and collected insects which contributed to financing Smeathman and many other scientists' following fieldwork trips (Douglas, 2009). The sole acknowledgement of these indigenous Africans seems to be in a painting from 1781 (see Figure 2).

Even the English naturalist Charles Darwin, who is universally famed for his contributions to the natural sciences, was taught taxidermy and how to preserve birds by a Guyanese freed slave named John Edmonstone. Edmonstone was an unsung early mentor to Darwin in 1826, when Darwin was at Edinburgh University. Edmonstone's training enabled Darwin to perform taxidermy during his voyage on the *Beagle* from 1831 to 1836. Although Edmonstone is one of Patrick Vernon's '100 Great Black Britons' (Veron, n.d.), it was only in 2009 that this hidden figure emerged and was acknowledged, during the 150th anniversary of the publication of Darwin's

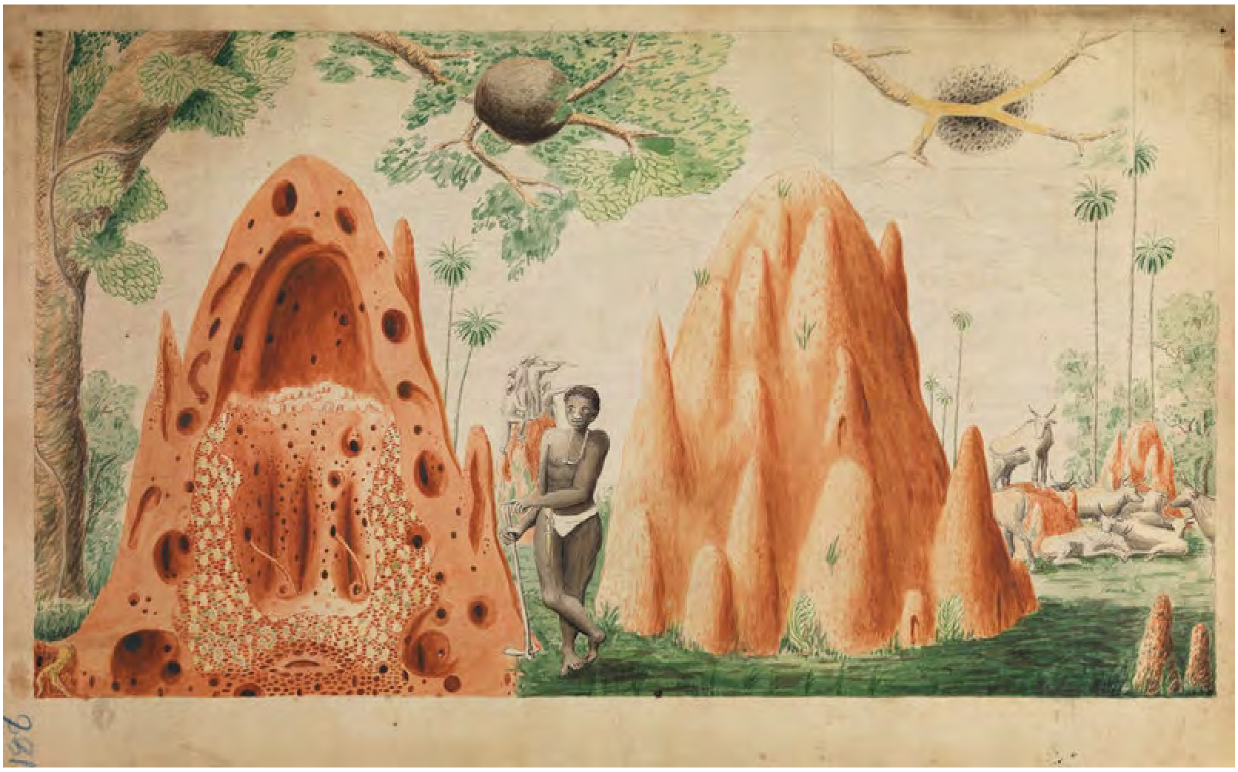


Figure 2. African who helped excavate termite mounds, Smeathman 1781.

Origin of Species. Wedgwood porcelain works produced a plaque in honour of Edmonstone, which is affixed to a bar in Edinburgh (Figure 3).

Figure 3. John Edmonstone, the freed Guyana slave who taught Charles Darwin how to preserve bird specimens.

For the NHM, arguably the most important colonial story of the collections is of those specimens collected by Sir Hans Sloane (1660 – 1753), which form the core collections of the museum. At the age of 27, Hans Sloane set off on his travels, eventually settling in Jamaica where he collected over 800 plant specimens, as well as live animals, shells, and rocks. He also wrote notes on local plants, animals, and people's customs. These documents and specimens became the founding collections of the British Museum, with many of the natural history specimens subsequently housed at the NHM from 1881. As Delbourgo makes clear in his biography, Sloane's medical and scientific careers, including the eventual formation of the British and Natural History Museum collections, were directly funded by profits from slavery (Delbourgo, 2017: p.187). Working as a plantation doctor in Jamaica, Sloane was complicit in slavery, as well as the transfer of plants by slave traders from West Africa to the Caribbean. His writings described many aspects of enslaved Africans' lives in detail, and he also collected a number of their cultural artefacts, including musical instruments. While his personal views on slavery and the slave trade are not clear, Sloane wrote in detail about the knowledge enslaved Africans had of plants, though he did not seem to value their medical traditions and interpretations. He wrote that local people were helpful in locating plants, but he thought they could not use them beneficially without wider knowledge, and indeed may have done harm with them. Sloane also wrongly thought no diseases or medical conditions existed in the Caribbean that he had not seen in Europe, and therefore preferred treatments used by Europeans, such as bloodletting and purging, to traditional local cures (Delbourgo, 2017: p.52).

Forward together: decolonising the natural history museum

The examples above demonstrate that the current absence of decolonial interpretation in contemporary natural history museums is problematic. At best, it misrepresents historical fact; at worst, it alienates audiences. This resonates with other research, including Garibay and Gynlenhall (2015), in science and natural history museum contexts, and also research from further afield in art galleries and social history museums (Dixon, 2012; Dixon, 2016; Hahn, 2016; Jennings and Jones-Rizzi, 2017). As such, there is clearly an exciting opportunity for us to change the interpretation of natural history collections to better reflect their histories, exploring them through the lens of colonial history. As Dawson puts it, "Inviting people from minority ethnic and/or socio-economically disadvantaged backgrounds into spaces or practices that reflect dominant values of Whiteness and class privilege, without fundamentally reimagining the practices involved, is clearly insufficient. Instead", she proposes, "…museums that reimagine collections with marginalised groups in ways that surface their assets (rather than deficits) and do justice to their histories, practices and values may be able to disrupt their role in social production by developing more equitable experiences" (Dawson, 2018: p.13).

If visitors feel alienated from museums because their own histories and stories are being misrepresented, the solution is simple: we, collectively as museum professionals, need to do better at acknowledging past wrongs for what they are, and telling the whole of the story of science. We propose that the first step to redressing these potentially racist misrepresentations is to acknowledge the colonial past of natural history collections and to present the stories about the history of these collections alongside existing interpretation about the specimens and their role in the natural world. An example of this is through the first NHM black history public tours of Hintze Hall held in October 2018, developed and led by Principal Curator Miranda Lowe. These tours recognise contributions of indigenous people to the world of science and natural history. We agree with Marks that there is a moral imperative for scientists to acknowledge that they are not apart from society, but in fact play a fundamental and potentially positive role within it (Marks, 2017). We extend this position to individuals and institutions whose role is to engage public audiences with science, particularly those who work in natural history museums.

The depiction of *Quassia amara* in the ceiling of the Hintze Hall bears witness to the connections between European scientists and enslaved and indigenous experts like Kwasi and Ali. The same is true for the specimens which compose the NHM's collections, particularly those which came from Sloane's collections at the British Museum in 1881. These and other historical specimens collected during the period of slavery and from countries which were being explored through colonial encounters, are testimony to the contributions of non-white people to Western science. As such, they contain and have the potential to relate decolonial stories to the public. Museums, originally established as colonial tools, are well-situated to do the work of public acknowledgement because their collections include objects and specimens which relate directly to that colonial history.

Govier outlines the benefits of such public acknowledgement of past wrongs as fundamental to future progress. "To receive acknowledgement that these things did happen, that they were wrong and should not have happened, and that those to whom they happened were human beings with human rights, persons possessing the same dignity and worth that belong to other human beings", she says, "is to receive confirmation, validation of one's dignity and status as a human being, and a moral being of equal worth" (Govier, 2000: p.18). She goes on to say, "Most of us do not do well preserving a sense of who we are and what we do in a context that denies or ignores the value of these things. Where they have been denied or ignored, acknowledgment removes a barrier between self and others, a confirmation of who one is and what one has lived through…" (Govier, 2000: p.19). In the context of interpreting natural history collections, we argue that acknowledging the origins of these collections is a critical step in bridging an existing gap between natural history collections and non-white audiences. By telling the stories of where the specimens came from, and, more importantly, relating the context of why they were collected and being honest about how this furthered the colonial project, we will remove an obstacle that is actively blocking wider participation. This acknowledgement will show that we as museum professionals are aware of the stories of people who come from the same parts of the world as our museum specimens, and that we are not trying to deny their history or contribution. It is a crucial step towards ensuring we are all involved in our collective project of learning about the natural world.

The fact that our work as natural history curators is scientific does not mean we should close our eyes and ears to the difficult origins of the specimens in our collections. The natural history knowledge from indigenous people from around the world, captured through colonial encounters, needs to be more widely acknowledged for their impact on society, with their narratives sitting proudly alongside those specimens and artefacts within natural history museums.

References

Arnold, K., 2006. *Cabinets for the curious: looking back at early English museums*. Aldershot: Ashgate.

Barringer, T.J., 1998. South Kensington Museum and the colonial project. In: Barringer, T.J. and Flynn, T. (eds). Colonialism and the object: empire, material culture and the museum. pp.11-27. London: Routledge.

Bennett, T., 2004. *Pasts Beyond Memory. Evolution, Museums, Colonialism*. London and New York: Routledge.

Birchall, D., 2016. *Twitter update, 11 December*. [online] Available at: <https://twitter.com/dannybirchall/status/805367870930685952> [Accessed 11 December 2016].

Challis, D., 2016. Skull Triangles: Flinders Petrie, Race Theory and Biometrics. *Bulletin of the History of Archaeology*, 26(1), 5, pp.1-8.

Cornish, C. and Wilkey, B., 2018. "Specimens Distributed": The Circulation of Objects from Kew's Economic Botany Collection. *Outputs of the Mobile Museum*. [online] Available at: <https://intranet.royalholloway.ac.uk/geography/research/mobile-museum/outputs.aspx> [Accessed 27 July 2018].

Dawson, E., 2018. Reimagining publics and (non) participation: Exploring exclusion from science communication through experiences of low-income, minority ethnic groups. *Public Understanding of Science*, 00(0), pp.1-15.

#DecolonizeThisPlace, 2016. *Rename The Day – Remove The Statue – Decolonize This Museum*. [online] Available at: <http://www.decolonizethisplace.org/post/rena

me-the-day-remove-the-statue-decolonize-this-museum> [Accessed October 2017].

Delbourgo, J., 2017. *Collecting the World: The Life and Curiosity of Hans Sloane*. Allen Lane.

Desmond, A. and Moore, J., 2009. *Darwin's Sacred Cause: Race, Slavery and the Quest for Human Origins*. London: Penguin Books Ltd.

Dias, N., 1998. Chapter 3. The visibility of difference: nineteenth century French anthropological collections. In: McDonald, S. (ed.), *The Politics of Display, Museums, Science, Culture*. London and New York: Routledge.

Dixon, C.A., 2012. Decolonising the museum: Cité Nationale de l'Histoire de l'Immigration. *Race & Class*, 53(4), pp.78-86.

Dixon, C.A., 2016. The 'othering' of Africa and its diasporas in Western museum practices. Ph.D. University of Sheffield.

Douglas, S., 2009. The making of scientific knowledge in an age of slavery: Henry Smeathman, Sierra Leone and natural history. *Journal of Colonialism and Colonial History*, 9(3). DOI: 10.1353/cch.0.0029

Fletcher, R., 2012. The Art of Forgetting: imperialist amnesia and public secrecy. *Third World Quarterly*, 33(3), pp.423-439.

Fredericksen, G.M., 2002. *Racism - A Short History*. Princeton and Oxford: Princeton University Press.

Garibay, C. and Gyllenhaal, E., 2015. Habitat Dioramas and Sense of Place: Factors Linked to Visitors' Feelings About the Natural Places Portrayed in Dioramas. In: Tunnicliffe, S.D. and Scheersoi, A. (eds.), *Natural History Dioramas; history, construction and educational role*. Dordrecht, London: Springer. pp.209-225.

Gould, S.J., 1981. *The Mismeasure of Man*. New York: W.W. Norton & Company.

Govier, T., 2000. *What is Acknowledgement and Why is it Important?* OSSA Conference Archive, 1, 15 May 1999. [online] Available at: <http://scholar.uwindsor.ca/ossaarchive/OSSA3/keynotes/1> [Accessed 14 August 2017].

Hahn, C.N., 2016. The Political House of Art: the South African National Gallery 1930 – 2009. Ph.D. Goldsmiths College, University of London.

Harari, Y.N., 2014. *Sapiens: A Brief History of Humankind*. London: Vintage.

Jenkins, S., Lisk, J., and Broadley, A., 2013. *The Popularity of Museum Galleries: Evaluation for Natural Sciences Collections Association*. Report by Jenesys Associates Ltd.

Jennings, G. and Jones-Rizzi, J., 2017. Museums, white privilege and diversity: A systemic perspective. *Dimensions*, pp.63-74.

Knapp, S. and Press, B., 2005. *The Guilded Canopy: Botanical Ceiling Panels of the Natural History Museum*. London: Natural History Museum.

Linnean Society of London, n.d. *Quassia amara*. [online] Available at: <http://linnean-online.org/5881/> [Accessed June 2018].

Marks, J., 2017. *Is Science Racist?* St. Ives: Polity.

Mason, R. and Sayner, J., 2019. Bringing museal silences into focus: eight ways of thinking about silence in museums. *International Journal of Heritage Studies*, 25(1), pp.5-20. DOI: 10.1080/13527258.2017.1413678

Moser, S., 2006. *Wondrous Curiosities: Ancient Egypt at the British Museum*. Chicago and London: University of Chicago Press.

Price, R. and Price, S. (eds), 1988. *John Gabriel Stedman: Narrative of a Five Years' Expedition Against the Revolted Negroes of Surinam, transcribed for the first time from the original 1790 manuscript*. Baltimore and London: John Hopkins University Press.

RACE: are we so different?, 2016. *Understanding Race*. [online] Available at: <http://www.understandingrace.org> [Accessed July 2017].

Redman, S.J., 2016. *Bone Rooms: from scientific racism to human prehistory in museums*. Cambridge, Massachusetts and London, England: Harvard University Press.

Rhodes Must Fall Oxford, 2019. *#RHODESMUSTFALL* [online] Available at: <https://rmfoxford.wordpress.com/> [Accessed 14 February 2019].

Rutherford, A., 2016. *A Brief History of Everyone Who Ever Lived: The Stories in Our Genes*. London: Weidenfeld & Nicolson.

Said, E.W., 1978. *Orientalism*. London: Routledge and Kegan Paul.

UCL, 2014. *Why is My Curriculum White?* [online] Available at: <https://www.youtube.com/watch?v=Dscx4h2l-Pk> [Accessed May 2015].

van Wyhe, J. and Drawhorn, G.M., 2015. 'I am Ali Wallace': The Malay Assistant of Alfred Russel Wallace. *JMBRAS*, 88(1), pp.3-31.

van Wyhe, J and Rookmaaker, K. (eds), 2013. *Alfred Russel Wallace: Letters from the Malay Archipelago*. Oxford: Oxford University Press.

Veron, P., n.d. *100 great black Britons: John Edmonstone*. [online] Available at: <http://www.100greatblackbritons.com/bios/john_edmonstone.html> [Accessed 5 July 2017].

Wallace, A.R., 1905. *My life: A record of events and opinions* (2 volumes). London: Chapman and Hall.

Mollusca Types in Great Britain: founding a union database

Jonathan D. Ablett[1]*, Jennifer Gallichan[2], Anna Holmes[2], Graham Oliver[2], Ben Rowson[2], Andreia Salvador[1], James Turner[2], and Harriet Wood[2]

Address: [1] *Department of Life Sciences, Natural History Museum, London, SW7 5BD*
[2] *Department of Natural Sciences, Amgueddfa Cymru - National Museum Wales, Cardiff, CF10 3NP*

**Corresponding author: j.ablett@nhm.ac.uk*

Received: 20/08/2018
Accepted: 26/11/2018

Citation: Ablett, J.D., Gallichan, J., Holmes, A., Oliver, G., Rowson, B., Salvador, A., Turner, J., And Wood, H., 2018. Mollusca Types in Great Britain: founding a union database. *Journal of Natural Science Collections,* 6, pp.15-30.

Abstract

Type specimens are essential to the study of malacology and are distributed across a wide range of museums in the UK. This initiative, funded by the John Ellerman Foundation, is the beginning of an integrated access and learning project bringing together curators from across the museum sector. Malacological curators from Amgueddfa Cymru - National Museum Wales (AC-NMW) and The Natural History Museum, London (NHM) worked with staff at seven partner museums in six UK cities. Together they developed a database and online resource connecting the Mollusca collections of National and other museums for the first time. At the time of publication, data on over 1800 type lots are available on the 'Mollusca Types in Great Britain' website. Since the launch in March 2018, some 1,189 users have accessed the site from over 60 countries. The database and website continue to be developed and new entries can be made at any time. The regional museum partners were given training focused on building confidence in recognising, researching, and interpreting the molluscan type specimens in their collections. The broader aims of this project were to strengthen and develop curatorial skills in specialist areas that could be transferable to other historically important natural history collections.

Keywords: Type specimens, Mollusca, database, collections, digitisation, holotype, syntype, malacology, conchology, handwriting, taxonomy

Introduction

Molluscs (e.g. snails, slugs, clams, and octopuses and their relatives) are an enormous group of animals, with around 80,000 known species in terrestrial and aquatic environments worldwide (Rosenberg, 2014). Eminently collectible, molluscs have been gathered and used by people since prehistory and their influence reaches many areas of human life (Dance, 1986; Coan and Kabat, 2018). Many are of social, economic, or medical importance as sources of food, jewellery, dye, calcium, and even cloth or musical instruments, or as pests or vectors of disease (Tucker Abbott, 1989; Wilson, 2007; Thomas, 2007). The study of molluscs is a specialist endeavour heavily reliant on collections, and is known as malacology or conchology. Shells form the nucleus of many great natural history collections, with older collections in the UK particularly rich in types (Dance, 1986).

Nomenclatural type specimens, 'types', in natural history collections are the original specimens used to describe species. They are objects of permanent and global value, the fundamental basis of scientific naming and biodiversity inventories, and hence vital to environmental research (ICZN, 1999). Types are still necessary and sought out by researchers, but many curators today are insufficiently specialised, or lack resources, to attend to their research and curation (Kemp, 2015; Deucher, 2017). Such types risk being 'lost' to the international scientific community, which is unaware of their location. This is exacerbated by the fact that the UK is remarkably rich in museums that hold type specimens, a situation not seen in many other parts of the world. In our own experience, researchers from overseas often assume that types are found only in centralised collections in a state's capital city, and may overlook the smaller regional collections. Due to the historical reach of the British Empire and the UK's global position in trade and industry, many UK museums hold type specimens not just of national but also of international importance. In order to improve our understanding of the natural world, information on type specimens is desperately needed by the global scientific community in order to (re-)define what a species actually is. Taxonomy and systematics is, however, not the only beneficiary of such research. When researched, understood, and documented, types can become the stars in stories of historic, global exploration (e.g., Fraussen and Terryn, 2007; Breure, Audibert and Ablett, 2018) and discovery by local pioneering naturalists (Emberton, 1907; Norman, 1907). They offer continuity between the fervour of museums' founding years and contemporary scientific research.

The curatorial teams in AC-NMW and NHM were uniquely placed to undertake an initiative to digitally unite these scientifically valuable specimens for global access and highlight the contribution of dispersed regional museums' collections to worldwide science. The mollusc collections in these two institutions are the two largest in the UK, containing some of the most important collections worldwide, and are currently the only UK museums to have dedicated Mollusca curatorial staff. Together, we have specialist expertise in most groups of molluscs and access to huge comparative collections and libraries. In 2016, our curatorial team received a grant from the John Ellerman Regional Museums and Galleries Fund. Entitled 'Great British Mollusca Types', the aim of the project was to assist certain museums in England, Scotland and Wales to better recognise their Mollusca types so that they may be safeguarded and more widely used, and in turn for these natural history collections to be more widely accessible and celebrated. The key outputs of the project included the database, the dissemination of results, and enhanced skills and knowledge of the participating staff at each museum, as well as the stronger relationships forged between the institutions. Setting the scope of the project, in terms of the museums included, and its future expandability were given much thought.

There was no existing catalogue of Mollusca types for all British or UK museums, though types at Manchester were listed by McGhie (2008), at Edinburgh by Smaldon, Heppell and Watt (1974), and are sometimes covered in part by other works (e.g. McMillan, 1985 for Liverpool). Both AC-NMW and the NHM have their own institutional specimen databases (see Wood and Turner, 2012; Scott and Smith, 2014 respectively) and some specimen records are available online through other museums' databases. AC-NMW had previously verified, databased and imaged all their Mollusca holotypes and lectotypes. Due to the large size of the Mollusca type collection in the NHM (c. 60,000 specimens) only a subset of these specimen lots have been databased (19,183 as of 27th November 2018 - mainly from direct register transcription efforts) and only a very small fraction of these have been critically verified. Due to the conditions of the funding source, the fact that both lead institutions have permanent dedicated molluscan curatorial staff and the large amount of material involved, it was felt that the type holdings of both museums would not be included in any initial project stage. The focus was instead on verifying and uniting material from smaller UK museums.

It is not the only online initiative to focus on types in this way; others include GB3D Type Fossils Online (Howe and McCormick, 2013) and the JSTOR Global Plants Database (JSTOR, 2018). Such projects are indicative of the demand to draw type material together and how this can be well-served in practice by partnership projects that specialise in particular taxa or kinds of collections. MolluscaBase (MolluscaBase, 2018) is a well-known and well-used database of Molluscan taxonomic names, which aims to 'provide an authoritative, permanently updated account of all molluscan species'. Whilst such databases are invaluable to researchers MolluscaBase currently does not provide data on where the type specimens of these taxonomic names reside. The ideal information tool probably draws both names and specimens together.

Methods

The partners

We selected partner museums each known to have many mollusc types in varying stages of curation and research, but currently lacking a specialist malacology curator. Few of these types were traceable online or in print, and fewer still had been photographed. None were databased in a way that allowed all collections to be searched at once, or for the holding institutions and their contributors to be seen in context. As partners, we approached curatorial staff from seven museums across six cities (Figure 1). These were as follows: Kelvingrove Art Gallery & Museum, Glasgow (Richard Sutcliffe); The Hunterian Museum, Glasgow (Maggie Reilly); The Great North Museum: Hancock, Newcastle-upon-Tyne (Dan Gordon); The Manchester Museum (Rachel Petts); Leeds City Museum (Rebecca Machin and Clare Brown); World Museum, Liverpool (Tony Hunter); Royal Albert Memorial Museum, Exeter (Holly Morgenroth).

Mention may be made of the National Museums Northern Ireland, Belfast. Dance (1986) does not indicate what is present, though Ross (1984) suggests

Figure 1. Map showing distribution of project partners. © AC-NMW/NHM

that type, figured and cited material may be present in older collections. This is true of other UK museums which were not included in the first phase of this project, where institutions with large numbers of types were the focus. Inclusion of Mollusca types from this or other collections in Northern Ireland would give a broader reach to the current project and would make the adjective 'Great British' inappropriate. We would welcome such data and can alter the name of the website in the future if required.

Training

We began with baseline evaluation, by asking each partner museum to complete a questionnaire on their mollusc collections and their awareness, skills, and confidence in dealing with them. The recognition and research of types requires specialist literature and knowledge. We understood there would be a need to build capacity and community amongst the participants, who each had different levels of skills in this area and whose collections each face different challenges. Therefore, in June 2016, staff from our seven partner museums took part in a two-day training workshop at AC-NMW covering the scope of the project, and providing a chance to introduce each of the project partners to each other (Figure 2). This was a uniquely specialised workshop, requiring all eight of our project team to be involved in creating and delivering different sessions, including on the history of shell collecting and biographical data on key collectors and dealers. We covered malacological terms such as the different parts of the shell for the major molluscan groups and ran a technical session on imaging shells including the essential views to capture for each of the major groups. There was a section on type theory, with practical exercises on recognising types in collections using worked examples. Here we also introduced valuable research resources such as fundamental literature and websites. We also covered various aspects of collection management such as documentation, storage, and conservation. We were keen that project partners would be able to develop stories and educational materials from their specimens, and interpret the scientific, social, and local history behind them, so we also included aspects of outreach such as text writing, delivered by specialists from the Learning Department at AC-NMW. Each of the attendees testified to enhanced skills in recognising types, improved knowledge of their collections and collectors, and an increased awareness of each other's holdings.

Collections visits

Each participating museum was assigned two people, one from each of the AC-NMW and NHM project teams, who arranged collections visits of several days' duration to locate known and potential types.

Figure 2. Mollusca Types Training Workshop AC-NMW, June 2016. © AC-NMW/NHM

Top row L-R: J. Gallichan, A. Salvador, A. Holmes, J. Turner, H. Wood, J. Ablett, B. Rowson
Bottom row L-R: R. Machin, H. Morgenroth, T. Hunter, R. Petts, R. Sutcliffe, D. Gordon

Efficiently locating types in large collections needed both a subject and a contextual practical knowledge, so joint working with the participants was vital. Curators are the gatekeepers to their own collections and each of them held vital knowledge that helped locate potential type specimens within their collections. The visits were valuable for many reasons, including making new contacts, learning how different collections are organised and used, and highlighting specific conservation issues. The specimens were then loaned to AC-NMW or NHM for specialist photography, databasing, further taxonomic research and literature work by the team, and, as necessary, minor curation and conservation. Since the curators from AC-NMW and NHM are experienced in taxonomic research and type verification, and due to the time restraints of the project partners, it was felt that it was a better use of time and funds for these staff to lead on this aspect. It is hoped that with training and further collaboration staff at the partner institutions will feel empowered to begin future type examinations.

Evaluating Type Material

Researching and interpreting type specimens is a skill that requires training, practise and a good understanding of the International Code of Zoological Nomenclature. As previously noted, the reducing number of specialist curators, and the widening responsibilities of curators in general, has meant that many natural history curators no longer have the skills, time or resources to undertake a critical evaluation of their types. Evaluating the type status of historical material is often difficult because the available evidence may be poor or missing. Our approach has been to maintain rigorous standards, but to combine this, where appropriate, with a measure of pragmatism based on knowledge of collections, institutions and individuals. Much of this knowledge can only come from an in-depth understanding of a museum's history and associated people. Whilst in-depth instructions on how to recognise and check type material are outside the scope of this paper, we endeavour to outline the criteria used by the team in this project. Below is a list of the steps involved when evaluating type material:

- Locate original species description in the literature
- Compare collection locality, collector, and date information on label with specimen
- Compare figure, and measurements (if available) with specimen(s)
- Critically evaluate specimen data based on knowledge of institution, author, collectors, etc.
- Deduce type statuses from description – i.e. holotype, syntype, paratype etc.
- Check if original description is valid (or not, e.g. nomen nudum)
- Note reasoning for type designation if applicable and assign who verified type status.

The process of verifying type material is not an exact science and therefore, as more information is discovered and our understanding of the movement of collections and the interactions between malacologists become better known, the interpretation of material may change. Therefore where type status is in doubt we have labelled type material as 'possible' types. Where we feel that non-type material is important and could have future interest to those studying taxonomy and nomenclature, we have added these as 'non-type material'. Additional material, labelled as type, has been added subsequent to the launch of the project in March 2018. If not examined directly by the AC-NMW or NHM staff or other member of the project team, these have been annotated in the data set as 'unverified'. These are therefore visible to the community as a whole and can be investigated in the future.

Digitisation

The main digitisation element of the project was divided into three distinct processes:

1. Acquisition and aggregation of specimen data
2. Digital imaging of specimens and associated material
3. Development of a public-facing website to enable access to the images and data

The initial stage was to acquire collection datasets of Mollusca types held within each of the seven partner museums (i.e. not AC-NWM or NHM) and aggregate the data into a single purpose-built project database, developed following a Darwin Core schema. In most cases, datasets were exported from the partner museum's collections management system (CMS) in the form of Microsoft Excel spreadsheets. As would be expected when working across multiple institutions using a range of CMSs, the collection data was not consistent in regards to field terminology, naming protocols, and data formats, and therefore required a certain degree of 'cleaning' (e.g.

concatenation or splitting data, reformatting of data, etc.) prior to being mapped and aggregated into the database. The collated data was then further refined within the database as part of the taxonomic research and literature work of the team members.

The second stage consisted of specimen photography. In order to achieve consistency across the project, it was important to standardise the imaging process as much as possible. In the early stages of the project, protocols regarding specimen digitisation were discussed and agreed upon by the project team'. These included:

- Required views of specimens (Figure 3)
- Labels and documentation
- Lighting and backgrounds
- Image elements (scale bars, copyright information) and post-processing
- File formats and image resolution

These protocols allowed for flexibility where additional views and details were required to be captured, whilst still maintaining a reasonable level of consistency across the digitisation process.

All specimen labels and documentation were digitised, as was any documentation associated with the specimen lot. This also included relevant labelling or writing on the specimen storage containers. The mounting of some very historic material and the condition of some fluid-preserved material was such that it limited the ability to image some specimens to the desired level.

A Unique Identification Number (UID) corresponding to an image database record was assigned to each image and added as a printed label to each specimen lot. Specimen metadata, such as catalogue/accession number and type nomenclature, was stored in a separate image database and was used to link the image records back to the type specimen in the project database. Image file names were derived from the UIDs, and multiple versions of each image were retained as a data security measure. These consisted of a full resolution unprocessed RAW file (Adobe DNG) or Tiff; a full resolution Tiff processed and compressed (LZW + ZIP compression with layers); and Jpeg versions resampled to 1024px along the longest dimension and optimised for website use. Images and data are maintained and secured as part of the AC-NMW digital preservation protocols. Partner museums received duplicate copies of all images and data associated with their collections.

The final stage of the digitisation process was the development of a public-facing website to allow universal access to type specimen data and associated images, with each specimen clearly linked back to its holding institution. The model for this was similar to AC-NMW's own mollusc type website (Wood and Turner, 2012) but designed with current browsing standards and responsivity in mind. The website was developed using standard web programming languages (PHP, Javascript, HTML5) with queries to database records via the *Filemaker*® API for PHP. The website aims to comply with all Priority 1 requirements and Priority 2 of the W3C Web Content Accessibility Guidelines 2.1 (WCAG2.1) (W3C, 2018), otherwise known as Level AA compliance.

To ensure longevity of the website, maintenance costs were written into the funding application and have been set aside for such needs in the future.

Evaluation and Outreach

The project concluded with a two-day debrief workshop at the NHM, providing a forum to reunite participants and to share our results and experiences. On the second day, this was opened up to potential future partners at a joint meeting in the morning; it concluded with a presentation in the afternoon, as part of the NHM's regular Collections Seminar Series, to the partners and other interested parties.

Throughout the project we endeavoured to ensure that news from the project was widely disseminated before its conclusion through poster presentations at a range of conferences, including the Natural Sciences Collections Association (Cambridge, 2017), the Museums Association Conference (Manchester, 2017), the Molluscan Forum (London, 2017), a Regional Meeting of the Conchological Society of Great Britain & Ireland (Cambridge, 2017), Porcupine Marine Natural History Society Conference (Edinburgh, 2018), an iDigBio session at Bristol Museum and Art Gallery (2018) and the British Museum 'Museums and Digital Memory' National Programmes Conference (London 2018). In May 2018, the website was given a positive review in the Museums Association's Museums Journal (Knott, 2018). We also used various social media platforms to promote the project while it progressed.

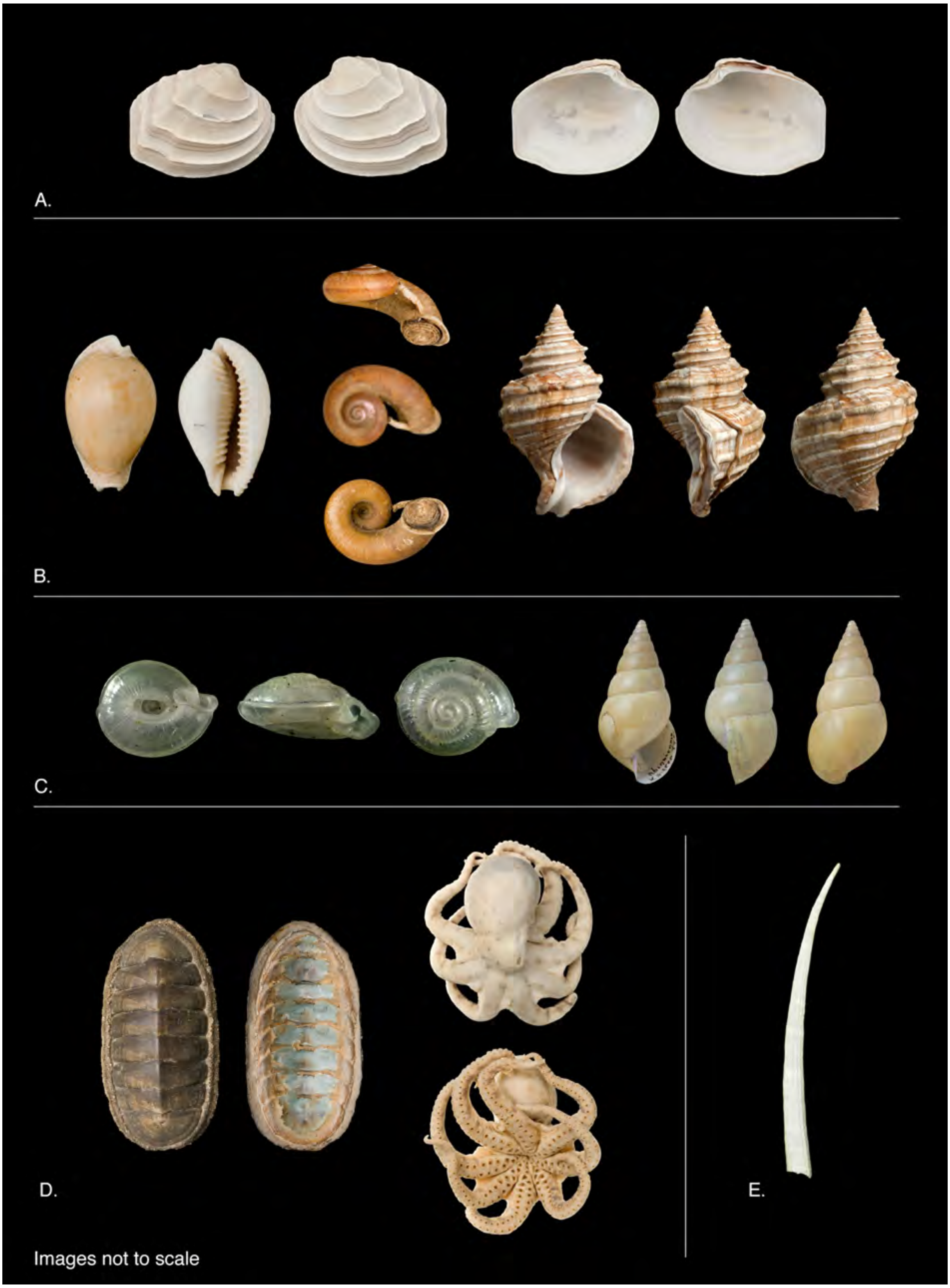


Figure 3. Views required for each type specimen. A. Bivalves – internal and external views of all shells. If the specimen is whole (i.e. not separate valves) then external views only; B. Marine Gastropods –dorsal/rear and ventral/apertural (apical, lateral or umbilical optional depending on species); C. Terrestrial Gastropods, High-Spired: apertural and rear (lateral optional), Low-spired: apertural, apical and umbilical (lateral optional); D. Polyplacophora, Cephalopoda: dorsal and ventral; E. Scaphopoda: lateral.

Results

Type specimens in collections

By the end of the project (May 2018) we had curated and conserved over 700 type and non-type lots from the seven partner museums' collections. All specimens were repackaged and relabelled, a particular success being the conservation of over 20 fluid-preserved sea slug type lots at Great North Museum: Hancock, which were in a vulnerable state (Figure 4). As hoped, we discovered previously unknown type material in most collections, making remarkable progress at Exeter Museum, where nearly 30 extra type lots were located in the Col. George Montagu and Miss J. E. Linter collections. The findings from this research have been published in a series of papers (Oliver, Morgenroth and Salvador, 2017; Oliver and Morgenroth, 2018). At least one previously 'lost' type of J. C. Melvill, untraced in the 1980s (Trew, 1987), was rediscovered unexpectedly at Liverpool, rather than Cardiff or Manchester where most of his material is known to be housed.

All material dealt with is now clearly labelled with its type status, image numbers, and relevant data, and is safely housed in each collection. High-resolution copies of the specimen(s), label photographs, and an export of the catalogue dataset have been distributed to each partner. A further outcome was that the research supported and allowed an application to Arts Council England for Designated status for the Montagu collection at Exeter.

The database and website

To provide universal access to the type specimens from the partner museums, the specialist photographs and specimen data have been made available in a single online database https://gbmolluscatypes.ac.uk, with each specimen clearly linked back to its holding institution (Figure 5). Each partner museum has remote access to their collection records on the database with the ability to change existing records and to add new ones as they acquire, or locate, new type material. All the

Figure 4. Fluid-preserved specimens of sea slug type lot (Doridopsis clavulata Alder & Hancock, 1864, NEWHM: 2002.H2557) © Great North Museum: Hancock, Newcastle, with images from original description inset (Alder & Hancock. 1864. pl.XXXI; figs.10, 11, 12).

participating staff are included as authors in the website citation (Rowson et al., 2018).

Our focus on mollusc types led to them becoming better-documented internally at each museum, as well as externally visible through the website. All partners reported an increased level of visibility of their type material online. By the end of April 2018, 547 types were catalogued on the website, nearly all of which were photographed in detail. All lots are fully researched and their type status confirmed (or amended), with clear links to the original publications. In the four months after the launch, the site had over 1,189 unique users, over 326 of these (27%) being from the UK, and the others from over 60 other countries (data from Google Analytics, 5 December 2018). We and the partners have dealt with several detailed enquiries from researchers (e.g. from the UK, France, Argentina, and the Netherlands) about the material featured. Many of the partner curators have indicated their desire to continue work on particular mollusc collections in their care (e.g. Lincolne (Manchester), Hunter (Glasgow)).

Throughout 2018, further records were added to the website, including primary types from AC-NMW (approx. 430 verified records); over 300 secondary types from Manchester (based on the list by McGhie, 2008), and over 500 records from Liverpool, from an unpublished list created by Ian Wallace (the source of these records being made clear on the website). The Liverpool dataset includes a number of specimens lost due to bombing in the 1939-1945 war. We have also included data on important collectors and collections held in the Booth Museum of Natural History, Brighton; the Cole Museum of Zoology, Reading; and the Warrington Museum & Art Gallery. Further records are in preparation.

The website also includes important information on handwriting, the location of collectors and collections worldwide, along with a list of other useful resources. We hope to expand upon these areas via future grants and projects, as we feel they are invaluable aids to curators and collections managers as well as visiting researchers and the public who wish to research molluscan collections.

Problems encountered

Most aspects of the project went well. We encountered few problems, most of which were minor. We had some issues transferring funds between museums in advance of the workshops to cover the travel and subsistence of the partner curators. We were not expecting the difficulty such

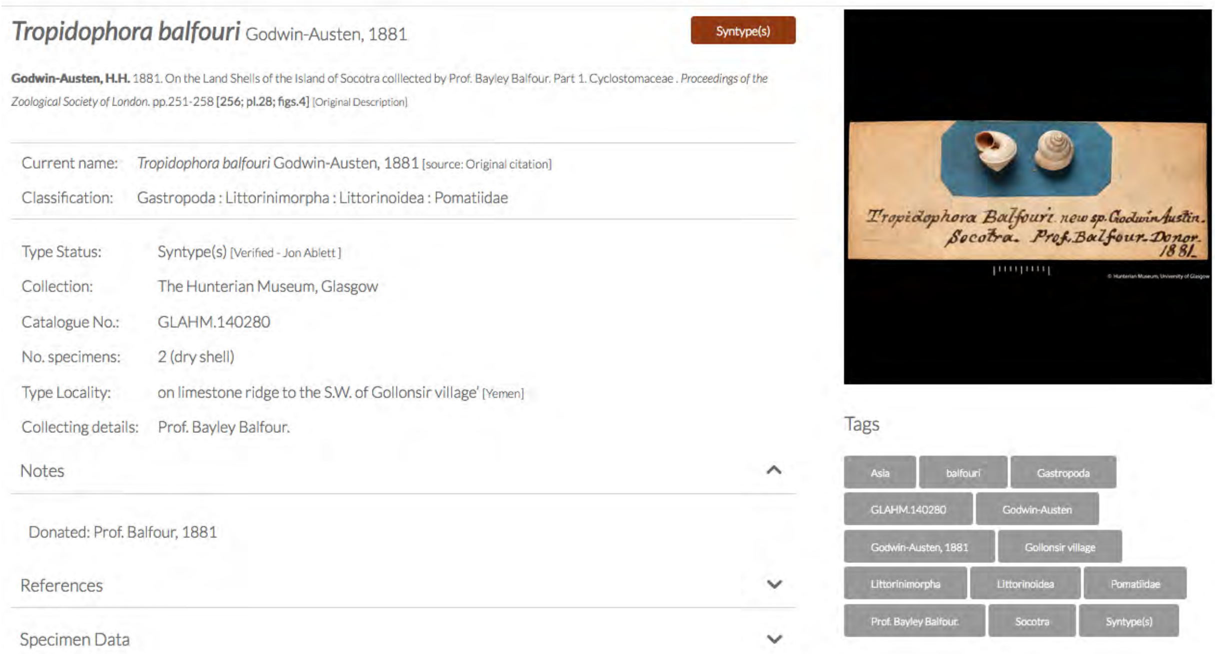


Figure 5. Screenshot of the published website: Mollusca Types in Great Britain © AC-NMW/NHM

transfers could cause, given the small amounts involved and that both the purpose and the source of the funds was clear.

We and the partner curators were asked for valuations and proof of insurance by two partner institutions at the point of issuing a loan agreement. This was slightly problematic since the assumed monetary (as opposed to scientific) value of type specimens is well below that required to qualify for the Government Indemnity scheme available to AC-NMW and NHM, and indeed so low that it is difficult to obtain commercial cover. After consultation with the AC-NMW staff Collections Management Group, we obtained a suitable policy from a broker to cover all loans for the project to a total of £10,000. Notional replacement cost valuations were undertaken by the partner curators and condition checks by a conservator were arranged for incoming material. The insurance requirement was most unexpected, being an issue that has scarcely arisen in our many years' experience of lending and borrowing type and scientifically valuable material from museums around the world (nor was it raised by participants during the application development or at the June 2016 workshop). It may be seen as a practice typical for museums whose loan traffic consists mainly of art and artefacts with much higher commercial values, and that lack special procedures for taxonomic specimens.

One aspect that was discussed repeatedly was the question of scope, and of titles for both the website and the project that would accurately reflect this. It was clear from the outset that the technical scope of the database content (e.g. regarding type status, verification and imaging standards) would need to be somewhat flexible even when following the Code consistently. We also necessarily had to restrict ourselves to the UK museums taking part in the project, notwithstanding the availability of type data from the NHM collection through its Data Portal (Scott and Smith, 2014). The title adopted for the website was 'Mollusca Types in Great Britain', to avoid any potential confusion about the geographic source of taxa that might stem from the project title 'Great British Mollusca Types'.

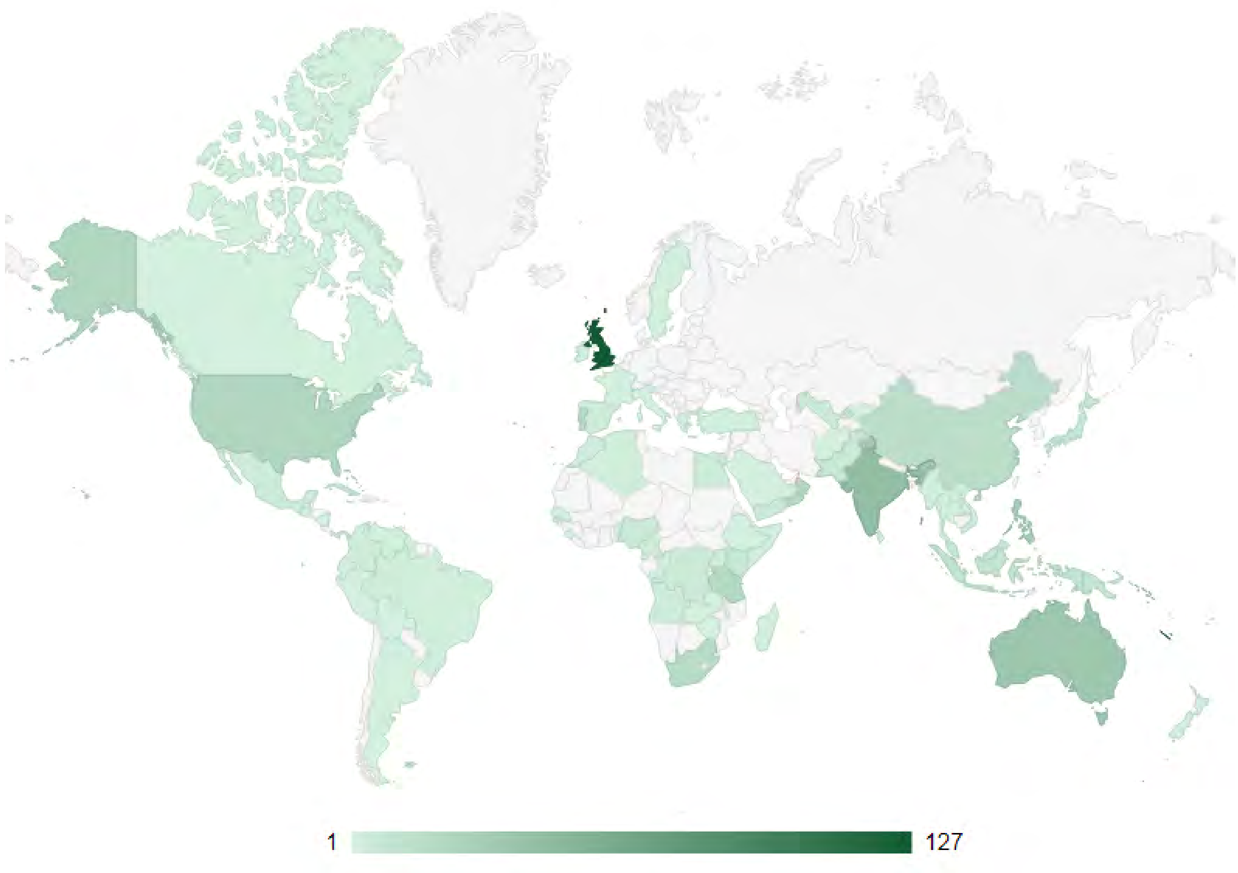


Figure 6. Countries/territories from which types came. © Google Analytics.

An analysis of collections

With an estimated 60,000 type specimens, the Natural History Museum, London has by far the largest concentration of Mollusca types, but most larger cities, ports, and towns have public museums incorporating natural history collections. Often, these collections were part of the nucleus around which the museum was built or developed, particularly in the 19th century (Alberti, 2002). Thanks to previous workers, we knew when embarking upon this project where most of the larger Mollusca type holdings were, but we did encounter some surprises. We also discovered that bringing a list of types together for the first time allowed us to analyse different aspects of the collections such as differences in the geographic and temporal acquisition of collections, along with any regional differences.

Molluscs from all major seas worldwide are represented, as are non-marine taxa from countries worldwide (Figure 6). Europe (mainly Britain), Africa, and Australasia are relatively better-covered than Asia or the Americas. Most of the major taxonomic groups are represented, with a preponderance of Neogastropoda (including cones, murexes, whelks and olives) and the stylommatophoran land-snails. These are popular groups in any global shell collection - the difference being that in this case, each species was brand new to both the collector and his or her contemporaries.

Notably, even some of the larger collections are dominated by the types of one or a few authors. Charts of the proportion of types in each museum and the proportions described by the most prolific authors are remarkably similar (Figure 7). This may reflect the non-random nature of deposition, where donors/sellers, and the curators/buyers, helped ensure each UK museum developed a good collection. However, this was seldom straightforward,

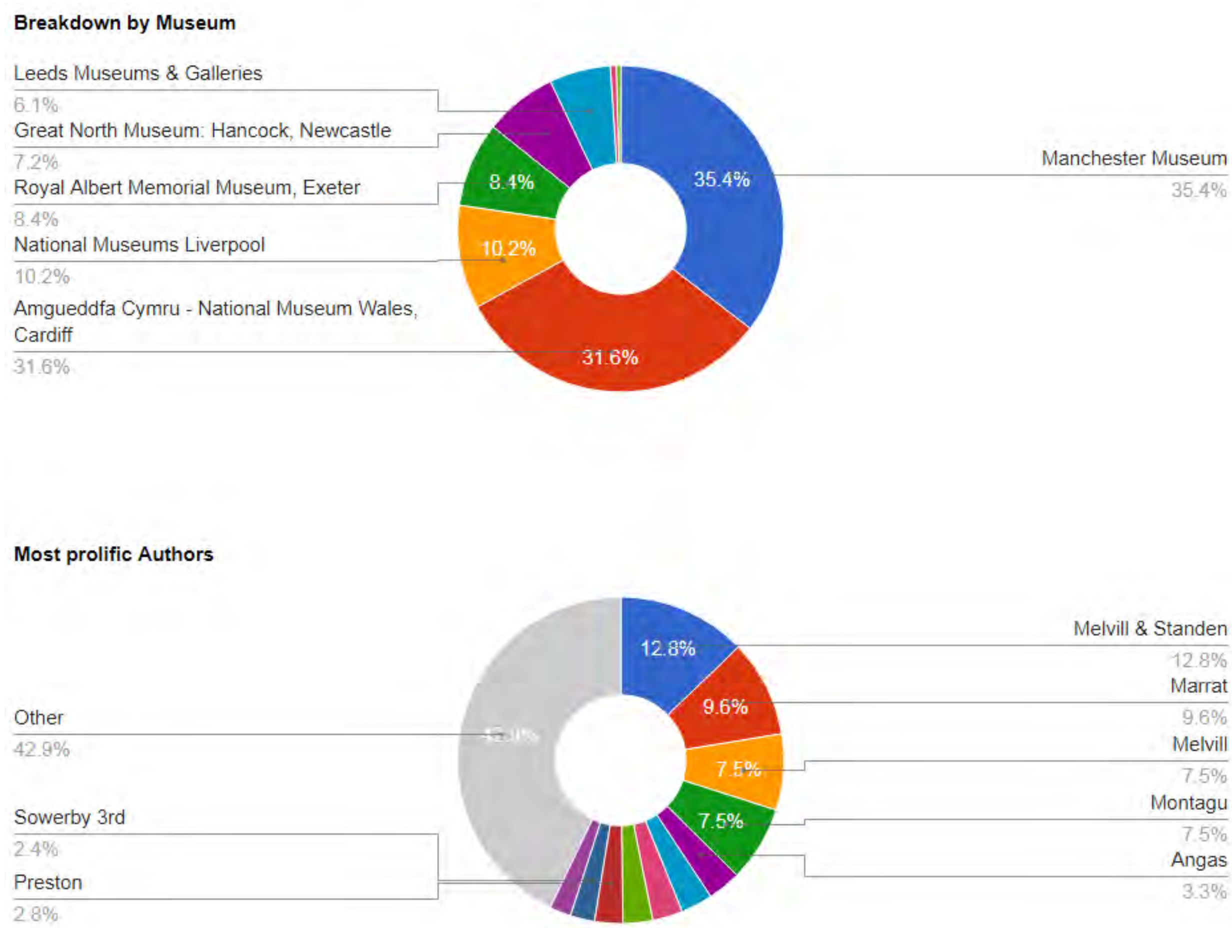


Figure 7. Proportions of the types in each museum, and those described by the most prolific authors. © AC-NMW/NHM

and collections such as Hanley's at Leeds (Coan and Kabat, 2012), and Montagu's at Exeter (Oliver, Morgenroth and Salvador, 2017), had already been partially dispersed. Other authors were museum employees, such as Marrat at Liverpool, and Standen at Manchester (McGhie, 2008; Bowden and Simkiss, 2003); while Alder and Hancock were naturalists whose ties to their local museum at Newcastle were forged over decades (Emberton, 1907; Norman, 1907). The types of J. C. Melvill, an establishment figure who was both wealthy and generous, came to rest in at least three UK museums (Trew, 1987; McGhie, 2008). Such diverse circumstances add to the story of the UK's museums and emphasises the fact that no two of the country's natural history collections are alike.

Most of the types were collected and named, perhaps unsurprisingly, in the late Victorian era (Figure 8), in the middle of what Dance (1986) termed the "abundant years" of conchology. Exotica imported from across the British Empire dominate, although new taxa in and around Britain were still being recognised. The chart also shows how few molluscs discovered in the last 100 years are represented by types at the museums dealt with here.

The majority of the scientific names that these types represent remain in use today, which is by no means always the case. Our estimate of the degree of synonymy, using MolluscaBase (2018), MUSSELp (Graf and Cummings, 2018) and other relevant sources for current nomenclature, suggests that on average 70% of each author's names are still accepted, although of course most have moved genus. The high synonymy rate for Montagu, pioneer as he was, might relate to most species in the British fauna being geographically widespread, and thus already described by other Europeans. The still higher rate for F. P. Marrat might reflect his being one of few British workers to flirt with the notorious methods of J. R. Bourguignat's 'Nouvelle Ecole' (Melvill, 1905; Dance, 1970). Yet his types at Liverpool remain in demand by specialists. The low synonymy rate of other authors may in some cases be attributable to a lack of recent revisions. It is only thanks to the care that the collectors, and succeeding generations of curators, took of these collections that such material will be available for study in the future.

Conclusion

At the time of writing (December 2018) the data set included 1898 records from all seven partner museums and AC-NMW, with the majority including images of both specimens and labels. This is the first time such a multi-institutional type data set has existed for Mollusca, and it is hoped that scientists, the regional, UK and wider public will benefit from much improved access to type specimens. Digitisation is one of the most efficient ways to help meet the expectation of continually-widening access to museum collections (Beaman and Cellinese, 2012). Type specimens held in regional museums have the potential to spark the imagination and pride of their constituents. Any natural history specimen has social

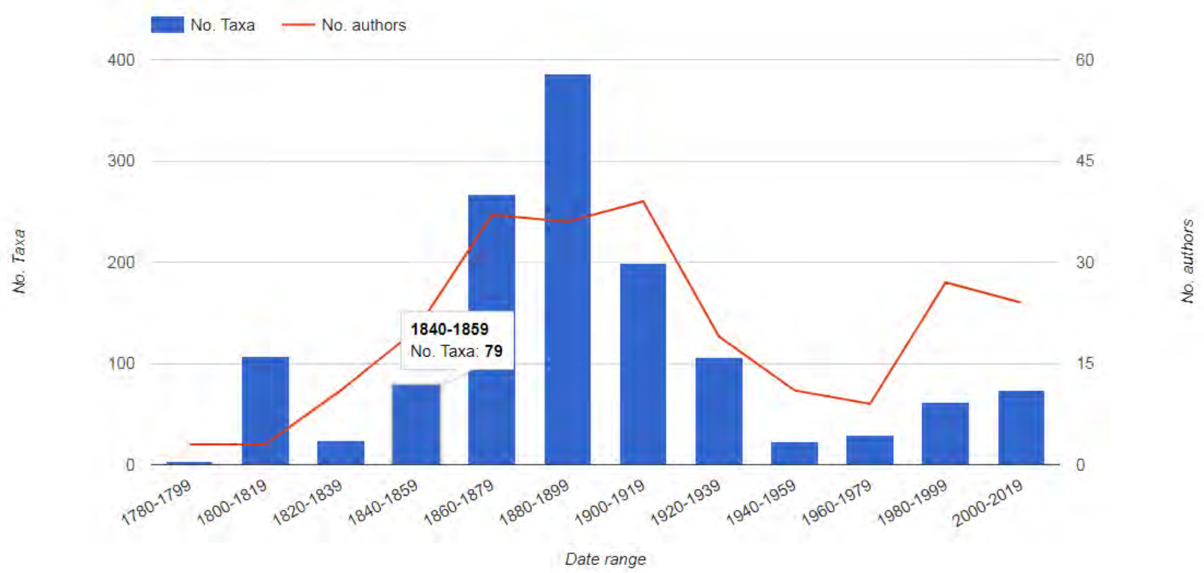


Figure 8. Number of taxa described, and number of authors, for each period. © AC-NMW/NHM

history, cultural, and aesthetic dimensions as well as the scientific one. Users may be interested in any one of these, or several, and any might inspire or attract newcomers of all ages. Making links between objects can help enrich local and national culture and may encourage participation and debate. The high-quality images and other products of research will be suitable for use in many contexts, and for years to come, including exhibitions, social media, events, merchandise, and publications.

This was a time-limited project of two years, yet we believe it will leave a strong legacy. Data has been recorded permanently on a universally accessible resource, with potential for future expansion as other UK museums contribute their Mollusca types to the database, and as new types are acquired. The existence of this resource could attract further type donations, which can be added by the contributing museums (including AC-NMW or NHM). The curatorial skills that this project helped strengthen will hopefully be developed at regional museums, and these skills are transferable to their other historically important natural history collections. Relationships between all our museums have been strengthened and enhanced, to the benefit of all participants and their wider audiences.

The project and its outputs were well-received at our organisations, as an example of how partnerships with regional museums help connect and support curators and collections around the UK. Our respective staff and those of the partner museums have benefited from and enjoyed working more closely with one another, and value has been added to their collections.

The team of over 15 staff spent around 200 days working together on the collections. This contributed to better mutual understanding of each collection, its history and linkages across regions, and better contacts between curators and their networks. Logistical relationships (e.g. with administrative staff and registrars) and collections awareness were also improved and testimonials were highly encouraging (Figure 9). The team also assisted with evaluation of a schools service mollusc collection in Leeds, shared literary references for a project in Glasgow, identified

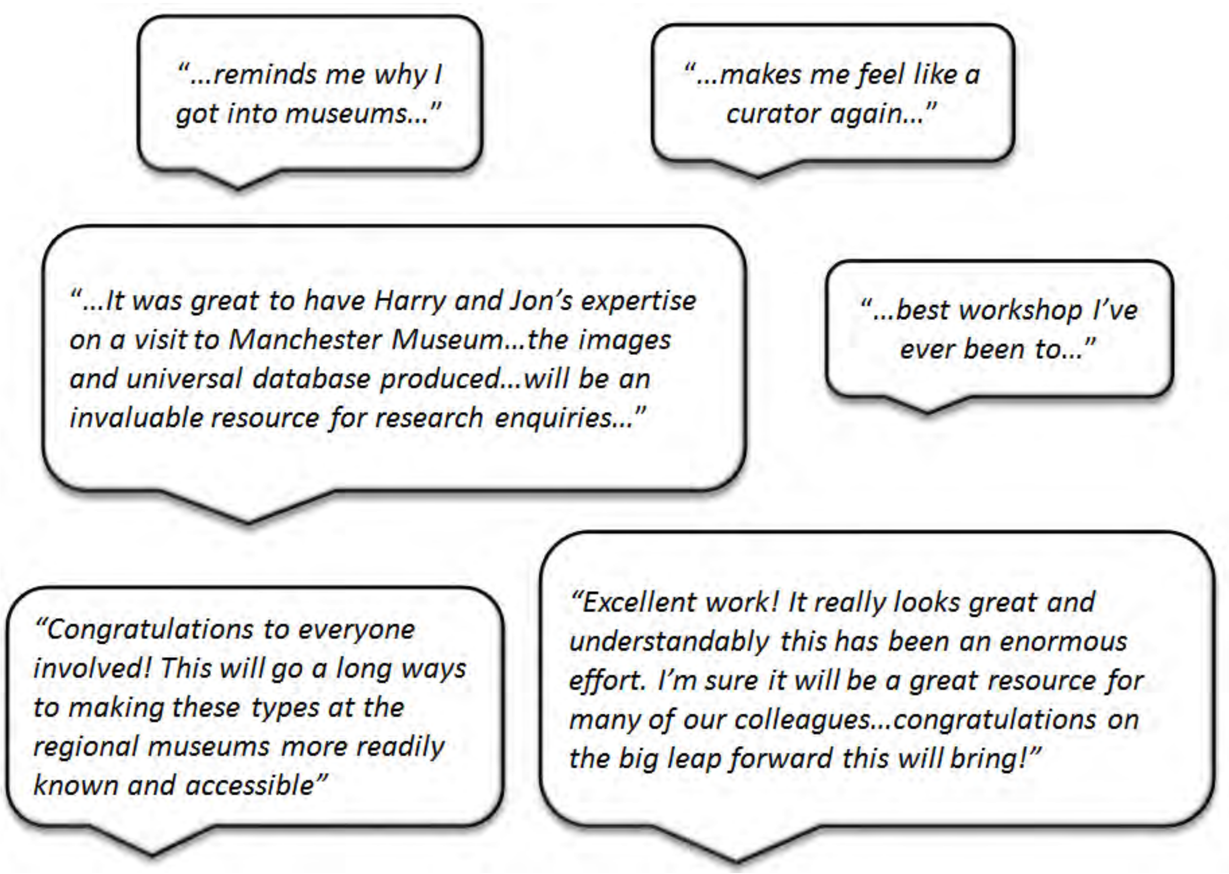


Figure 9. Selected quotes from project partner staff and website users. © AC-NMW/NHM

slugs for visitors at Liverpool, and discussed future partnership research with Manchester and Glasgow. We hope that if any perceived barriers between regional and national museums did exist, then we have made headway in removing them. It is hoped that these positive working relationships will extend outside the Mollusca collections to other areas. What we will take away from this project is the new relationships we have made. It proves that by sharing skills, we are stronger in the long run and the outlook for retaining these skills for the future is much improved.

As we look to the future of the database, we hope to build on and expand the datasets in several ways. By including a number of new partner museums, we could increase (and nearly complete) our coverage of the UK's Mollusca types outside NHM. We are currently in the process of applying for funding to add a further 11 institutions, and we plan to extend coverage to Northern Ireland and to the Republic of Ireland (thus becoming 'Mollusca Types in Britain & Ireland'). In order to create a true Union Database for the UK, it is hoped that the Mollusca types held in the NHM would also be added. At the present, an internal pilot study is being planned to understand the resources, impacts and challenges of such a large-scale digitisation project. We also plan to enrich the social and historical functionality of the website by developing a 'Biography' tab allowing users to search collectors, handwriting, and archive materials linked to type material spread across institutions. And finally, we hope to extend the database's reach by developing two-way links between each record and the global data aggregators for Mollusca and indeed, all taxa (MolluscaBase, 2018; GBIF, 2018).

Acknowledgements

We would like to thank the John Ellerman Foundation whose grant made it possible to realise almost exactly what we had hoped to achieve; in fact a little more in some respects. We would not have been able to embark on such a project without external funding, especially to cover the core (salary) costs. We are particularly appreciative that the Foundation saw fit to fund a collections-focused project in which the subject matter and the work of specialist curators was recognised as important to the UK's regional museums. The imprimatur of a foundation's support is valuable advocacy for curators, at a time when capacity is still being scaled back across the sector.

We would also like to thank staff at all the partner Museums, especially Clare Brown, Dan Gordon, Tony Hunter, Rebecca Machin, Holly Morgenroth, Rachel Petts, Maggie Reilly and Richard Sutcliffe. Special thanks for collections information go to Ian Wallace (Liverpool), Fred Woodward (Glasgow) and Henry McGhie (Manchester Museum). Clare Valentine, Suzanne Williams and John Taylor (NHM) provided support and guidance during the application process and project duration. Harry Taylor and Kevin Webb (NHM Photo Unit) provided assistance with photographic issues and Nemo Martin assisted with data entry of additional specimen data. Caroline Buttler, Andy Mackie, Linzi Tierney and Sarah Lendrum assisted at AC-NMW. Also thanks go to Bram Breure (Naturalis, Leiden) for testing a beta version of our database. We are grateful for the two anonymous reviewers for their careful reading of our manuscript and their many insightful comments and suggestions. Lastly, thanks for the enthusiasm and advice from those potential project partners with whom we hope to work with in the near future.

References

Alberti, S.J.M.M., 2002. Placing nature: natural history collections and their owners in nineteenth-century provincial England. *British Society for the History of Scienc*e, 35(3), pp.291-311.

Alder, J. and Hancock, A., 1864. Notice of a collection of Nudibranchiate Mollusca made in India by Walter Elliot, Esq., with descriptions of several new genera and species. *Transactions of the Zoological Society of London*, 5(3-4), pp.113-147.

Beaman, R.S. and Cellinese, N., 2012. Mass digitization of scientific collections: New opportunities to transform the use of biological specimens and underwrite biodiversity science. *Zookeys*, 209, pp.7–17.

Bowden, A.J. and Simkiss, W., 2003. Henry Hugh Higgins and Frederick Price Marrat: the reluctant palaeobotanists and the Ravenhead collection. *Proceedings of the Geologists' Association*, 114, pp.327-338.

Breure, A.S.H., Audibert, C., and Ablett, J., 2018. *Pierre Marie Arthur Morelet* (1809-1892) *and his contributions to malacology*. Leiden: Netherlands Malacological Society.

Coan, E.V. and Kabat, A.R., 2012. The malacological works and taxa of Sylvanus Hanley (1819-1899). *Malacologia*, 55(2), pp.285-359.

Coan, E.V. and Kabat, A.R., 2018. *2,400 Years of Malacology (15th ed.)*. [online] Available at: <http://www.malacological.org/2004_malacology.html> [Accessed 27 July 2018].

Dance, S.P., 1970. “Le fanatisme du nobis”: a study of J.-R. Bourguignat and the “Nouvelle Ecole”. *Journal of Conchology,* 27, pp.65-86.

Dance, S.P., 1986. *A history of shell collecting*. Leiden: E.J. Brill.

Deucher, S.D., 2017. What does a 21st-century curator need? *Museums Journal,* 117/11, p.14.

Emberton, D., 1907. Life of Albany Hancock. In: Hancock, A. *The British Tunicata. An unfinished monograph. Volume 2*. London: Ray Society. pp.xvii–xxviii.

Fraussen, K. and Terryn, Y., 2007. The family Buccinidae: Genus Neptunea. In: Poppe, G.T. and Gros, K. (eds.), 2007. *A Conchological Iconography*. Hackenheim: Conch Books.

GBIF: The Global Biodiversity Information Facility (2018). *What is GBIF?* [online] Available at: <https://www.gbif.org/what-is-gbif> [Accessed 17 July 2018].

Graf, D.L. and Cummings, K.S., 2018. *The Freshwater Mussels (Unionoida) of the World (and other less consequential bivalves), updated 9 August 2018*. [online] Available at: <http://www.mussel-project.net/> [Accessed 18 August 2018].

Howe, M. and McCormick, T., 2013. *GB3D type fossils online*. [online] Available at: <www.3d-fossils.ac.uk http://www.3d-fossils.ac.uk/home.html> [Accessed 13 August 2018].

ICZN, 1999. *International Code of Zoological Nomenclature. Fourth edition*. London: The International Trust for Zoological Nomenclature. [online] Available at: <http://www.iczn.org/> [Accessed 18 August 2018].

JSTOR, 2018. *Global Plants database*. [online] Available at: <https://plants.jstor.org/>. [Accessed 18 August 2018].

Kemp, C., 2015. Museums: The endangered dead. *Nature*, 518, pp.292–294.

Knott, J., 2018. Mollusca types in Great Britain. *Museums Journal,* 118(5), p.59.

McGhie, H.A., 2008. Catalogue of type specimens of molluscs in the collection of The Manchester Museum, The University of Manchester, UK. *ZooKeys,* 4, pp.1-46.

McMillan, N.F., 1985. Frederick Price Marrat, 'Conchologist etc'. *Merseyside County Museums Occasional Papers*, 3, pp.1-34.

Melvill, J.C., 1905. Frederick Price Marrat. *Journal of Conchology*, 11, pp.225-227.

MolluscaBase, 2018. *MolluscaBase*. [online] Available at: <http://www.molluscabase.org> [Accessed 17 July 2018].

Norman, A.M., 1907. Life of Joshua Alder. In: Hancock, A. *The British Tunicata. An unfinished monograph. Volume 2*. London: Ray Society. pp.xvii–xxviii.

Oliver, P.G., Morgenroth, H., and Salvador, A., 2017. Type specimens of Mollusca described by Col. George Montagu in the Royal Albert Memorial Museum & Art Gallery, Exeter and The Natural History Museum, London. *Zoosystematics and Evolution*, 93(2), pp.363–412.

Oliver, P.G. and Morgenroth, H., 2018. Additional type and other notable specimens of Mollusca from the Montagu Collection in the Royal Albert Memorial Museum & Art Gallery, Exeter. *Zoosystematics and Evolution*, 94(2), pp.281-303.

Rosenberg, G., 2014. A New Critical Estimate of Named Species-Level Diversity of the Recent Mollusca. *American Malacological Bulletin*, 32(2), pp.308-322.

Ross, H.G.C., 1984. Catalogue of the land and freshwater Mollusca of the British Isles in the Ulster Museum. Ulster Museum. Belfast: Ulster Museum.

Rowson, B., Ablett, J., Gallichan, J., Holmes, A.M., Oliver, P.G., Salvador, A., Turner, J.A., Wood, H., Brown, C., Gordon, D., Hunter, T., Machin, R., Morgenroth, H., Reilly, M., Petts, R., and Sutcliffe, R., 2018. *Mollusca Types in Great Britain*. [online] Available at: <https://gbmolluscatypes.ac.uk> [Accessed 17 July 2018].

Scott, B. and Smith, V., 2014. *Natural History Museum Data Portal*. [online] Available at: <data.nhm.ac.uk> [Accessed 27 November 2018].

Smaldon, G., Heppell, D., and Watt, K.R., 1976. Type specimens of invertebrates (excluding Insects) held at the Royal Scottish Museum, Edinburgh. *Royal Scottish Museum Information Series*, Natural History 4. 118 pp.

Thomas, I. 2007. *The Shell: A World of Decoration and Ornament*. London: Thames & Hudson.

Trew, A., 1987. *James Cosmo Melvill's New Molluscan Names*. Cardiff: National Museum of Wales, Cardiff.

Tucker Abbott, R., 1989. *Shells*. New York: Portland House.

W3C, 2018. *Web Content Accessibility Guidelines (WCAG) 2.1. W3C Recommendation 05 June 2018*. [online] Available at: <https://www.w3.org/TR/2018/REC-WCAG21-20180605/> [Accessed 13 August 2018].

Wilson, M.J., 2007. Terrestrial mollusc pests. In: Lacey, L.A. and Kaya, H.K. (eds). *Field Manual of Techniques in Invertebrate Pathology*. Dordrecht: Springer. XXXIV + 910 pp.

Wood, H. and Turner, J.A., 2012. *Mollusca Types Catalogue*. Amgueddfa Cymru - National Museum Wales. [online] Available at: <http://naturalhistory.museumwales.ac.uk/molluscatypes> [Accessed 17 July 2018].

Cambridge University Herbarium: rediscovering a botanical treasure trove

Lauren M. Gardiner

Address: Cambridge University Herbarium, Department of Plant Sciences, c/o Sainsbury Laboratory, Bateman Street, Cambridge, CB2 1LR, UK

Email: lauren.gardiner@plantsci.cam.ac.uk

Received: 05/08/2018

Accepted: 21/11/2018

Citation: Gardiner, L.M., 2018. Cambridge University Herbarium: rediscovering a botanical treasure trove. *Journal of Natural Science Collections,* 6, pp.31-47.

Abstract

The Cambridge University Herbarium has a rich history of over 300 years of plant collection, inventory, production of taxonomic literature, and teaching of botany. The herbarium of some 1.1 million dried, pressed plant specimens includes collections made by some of the great British botanists including Charles Darwin, Alfred Russel Wallace, Nathaniel Wallich, and Richard Spruce. Over its history, the Herbarium has experienced various stages of evolution, expansion, changing research focuses, and threats, and over the last 100 years was particularly important in European and British taxonomy and floristics. Currently the collections are relatively poorly known and have virtually no visibility outside the physical building in which they are housed. The historic specimens represent a treasure trove of unstudied material and are especially rich in nomenclatural type specimens. This paper aims to provide an overview of the history of the collection, and to raise awareness of its existence. Now with a new Curator, in an era of collections digitisation and interdisciplinary research, the potential to open this Herbarium up via collaborative research, teaching, and engagement is huge.

Keywords: Collections, Darwin, flora, herbaria, Lemann, Lindley, plants, species discovery, Rackham, Sell, Spruce, Wallace, Wallich

The Cambridge University Herbarium: location and context

The Cambridge University Herbarium, CGE (international herbarium code, Thiers 2018), is the University of Cambridge's main herbarium. Based historically and administratively within the Department of Plant Sciences (previously known as the Botany School), CGE is physically located within the Sainsbury Laboratory Cambridge University, a research institute itself based within the grounds of the Cambridge University Botanic Garden.

A major collection of dried, pressed plant specimens collected over more than 300 years, with enormous scientific and historical value, CGE has an important place in the history and development of scientific thinking about the natural world, and botanical discovery and description. Many of the specimens in the collection appear to have never been studied, or even properly documented, since they were originally collected.

Of the 552 herbarium codes for the UK listed on Index Herbariorum (Thiers, 2018), only 74 have been updated within the last 15 years and are recorded as holding more than 100 specimens. The three huge herbaria of the Royal Botanic Gardens, Kew (K), Natural History Museum (BM), and Royal Botanic Garden Edinburgh (E), each hold between 3-7 million specimens. CGE is currently recorded as the fourth largest collection in the UK, with a similar number of specimens as the University of Manchester (MANCH), the Oxford Herbaria (OXF and FHO), and the National Museum Wales (NMW).

Overview of the collections at CGE

CGE contains an estimated 1.1 million specimens, and is thought to house some 50,000 nomenclatural type specimens, a very high proportion and comparable to the major collections of the world. These type specimens are currently the focus of most research enquiries from outside Cambridge. In part due to the research focus of CGE during the 20th century, the collection is especially rich in Great Britain and Ireland (c. 300,000) and mainland Europe (c. 200,000) vascular specimens. CGE also has extensive and historically important vascular collections from the rest of the world, accounting for some 400,000 specimens, and where many of the as yet undesignated type specimens are to be found. These 'World' (i.e. non-European) collections have been little studied, and many have remained in their original papers since their arrival in Cambridge, in some cases nearly 200 years ago.

Some 148 images of CGE type specimens are available on JSTOR Global Plants., These were imaged during the Mellon Foundation African Plants Initiative (Smith and Figueiredo, 2014) in 2007, and only include those African specimens which were known to be types in the collection already plus four type specimens from Europe (Portugal). Anecdotally, these records on JSTOR Global Plants are quite misleading to researchers. Rather than encouraging them to look in CGE for further types, researchers have commented they had assumed that all of the CGE type collections must have been imaged and made available via JSTOR Global Plants. With some 12,000 type specimens physically curated into red paper folders at CGE, and new types being identified regularly by visiting researchers working on the 'World' collections, the 148 types available on JSTOR Global Plants is a tiny proportion of the likely total.

The bryophyte collections at CGE are substantial, perhaps accounting for over 80,000 specimens, and incorporate important collections made by William Edward Nicholson (1866-1945), Thomas Laflin (1914-1972), and Harold Leslie Keer Whitehouse (1917-2000). The algae, fungi, and lichen collections at CGE are smaller in number but similarly appear to have received very little attention since specimens were deposited. Based on the history and type-richness of the vascular collections and discussions with colleagues at other institutions, the non-vascular collections are likely to also contain many types and historically and scientifically important material, but the degree to which this is the case remains to be ascertained.

CGE is revealing itself to contain an enormous number of hitherto undocumented specimens from important collections and collectors over the last 300 or more years. These specimens have not yet been catalogued or imaged as part of the various projects to bring such specimens together internationally. Such specimens include those from important 19th century expeditions such as the H.M.S. Challenger Expedition (1872-1876), and the Ross Antarctic Expedition of H.M.S. Erebus and Terror (1839-1843) on which Joseph Dalton Hooker (1817-1911) (later the second Director of the Royal Botanic Gardens, Kew) collected. There appear to be a least one, if not more sets of specimens from the Herbarium of the British East India Company. The main set of this collection - also frequently referred to as the 'Wallich Herbarium', for Nathanial Wallich (1786-1854) who produced and distributed a list of the material along with the specimens - is at Kew, but multiple sets were distributed to other institutions and individual collections. Several separate sets appear to have come to Cambridge, in the collections of Henslow, Lindley, and Lemann (each discussed later in this paper). The situation seems to be similar for material collected by Richard Spruce (1817-1893), who travelled in the Amazon and the Andes between 1849 and 1864, sending back huge numbers of specimens and ethnographic material and information. There are large numbers of Spruce specimens at CGE, likely in the same three private collections mentioned above, now all housed in the same room.

In addition to preserved plant specimens, CGE also contains a substantial, virtually undocumented and unpublished collection of original botanical artwork, photographic slides, microscope slides, printed photographs, some portraits on various media, large format teaching illustrations, archive documents and collectors' notebooks, and an impressive botanical library, part of the Library of the University of Cambridge Department of Plant Sciences.

History of CGE and major collections to the end of the 19th century

18th century origins: Martyn's Hortus Siccus

The gift of John Martyn's *Hortus Siccus* and fine botanical library to the University of Cambridge, in the 1760s, is considered to be the foundation of the CGE collections. Martyn (1699-1768) was the second professor of botany at Cambridge, and combined his botanical career with being a London-based medic. In 1721, Martyn was one of a group who formed a botanical society, with Martyn as the secretary and Johan Jacob Dillenius (1684-1747) (later the first Sherardian professor of botany at Oxford University) as the president. Invited to give a series of lectures in Cambridge, teaching medical students basic plant morphology - as a precursor to learning to identify medicinal and poisonous taxa - ultimately led to his election to the chair of botany in 1733.

It is not currently clear how large Martyn's original collection was but it seems that over 3,000 specimens survive today (Figure 1). Martyn collected specimens around London and the west of England, and added specimens made by other British collectors including Patrick Blair (c.1666-1728), Samuel Brewer (1670-1743), John Clayton (1694-1773), Johan Jacob Dillenius (1684-1747), Robert Foulkes (c.1702-1729), William Houstoun (c.1695-1733), Joseph Miller (d. 1748), Richard Pultaney (1730-1801), Isaac Rand (d.1743), James Sherard (1666-1738), William Sole (1741-1802), and Daniel Carl Solander (1733-1782).

Thomas Martyn (1735-1825), succeeded his father in 1762 to become the third professor of botany in Cambridge, and although he is not thought to have added significantly to the number of specimens in the collection over his lifetime, he is known to have gone through his father's collection and added Linnean binomial names, genus and specific epithet, to each specimen. Meticulously, he often seems to have included the reference to the page in Carl Linnaeus' *Species Plantarum*, published in 1753 after many of the specimens were made, on these 18th century 'det. [*determinavit*] slips'. Holding the chair of botany in Cambridge for over 60 years, Thomas Martyn did not teach (or live) in Cambridge for the last 30 years of his tenure and the Herbarium was left in poor conditions, subject to attack by pests and damp, in spite of Thomas Martyn lobbying the university for better accommodation for the specimens.

Henslow's rescue and scientific development in 19th century

In 1825, John Stevens Henslow (1796-1861), became the fourth professor of botany in Cambridge. One of the tasks he set about early in his new position was the recovery and conservation of as many specimens as possible from Martyn's collection, which were by now in a terrible condition. Lobbying the University for funds to purchase suitable paper for the specimens, Henslow seems to have single-handedly remounted over 3,000 of the original 18th century specimens, stamping or labelling each as 'Mus. Martyn', but the rest of the material could not be salvaged and was destroyed.

Over the next 20 years, Henslow added over 3,500 of his own specimens to the collection, many from locations in Cambridgeshire, neatly labelled in his meticulous handwriting with the taxon, location, collection date, and collector name, and a label marking the sheet as part of 'Mus. Henslow'. The majority of Henslow's specimens show his quite unusual 'collated sheet' method (Figure 2), where he effectively records the variability seen in a plant population, from smallest to largest in size, and different growth forms, with multiple plants arranged on a single sheet. Many of these collated sheets have the plants arranged in an aesthetically pleasing manner, in ascending or descending order of height, or bell curves. Besides variability, Henslow's specimens also show his interest in recording and studying nature's 'monstrosities' (i.e. mutant forms), hybridisation, and his teaching practices, and include many hand drawn diagrams and illustrations cut out from journals (Figure 3).

Henslow was an innovative teacher and CGE is home to a wide selection of his materials, including hundreds of his illustrated teaching sheets which would be used in his lectures and practical classes, and a complete (and recently conserved) set of nine large format teaching diagrams produced by the Department of Art and Science in 1857 and distributed around the country. Few complete sets of these illustrations, precursors to the far better-known German botanical illustrations produced by Dodel-Port, Kny, and others, seem to exist today. Henslow's original hand-drawn, large-format illustrations - which were used in the Cambridge School of Botany up until the mid-20th century - are now in a large collection of botanical illustrations held in the University's Whipple Museum of the History and Philosophy of Science.

Figure 1. Anemone nemorosa specimen in Martyn herbarium (CGE08887) © Cambridge University Herbarium

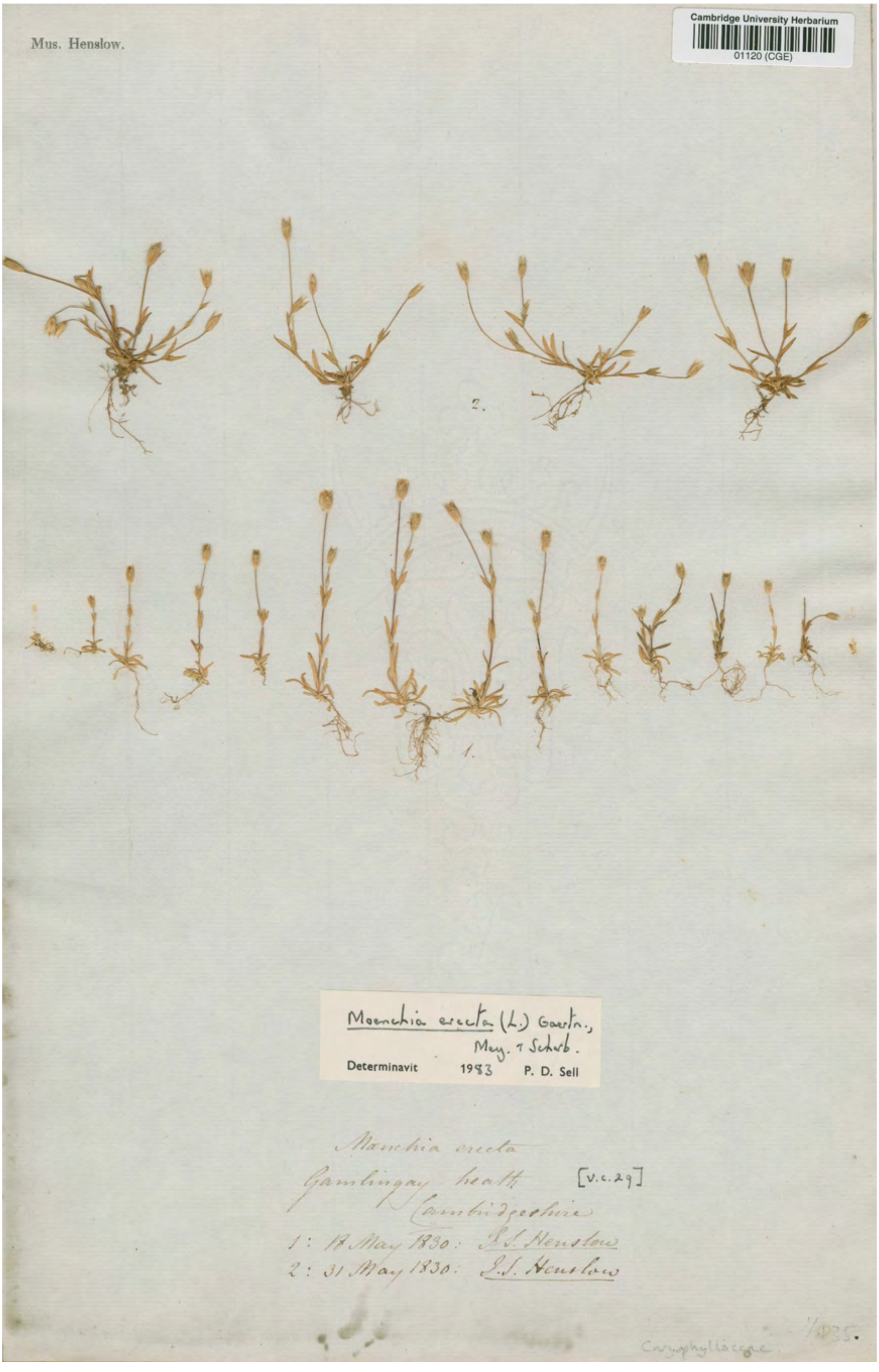


Figure 2. Moenchia erecta specimen showing Henslow's 'collated sheet' method (CGE01120) © Cambridge University Herbarium

Henslow was extremely well connected to other members of the British scientific community of the age, and with his friend Adam Sedgwick, professor of geology in Cambridge, had founded the Cambridge Philosophical Society back in 1819. The entomologist Leonard Jenyns (1800-1893) was a lifelong friend, collecting many specimens with Henslow, and became his brother-in-law, having introduced Henslow to his sister. Henslow corresponded with his student Charles Darwin throughout his life, and with other influential scientists including Kew's first Director, William Jackson Hooker (1785-1865) and his son Joseph, later to become Kew's second Director. Indeed, Joseph Hooker's first wife was Henslow's daughter, Frances Harriet (1825-1874). Many additions to CGE under Henslow would have been due to his network of friends and fellow botanists, and other notable acquisitions included specimens from Richard Thomas Lowe (1802-1874), William Swainson (1789-1855), and the herbaria of Charles Morgan Lemann and Charles Darwin.

Charles Morgan Lemann (1806-1852)

Lemann studied medicine at Trinity College, Cambridge, and in his short lifetime travelled and collected botanical specimens in Madeira, Gibraltar, Italy, Tenerife, and Spain. He built up a collection of over 50,000 specimens, incorporating others' collections from all over the world, especially from southern Europe, North America, Brazil, Guiana, the Cape of Good Hope, and Australia. Known to be rich in type specimens, the Lemann herbarium is even more interesting on the basis that a condition of Lemann's will was that the collection be bequeathed to Cambridge - but only after George Bentham (1800-1884), Secretary of the Royal Horticultural Society 1829-1840) and later based at the Royal Botanic Gardens, Kew, was allowed to name and arrange it first. Bentham spent much of the next seven years mounting, naming, arranging – and adding to – the collection. In 1860, the collection came to Cambridge

Figure 3. Eschscholzia californica specimen showing Henslow's illustration and interest in 'monstrous' forms (CGE01967) © Cambridge University Herbarium

and, under Charles Babbage, was incorporated into the main 'World' section of CGE.

Charles Robert Darwin (1809-1882)

Charles Darwin is one of Cambridge's most famous students, and the bulk of his botanical specimens reside within CGE, and form the most well-known part of the collections. Darwin was a student at Christ's College from 1828 to 1831, officially studying theology but able to attend other lecture series alongside his religious studies. Encouraged by his cousin, also at Christ's, Darwin became fascinated with natural history and attended Henslow's innovative lecture series on botany three years running. Henslow would take his students on field excursions in Cambridgeshire, during which many of the 'Mus. Henslow' specimens were made, and Darwin's attendance at these 'herborizing' trips and Saturday rambles was so consistent that the otherwise unknown student came to be referred to as 'the man who walks with Henslow'.

It was Henslow who recommended Darwin to Captain Fitzroy to act as the ship's naturalist and a companion for Fitzroy on the voyage of the H.M.S. Beagle, and to Henslow that Darwin sent all of his botanical, zoological, and geological specimens during the five-year voyage (1831-1835). Henslow and Darwin corresponded throughout the voyage, and much of this correspondence is held in the Cambridge University Library, and has been digitised as part of the Darwin Correspondence Project (Burkhardt et al*.,* 1985–). Kohn et al. (2005) discussed the impact of Henslow's teaching on Darwin and his scientific thinking, focusing particularly on variation, 'monstrous' forms (i.e. mutants), and hybridisation, based on the evidence presented in Henslow and Darwin's herbarium specimens, all held at CGE.

Darwin collected approximately 1,400 plant specimens during his circumnavigation of the world (Figure 4). Henslow mounted and labelled these on their arrival in Cambridge, sending many to the Royal Botanic Gardens, Kew and others to identify (and in several cases name and publish new species), allowing them to retain duplicated specimens for their own herbaria. The Galapagos specimens received particular attention and were studied by Joseph Hooker at Kew, who published his findings in a series of papers (Hooker, 1847a; 1847b). The vast majority of the Beagle specimens were returned to CGE, and today comprise nearly 1,000 sheets, alongside a number of specimens Darwin made in the UK before and after the voyage, including the first known specimens attributable to Darwin, made at the end of a trip to north Wales with the Cambridge professor of geology, Adam Sedgwick, just months before H.M.S. Beagle departed with Darwin on board.

Babington's tenure: a period of acquisition

The fifth professor of botany, Charles Cardale Babington (1808-1895) had been a contemporary of Charles Darwin studying under Henslow, and later became a demonstrator for Henslow's lectures. When Henslow moved to a country parish in Hitcham, Suffolk, in 1839, only returning to deliver his annual lecture series, Babington became his deputy in the Botany School. Babington collected his own specimens across the British Isles and also in Iceland, and his personal herbarium of c. 55,000 sheets was incorporated into the main collection at CGE during his lifetime. During Babington's tenure, CGE gained its first Curator, William Hillhouse (1850-1910) in 1880, followed by Thomas Hughes Corry (1859-1883) in 1882, Michael Cresse Potter (1858-1948) in 1883, and Isaac Henry Burkill (1870-1965) in 1891. Burkill rearranged the entire herbarium in accordance with Bentham and Hooker's recently published three-volume *Genera Plantarum* (Bentham and Hooker 1862-1883), and the bulk of the 'World' collections remain in this sequence. Babington was responsible for the enormous growth of CGE with the acquisitions of many specimens, via purchase and bequests, including several herbaria of a similar size and scale to his own – most significantly with the collections of John Lindley, Charles Fox Bunbury, John Edward and Maria Emma Gray, and Leon Gaston Genevier. He also acquired an outstanding personal library which he left to the University.

John Lindley (1799-1865)

Lindley worked as an assistant librarian for Joseph Banks in 1819, before being employed to edit the *Collectanea Botanica* (1821) for William Cattley (1788-1835), the merchant and amateur orchid collector for whom the orchid genus *Cattleya* was named. He then created his own *Rosarum Monographia* in 1820 and monograph of *Digitalis* in 1821. In 1822, Lindley became assistant secretary of the Horticultural Society (which would later become the Royal Horticultural Society), under Joseph Sabine (1770-1837), then vice-secretary 1841-1858, before becoming secretary and a member of council. Working with George Bentham, he initiated the first of the society's flower and fruit exhibitions, established Gardeners' Chronicle in 1841, and became a prolific author of botanical publications

Figure 4. Sicyos villosa specimen collected by Charles Darwin in 1835 © Cambridge University Herbarium (CGE00353)

Figure 5. Echeveria acutifolia specimen collected by Carl Hartweg in 1842 © Cambridge University Herbarium (CGE05621)

and newly described species. The Horticultural Society, and Lindley himself, became a hub for the publication and promotion of the thousands of species new to western science being collected around the world. These new species came from the Society's own plant collectors, including Karl Theodor Hartweg (1812-1871) (Figure 5), and those of the great Victorian nurseries of James Veitch and Sons in Chelsea, and Loddiges in Hackney. Specimens from Richard Spruce (1817-1893), Thomas Lobb (1820-1894), William Lobb (1809-1864), David Douglas (1799-1834), James Drummond (c.1784-1863), Alfred Russel Wallace (1823-1913), and many other great collectors of the Victorian era are held in this collection.

After Lindley's death, the University of Cambridge purchased his herbarium of 58,000 sheets (excluding the orchids, which the Royal Botanic Gardens, Kew, bought) in 1866. The collection is extremely rich in type specimens, especially for species described by Lindley himself, often in the highly illustrated Botanical Register (which he edited between 1829-1847) the Gardeners' Chronicle, and his other publications (Lindley 1820; 1821a; 1821b). During his life, Lindley's friends and correspondents George Bentham, William and Joseph Hooker, Jacob George Agardh (1813-1901), and Christian Gottfried Daniel Nees von Esenbeck (1776-1858) contributed to and studied the collection. It has been suggested anecdotally by multiple colleagues and visitors that it is likely duplicates of important specimens (including types) destroyed in the Berlin Herbarium in Germany during the second world war may yet be identified from this collection. These specimens may be likely to reside in Lindley's collection and also Babington's own herbarium, Babington having long corresponded with German botanists including Heinrich Gottlieb Ludwig Reichenbach (1793-1879), Wilhelm Daniel Joseph Koch (1771-1849), and Jacob Sturm (1771-1848).

Charles Fox Bunbury (1809-1886)

Bunbury studied at Trinity College, Cambridge. He collected plants in the UK, especially in East Anglia, and also South America (1833-1834), South Africa (1838-1839), Madeira (1853), and Tenerife (1853). He also brought together specimens from correspondents and family members from around the world, including South American material from his uncle Henry Stephen Fox (1791-1846), the herbarium of the author Charles Kingsley (1819-1875) from Devonshire, Tenerife, and the West Indies, and collections made by Charles Darwin in the UK. Bunbury's herbarium, thought to be 6,000 sheets, came to CGE on his death in 1886, but has never been incorporated into the main collection. It appears to have been the subject of virtually no research to date.

Gray and Genevier

Other substantial collections added to CGE during Babington's professorship include the Gray algae collection added in 1877, and the Genevier herbarium in 1869. John Edward Gray (1800-1875) and Maria Emma Gray (1787-1876) left their collection of 3,000 algae specimens to Cambridge University. The Keeper of Zoology at the British Museum (now the Natural History Museum) between 1840-1875, John Gray was also an algologist and hepaticologist, and Maria Gray (nee Smith) was a conchologist and organised the cryptogam collections at the British Museum. The large herbarium of Leon Gaston Genevier (1830-1880) was purchased by Babington and incorporated into the main collection, with the exception of the 6,000 sheets of *Rubus* specimens, an important collection which remains separate.

The evolution of CGE through the 20th century and into the 21st

Marshall Ward and the new 'Cambridge Botany'

In 1895, after the death of Babington, the chair of the Botany School in Cambridge was awarded to a student of Thomas Huxley, Harry Marshall Ward (1854-1906), father of the botanist and explorer Frank Kingdon-Ward. Marshall Ward oversaw the building of a new Botany School building, on the Downing Site in central Cambridge (Figure 6), opened by King Edward VII and Queen Alexandra on 1 March 1904. The herbarium was moved to occupy a purpose-built space on the ground floor of the new state of the art steel-framed building.

Figure 6. Botany School, University of Cambridge, 1904 © Department of Plant Sciences, University of Cambridge

During Marshal Ward's tenure, however, there was a move away from more traditional taxonomic botany, towards other aspects of plant science, such as physiology, pathology, and ecology. This continued under the next professor of botany, Albert Charles Seward (1863-1941), appointed in 1906. Herbarium Curators during the Marshal Ward and Seward periods were Henry Harold Welch Pearson (1870-1916) in 1898, Richard Henry Yapp (1871-1929) in 1900, Robert Heath Lock (1879-1919) in 1905, and Charles Edward Moss (1870-1930) in 1907.

The inter-war period: British and European taxonomy start to flourish

The appointment in 1921 of Humphrey Gilbert Carter (1884-1969) as Curator of the Herbarium, and also Director of the Cambridge University Botanic Garden (CUBG), reinvigorated botanical taxonomy in Cambridge via Gilbert Carter's inspirational teaching. Many now well-known botanical names passed through Cambridge during this and the post-war period.

John Scott Lennox Gilmour (1906-1986) followed Gilbert Carter in the Curatorship of the Herbarium 1930-1931, and Gilbert Carter continued as Director of CUBG until his retirement in 1951. After periods at the Royal Botanic Gardens, Kew and the Royal Horticultural Society between 1931-1951, Gilmour became Director of CUBG, a post he held for the next two decades. Gilmour and Tutin (1908-1987) published a booklet in 1933 about the 'more important collections' at CGE (Gilmour and Tutin, 1933) with the help of a young William Thomas Stearn (1911-2001), who worked in CGE during his lunch breaks in the 1930s. Stearn went on to work at the Lindley Library, Royal Horticultural Society, and then the Natural History Museum, London. David Henriques Valentine (1912-1987) was Curator of CGE in 1936-1945, going on to become the Professor of Botany at the University of Durham, and later of the University of Manchester.

Major collections bequeathed to CGE in the inter-war years were the British herbarium of Edward Shearburn Marshall (1858-1919), comprising some 23,000 sheets; the mostly Indian plant collections of William Philip Hiern (1839-1925); approximately 4,000 sheets of North American plants from Kenneth Kent Mackenzie (1877-1934); 6,000 sheets of British plants from Joseph Edward Little (1861-1935); and 24,000 sheets of British plants from Spencer Henry Bickham (1841-1933).

Post-World War II: The years of immense toil

The end of the second World War and the arrival of (Stuart) Max Walters (1920-2005) in 1948 as Curator of CGE heralded the start of a highly productive era of taxonomy and systematic botany in Cambridge (Walters, 1981). Signs in 1944 had not been promising, however; as Peter Derek Sell (1929-2013) later recalled, the Cambridge University Herbarium was 'a dead and dreary place' (Sell and Murrell, 2018). Peter Sell worked in CGE from 1944 until (and well after) his retirement in 1997, becoming Assistant Curator in 1972. In spite of his initial impressions, he later referred to the subsequent and extremely productive decades in the Herbarium as 'the years of immense toil'.

During the second half of the 20th century, the Cambridge Botany School, as with those in most other British universities, continued to move into more developmental, physiological, ecological, and molecular research areas, becoming the Department of Plant Sciences. The Herbarium and discipline of taxonomy formed a distinct 'group' within the department, as with most botany departments in UK universities. CUBG experienced a sustained period of expansion in the 1950s, with the substantial injection of funding provided by the Cory bequest, from Reginald Radcliffe Cory (1871-1934), who also left generous bequests for the Royal Horticultural Society's Lindley Library. Strong links with CUBG were maintained and aided by the now common (but not continuous) practice of co-appointment of the Herbarium Curatorship and Directorship of the Botanic Garden – Max Walters became Director of CUBG in 1973, handing over the Curatorship of the Herbarium to David Briggs.

Botanists based in Cambridge and at CGE formed an important base for much of the *Flora Europaea* (1964–93) project, with the six volumes published by Cambridge University Press (Tutin et al., 1964-1993) and contributors from 30 countries attending the final conference held at King's College, Cambridge in 1977. The resulting collections at CGE for continental Europe are large and comprehensive, but have been relatively little studied since this period. Over his lifetime, Sell added some 50,000 of his own specimens to CGE from across Great Britain and Ireland, many collected with Gina Murrell, who was Assistant Curator from 2002-2012 and his co-author on the five-volume *Flora of Great Britain and Ireland*, published between 1996 and 2018 (Sell and Murrell, 2018).

The Department's appointment of researchers and Chairs in subjects such as forestry, ecology, and tropical ecology, including the eminent figures of Augustine Henry (1857-1930), Arthur George Tansley (1871-1955), Edred John Henry Corner (1906-1996), Oliver Rackham (1939-2015), and Peter Grubb (1935-), whose work involved using and depositing specimens in CGE (Grubb, Stow and Walters, 2004), continued to add to and enrich the collections. CGE was part of the undergraduate teaching syllabus into the 1990s. Many students of these individuals went on to have prominent roles in botanical research around the world, and their collections and annotations on specimens at CGE alongside those of their supervisors further developed the herbarium. Henry's working set of specimens for the seven-volume *The Trees of Great Britain and Ireland* (Elwes and Henry, 1906-1913) are at CGE, as are many of Corner's South East Asian fig (*Ficus*, Moraceae) and mycological specimens.

Later in the 20th century, focus shifted away from taxonomic teaching, but new interest in some of the historical specimens at CGE developed. A substantial body of botanical research was produced based on the Darwin Beagle specimens, mostly in works published by Duncan Porter (1980a; 1980b; 1983; 1984; 1985; 1986; Porter, Murrell and Parker, 2009), but also via an early digitisation project based at CGE and funded by Microsoft. This project involved imaging and databasing the Darwin Beagle specimens and making them available online (although for some years now this dataset has been unavailable and only low resolution images have been available via the Herbarium's own simple website). During his time in Cambridge, John Stewart Parker, Director of CUBG and Curator of CGE between 1996 and 2010, undertook an enormous amount of work studying the specimens and writings of John Stevens Henslow, the influence of his innovative teaching methods in Cambridge and in his parish of Hitcham and their wider reach. In response to declining funding for CGE from the Department of Plant Sciences, Parker set up an informal 'Friends of the Herbarium' group of volunteers, several of whom continue to contribute much appreciated time and energy at CGE today.

21st century changes and challenges

In 2011, CGE moved physical home again, after over 100 years in Marshall Ward's at-the-time cutting-edge building into the 21st century equivalent, the £82 million Sainsbury Laboratory Cambridge University (SLCU) (Figure 7). Funded by the Gatsby Charitable Foundation, the SLCU is an ultra-energy efficient Stirling Prize winning building, housing state-of-the-art laboratory facilities and plant growth facilities, as well as facilities for CUBG and space for CGE in the basement of the building. A separate research institution within the University of Cambridge, research groups in the SLCU specialise in fundamental plant growth and development.

Figure 7. The Sainsbury Laboratory Cambridge University © Stanton Williams Architects.

Recognising that the facilities in the Department of Plant Sciences building in central Cambridge were not ideal for CGE, and that pest problems were an increasing risk to the specimens, CGE was moved into the new building and into modern compactor storage (Figure 8), with -30°C freezers for specimen quarantining. In addition, for the first time in many years, the entire CGE collection was able to be brought together and housed in the same space; the bryophytes had long been stored in another part of the Department, and much of the historic material had been stored off-site in various non-ideal locations, or in inaccessible locations in the old herbarium.

The move of CGE into new facilities corresponded with a number of key retirements in the herbarium, including that of the Curator (who had also been the Director of CUBG) and the Assistant Curator two years later in 2012, leaving the collections with a part-time

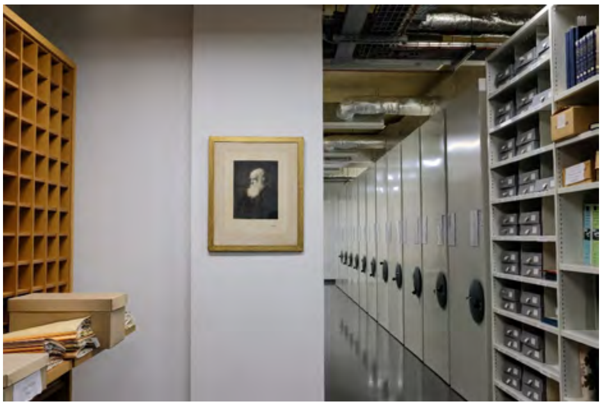


Figure 8. Compactor units inside the new Cambridge University Herbarium © Fu Xiang Quah, https://fxquah.smugmug.com

Technician as the sole member of staff until they, too, retired in 2017. In recent decades, CGE has had relatively limited research use by members of the Department, other Cambridge University Departments, and external individuals and organisations, and little integration into undergraduate or postgraduate teaching. Most recent research use has understandably focused on the Great Britain and Ireland collections, and CGE is relatively well-known to British and Irish botanists through Sell and Murrell's flora, and organisations such as the Botanical Society of the British Isles (BSBI). The other main research use of CGE is the many external enquiries received each week from botanists looking for Darwin or historical type specimens, especially those relating to names published by Lindley.

Current priorities for CGE

The potential of the CGE collections is significant, and the specimens a rich and a virtually untapped mine of scientific and historical research data but current knowledge or use of the Herbarium is very limited. With the appointment of a new Curator in late 2017, the role of the Herbarium (within the Department of Plant Sciences, University of Cambridge more widely, and internationally within the botanical and collections community and beyond), is being reassessed and new initiatives and collaborations planned.

A priority is to make the collections more accessible and usable for researchers, updating and creating policies for research use, loans, destructive sampling, and accessions, as well as upgrading collections care procedures and facilities, looking particularly at environmental and pest monitoring and control. The high-resolution digitisation of specimens, especially nomenclatural type specimens and particularly important collections such as the Martyn specimens, is now possible with the funding and acquisition of a new high-resolution imaging set-up and database, using international standards. It is planned that herbarium specimen images will be made accessible online via commonly used portals such as JSTOR Plants, the Global Biodiversity Information Facility (GBIF), and also on the Cambridge Digital Library (part of the Cambridge University Library, and home to digital versions of a huge array of internationally important documents including Isaac Newton's *Principia*, Stephen Hawking's PhD thesis, a copy of the Gutenberg Bible, and a Shakespeare First Folio edition).

Embedding CGE into the present-day research and teaching of the Department of Plant Sciences will be an important way of securing the collection's long-term future, and a productive way through which to explore the collections and stimulate their investigation. Raising awareness of the collections within the Department and other parts of the University via small group tours, open to all researchers, students, technical and administrative staff has been a remarkably successful approach. These tours have initiated many conversations about collaborative projects, teaching integration, and exhibitions, and work has started on a number of these activities already.

The investment of the University in housing the CGE within the Sainsbury Laboratory is significant, and the conditions in which the collections are now housed are far superior to those ever possible previously. Unfortunately, there are currently no financial resources to employ staff in Curatorial Assistant, Collections Manager, or Digitisation Assistant posts. Volunteer and student assistance is proving invaluable in order to maintain the basic functioning of the Herbarium, but also to initiate small 'proof of concept' projects via which to scope and properly cost funding applications for more significant and impactful activities. Further development of the number and range of volunteer and student opportunities is planned, but relying on unpaid assistance to fulfil the core tasks and functions of a herbarium is unsustainable and unethical. It will be essential to secure funding for even a modest level of staffing in the future, in addition to underwriting the position of Curator, who is currently appointed on a fixed-term basis only.

The first step of most research projects will simply involve documenting the relevant specimens in the collections and digitising them, and in doing so, build a database of CGE specimens. The nature of the arrangement of many of CGE's specimens, in quite atomised sections either relating to specific collectors or collections, taxonomic groups, or geographic areas, lends itself to a series of discrete small (50-1,000), medium (1,000-99,000), or large (100,000s of specimens) digitisation projects which could be undertaken at different funding levels. It is envisaged that these independent but linked projects would open up new avenues for further impactful research, and myriad 'stories' which could be used in teaching, engagement, and outreach. A priority will be to image Darwin's non-Beagle material and more recently discovered specimens which were previously elsewhere in the collection; the 12,000 type specimens already separated into red folders; and the 18th century Martyn collection.

The Herbarium is now part of the University of Cambridge Museums network, providing a pool of experienced colleagues across disciplines and areas of expertise – including conservation care, volunteer coordination, research impact, and public engagement. Staff, students, and volunteers are starting to investigate links between herbarium specimens at CGE and existing research going on in the Department and connections with the other University of Cambridge collections. Such links include those between the plant voucher specimens collected on the 1898 Haddon expedition to the Torres Strait Islands and the anthropological objects, notebooks and manuscripts housed at the Museum of Archaeology and Anthropology, and the re-discovery of the links between the teaching illustrations in CGE and the Fitzwilliam Museum and the Whipple Museum of the History and Philosophy of Science. The 'Bunbury' collection, only recently unwrapped from the paper bundles in which it had been stored for decades (if not longer), is currently being curated and this collection will be digitised and made available for study as a discrete project.

As CGE is explored and documented further, new type specimens, undescribed species, and previously unrecognised but important specimens will be discovered. In 2011, the largest known surviving set of plant specimens collected by Alfred Russel Wallace (41 fern sheets from Borneo), were discovered in the Lindley collection (Cicuzza, 2014; Figure 9); in 2012 several previously undocumented Darwin specimens, still in the original newspapers they were collected into, were found (Figure 10); and in 2018, part of Darwin's type collection of the fungus *Cyttaria darwinii*, collected in Tierra del Fuego. The Cambridge University Herbarium still has many secrets to be revealed.

Acknowledgements

The author would like to thank the NatSCA committee for their support in attending the 2018 conference; Share Museums East Natural History group for additional funding towards attending the conference; the Department of Plant Sciences, Cambridge University, and the University of Cambridge Museums & Botanic Garden for their ongoing support; the CGE volunteers whose contributions are very gratefully appreciated; Chris Preston and Thomas Walton for their invaluable comments on earlier drafts of this paper; two anonymous reviewers, Donna Young, and Yvette Harvey, who also helped to shape this paper.

References

Bentham G., and Hooker, J.D., 1862-1883. *Genera plantarum ad exemplaria imprimis in herbariis kewensibus servata definita*. London: L. Reeve & Co.

Burkhardt, F. et al. (eds.), 1985–. *The correspondence of Charles Darwin*. Cambridge: Cambridge University Press.

Cicuzza, D., 2014. A rediscovery of Alfred Russel Wallace's fern collection from Borneo at the Cambridge University Herbarium. *Notes Rec. R. Soc. Lond.*, 68(4), pp.403-412.

Elwes, H.J., and Henry, A., 1906-1913. The Trees of Great Britain and Ireland. Volumes 1-7. Cambridge: Cambridge University Press.

Gilmour, J.S.L. and Tutin, T.G., 1933. A list of the more important collections in the University Herbarium Cambridge. Cambridge: Cambridge University Press.

Grubb, P., Stow, E.A., and Walters, S.M., 2004. 100 Years of Plant Sciences in Cambridge: 1904-2004. Cambridge: Department of Plant Sciences, Cambridge University.

Hooker J.D., 1847a. An enumeration of the plants of the Galapagos Archipelago; with descriptions of those which are new. *Trans. Linn. Soc.*, 20, pp.163–233.

Hooker J.D., 1847b. On the vegetation of the Galapagos Archipelago as compared with that of

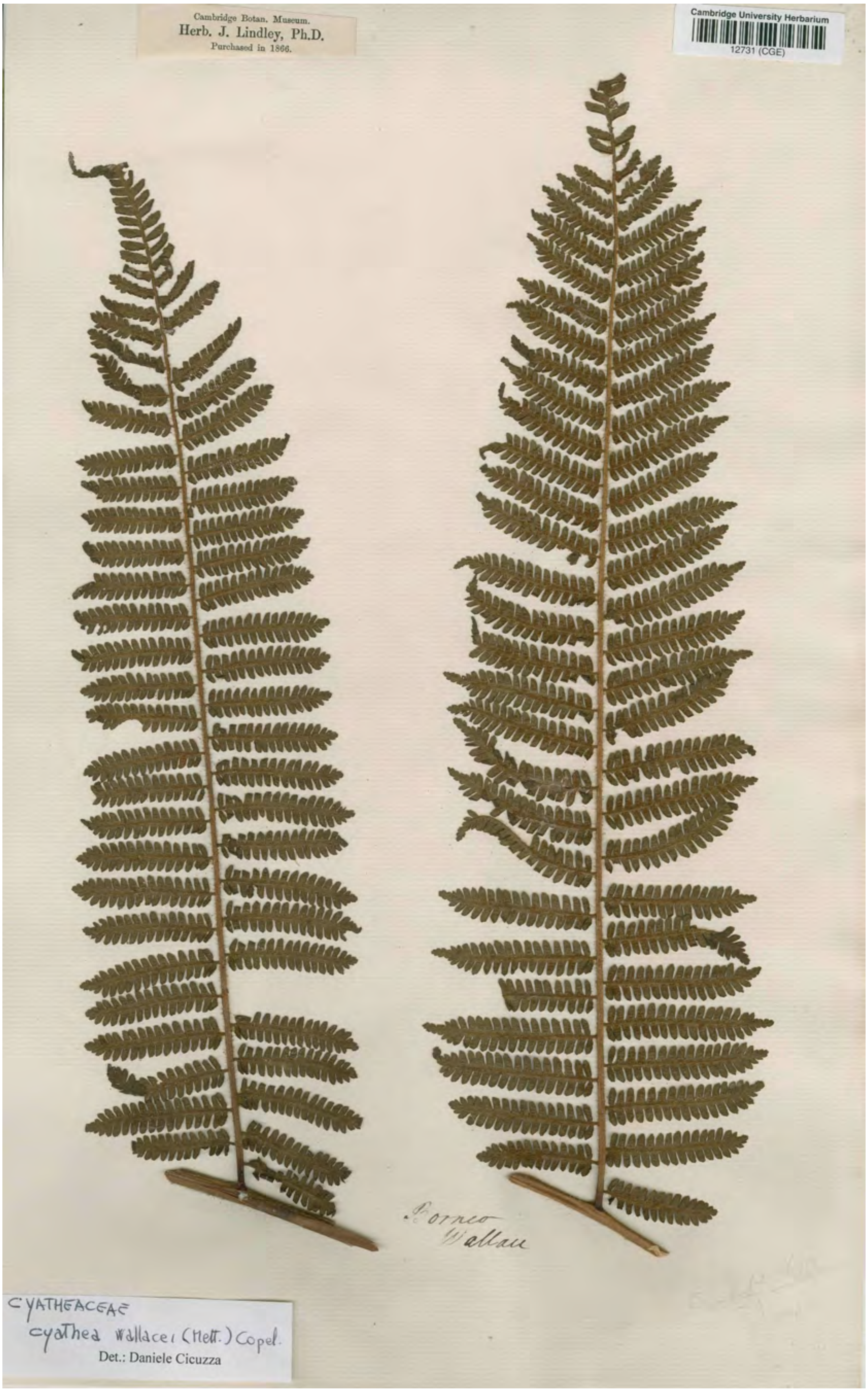


Figure 9. Cyathea wallacei specimen collected by Alfred Russel Wallace in Borneo (CGE12731) © Cambridge University Herbarium

Figure 10. Fungi specimens collected by Charles Darwin on the Voyage of the H.M.S. Beagle in their original newspapers (CGE12472-124727) © Cambridge University Herbarium

some other tropical islands and of the continent of America. *Trans. Linn. Soc.*, 20, pp.235-262.

Kohn, D., Murrell, G., Parker, J., and Whitehorn, M., 2005. What Henslow taught Darwin. *Nature*, 463, pp.643-645. https://doi.org/10.1038/436643a.

Lindley, J., 1820. *Rosarum Monographia; or, a Botanical History of Roses*. London: J. Ridgway.

Lindley, J., 1821a. *Collectanea Botanica; or, Figures and Botanical Illustrations of Rare and Curious Exotic Plants*. London: R. & T. Taylor.

Lindley, J., 1821b. *Digitalium monographia*. London: R. & T. Taylor.

Porter, D.M., 1980a. Charles Darwin's plant collections from the voyage of the Beagle. *J. Soc. Bibl. of Natural History*, 9, pp.515–525.

Porter, D.M., 1980b. The vascular plants of Joseph Dalton Hooker's 'An enumeration of the plants of the Galapagos Archipelago; with descriptions of those which are new'. *Bot. J. Linn. Soc.*, 81, pp.79–134.

Porter, D.M., 1983. Charles Darwin, the Cape Verde Islands and the Herbarium Webb. *Webbia*, 36, pp.225–228.

Porter, D.M., 1984. William Jackson Hooker and Charles Darwin's Beagle plants. *Huntia*, 5, pp.107–116.

Porter, D.M., 1985. The Beagle collector and his collections. In: Kohn D, ed. *The Darwinian heritage. Princeton: Princeton University Press*, pp.973–1019.

Porter, D.M., 1986. Charles Darwin's vascular plant specimens from the voyage of HMS Beagle. *Bot. J. Linn. Soc.*, 93, pp.1–172.

Porter, D., Murrell, G., and Parker, J., 2009. Some new Darwin vascular plant specimens from the Beagle voyage. *Bot. J. Linn. Soc.*, 159, pp.12–18.

Sell, P.D., and Murrell, G., 1996-2018. *Flora of Great Britain and Ireland. 5 volumes.* Cambridge: Cambridge University Press.

Smith, G.F., and Figueiredo, E., 2014. The Global Plants Initiative: Where it all Started. *Taxon*, 63(3), pp.707-709.

Thiers, B., 2018. Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. [online] Available at: <http://sweetgum.nybg.org/science/ih/>.

Tutin, T.G., Heywood, V.H., Burges, N.A., Valentine, D.H., Walters, S.M., and Webb, D.A., 1964–1993. *Flora Europaea*. Cambridge: Cambridge University Press.

Walters, S.M., 1981. *The shaping of Cambridge botany: a short history of whole-plant botany in Cambridge from the time of Ray into the present century*. Cambridge: Cambridge University Press.

The Murphy spider collection at the Manchester Museum: a valuable research resource for arachnologists

Diana Arzuza Buelvas

Address: Manchester Museum, University of Manchester, Oxford Road, Manchester, M13 9PL, UK

Email: diana.arzuzabuelvas@manchester.ac.uk

Received: 10/06/2018

Accepted: 26/09/2018

Citation: Arzuza Buelvas, D., 2018. The Murphy spider collection at the Manchester Museum: a valuable research resource for arachnologists. *Journal of Natural Science Collections,* 6, pp.48-59.

Abstract

Manchester Museum has the third largest spider (Arachnida, Araneae) collection in the UK with c. 175,000 specimens. Following a brief account of the principal spider collections acquired by the Museum between 1910 and 2017, this paper gives an overview of a major collection donated by the British arachnologist John A. Murphy in 2015. The collection contains 45,415 specimens in 25,141 vials, associated archives, and an electronic catalogue analysed in this paper. The collection constitutes an important taxonomic resource, composed of 95 families (80% of the globally known spider families), 1,133 genera (30% of the world genera) and 3,063 species, including type specimens from 14 species of Dysderidae, Zodariidae, and Uloboridae. The collection is global in scope, with species from 72 countries within six of the world's eight biogeographic regions. The Palaearctic region has the highest number of specimens (21,077), representing 1,515 species from 29 countries. The Murphy spider collection also contains c. 90% (579 species) of the known British spider species from 34 families. Currently, this collection is under recuration and documentation, with some 11,000 records already entered in the Museum database. This collection has been used as a reference for several papers and books, with 911 specimens currently on loan, and five articles published since the collection was acquired by the Manchester Museum in 2015. More than 16,000 specimens have yet to be identified, opening up the possibility for future taxonomic research and publications.

Keywords: Arachnida, Araneae, British arachnology, John A. Murphy, Frances M. Murphy, natural history collections, spiders

Introduction

Since the official opening of the Manchester Museum in 1888, entomology collections have always been an important component. The Museum's Entomology Department currently holds more than 2.5 million specimens of insects and other arthropods (Logunov and Merriman, 2012). Within the arthropods, the worldwide spider collection (class Arachnida, order Araneae) has benefited from nine major acquisitions, of which the Murphy collection is the largest to have been donated, forming the subject of this paper. With this donation, the spider collection at the Manchester Museum has become the third largest spider depository in the UK, with over 175,000 specimens belonging to more than 3,500 species. The collection currently contains 173 type specimens, with 25 species being represented by the holotypes and 32 by the paratypes.

This paper, following a brief history of the acquisition of several spider collections by the Manchester Museum, aims to (1) provide an overview of the Murphy spider collection with regard to its taxonomic diversity and geographical scope (countries and biogeographical regions); (2) describe the ongoing recuration of the collection; (3) provide brief details of the collectors, Frances and John Murphy; and (4) summarise the collection's use since its acquisition by the Museum in order to encourage its future use. As such, this paper does not attempt to provide an exhaustive review of the Murphy's complete bibliography.

Major spider collection acquisitions at the Manchester Museum

More than 80% of the spider specimens at the Manchester Museum come from nine personal collections, acquired between 1910 and 2017 (Figure 1). The first collection was donated by Henry Wybrow Freston (1867-1936) in 1910, with a total of 2,925 specimens representing 273 species. It was received by John Ray Hardy (1844-1921), the first to organise the Entomology Department as Senior Assistant Keeper and Curator of Entomology. He worked at the Museum until his retirement in 1918 (Logunov, 2012). In 1925, the L. A. Carr spider collection was purchased by the Museum, with a total of 7,188 specimens, adding 263 species to the museum. The reference collection belonging to David Mackie (1902-1984), composed of 4,535 specimens (436 species), was then bequeathed to the Museum in 1984. D. Mackie was one of the founders of the British Arachnological Society (BAS) in 1964. Later, in 1991, two collections were received: from Alexander La Touche (1896-1981), containing 15,799 specimens (570 species), and from George Hazelwood Locket (1900-1991), containing 8,684 specimens (543 species). The second largest collection received to date was from John Crocker (?-2006), who donated 40,000 specimens in 2004, representing 498 species. In 2011, Eric Duffey donated 12,581 specimens (560 species) (Logunov, 2011; Breitling, 2018).

In November 2015, an important spider collection assembled by the notable British arachnologists John A. Murphy (b. 192?) and Frances M. Murphy (1926–1995) was received. The collection (42 drawers with 25,141 vials and 45,415 specimens) was donated with a corresponding archive consisting of 388 items (letters and various species lists) and an electronic catalogue (a large Microsoft Excel spreadsheet) containing detailed data labels for all collected species. This collection was the Museum's most important acquisition in terms of the number of spider specimens and species, representing an addition of nearly 50% of the specimens housed in the museum at the time (c. 90,000). Finally, in 2017, a collection of approximately 10,000 spider specimens was donated by Richard David Curtis Jones (1943–2017), a friend of John Murphy. The short historic account given above (Figure 1) does not include smaller spider collections from Russia, Central Asia, the Caucasus, the Mediterranean, Africa, etc. donated

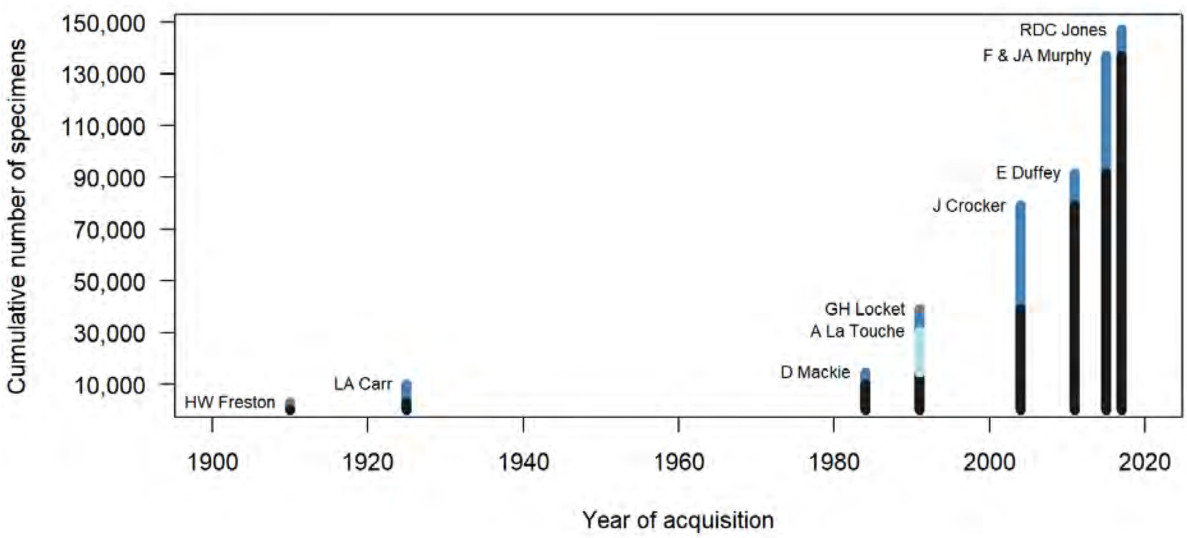


Figure 1. Cumulative numbers of specimens received over time by the Entomology Department of the Manchester Museum, from major donations (coloured/lighter portions of bars show size of each individual collection).

to the Manchester Museum by many other arachnologists or collected by the museum curator (Dmitri V. Logunov) during fieldwork; a full account of the history of Museum's arachnological collections will be provided elsewhere by the curator.

John A. Murphy (b. 192?) and Frances M. Murphy (1926–1995)

Transforming from keen naturalists to spider experts, the British arachnologists John and Frances Murphy (Figure 2) spent many years assembling a large spider collection, participating as active members of the British Arachnology Society, and contributing to the Spider Recording Scheme since its creation in 1954 (O'Neill, 1995).

Frances Mary Murphy, enthusiast naturalist, was one of the founder members of the British Arachnological Society as well as a member of 12 other arachnological groups and natural history societies. Part of her work included encouraging young arachnologists through field study courses and surveys, mainly in the south of England. The Murphy house in Hampton, UK, was described as 'a world full of spiders' in one of the BAS member handbooks; they kept in their living room not only literature (two walls of bookcases) but also specimens in tubes, in cabinets and boxes, cages with live spiders and, of course, flies to feed them (O'Neill, 1995). Frances published two books on keeping spiders and land invertebrates in captivity, with an identification guide included in one of them. These books are still invaluable resources for naturalists. Frances also contributed five papers to the Bulletin of the British Arachnology Society, over a dozen reports in the BAS newsletter, two papers for other journals, and many other notes, comments, trip reports, survey descriptions, and literature reviews.

Frances and John Murphy travelled regularly to attend national and international conferences, events and courses, and also on holiday, where they were able to collect many of their specimens. Indeed, they did not miss any opportunity to collect spiders, and more than 3,600 specimens mention 'garden' in their notes on habitat and 10 of them were reported as imported to the UK. They described some of their remarkable journeys in the BAS Newsletters. For example, two journeys to the United States: to attend the American Arachnology Conference in New Mexico in 1973, and the International Meeting of the American Arachnological Society in Missouri in 1975. After the meetings, they spent time collecting spiders in the Arizona desert, at the South West Research Station of the American Museum of Natural History, and in Missouri and California (Murphy and Murphy, 1976). The review of a 'social' expedition with fellow arachnologists around Brittany in 1992 was published in the BAS Newsletters, detailing (among the personal experiences) a list of the new species for Brittany and other possible new species to France (Murphy, 1994). Another remarkable trip was to Malaysia and Borneo, where they collected in many different places, including spending nights hunting and watching spiders in the rainforests of the pristine Kinabalu National Park and in the garden around the cabin in which they stayed (Murphy and Murphy, 1980). After their second visit to South East Asia, Frances agreed to write about the spiders of this region. Tragically, she only prepared the outline of her text before

Figure 2. a) John A. Murphy; photo: Torbjörn Kronestedt, 2004. b) Frances M. Murphy; photo: Rowley Snazell, 1988.

succumbing to illness in the winter of 1995. Her husband John completed and published the book in 2000 (Murphy and Murphy, 2000).

John A. Murphy's contributions to arachnology are focused on taxonomy, especially revisionary works, and various changes in spider classification. He is also keen to add new spiders to country checklists. He was a co-author of a complete revision of the list of British spiders (Merrett and Murphy, 2000), in which 24 species were added since the previous checklist and a new taxonomic sequence of families was proposed. He has published three books and many articles, mostly for the Bulletin of the British Arachnological Society, but also in other scientific journals, such as American Museum Novitates and Zootaxa (WSC, 2018; BAS, 2018). J. Murphy donated his extensive library to the British Arachnological Society, including 19th and early 20th century reprints (Stanney, 2016).

John Murphy is a current honorary member of the International Society of Arachnology, in recognition of his important contributions to arachnology. In 2013, J. Murphy received the Brignoli Award in recognition of his exceptional taxonomic revision of Gnaphosidae genera, published in a two-volume book in 2007 (Murphy, 2007), including an identification atlas (Dunlop, 2013).

Overview of the collection

The following analysis is based on the electronic catalogue received with the Murphy spider collection. The catalogue is kept in the electronic archive of the Manchester Museum and is accessible through requests to the Museum's Curator of Arthropods, Dr Dmitri Logunov (dmitri.v.logunov@manchester.ac.uk). This catalogue contains the following information: collector's number, number of individuals per vial, sex (male, female, and juvenile), taxonomy (family, genus, and species), collecting date, country and location of origin, habitat (in some cases), name of the person who identified the species and an ID date. In this report, nomenclature was checked with and updated following the World Spider Catalog (WSC, 2018). Country names were standardised using Geographic Administrative Division Map (GADM, 2018) and assigned to exclusive biogeographic regions, following Olson et al. (2001).

The Murphy spider collection contains 25,141 vials housed in 42 drawers with a total of 45,415 specimens (24,936 females, 16,360 males, and 4,119 juveniles). The specimens belong to 95 families representing more than 80% of the world's known spider families (WSC, 2018; Table 1). Nearly 30% of globally known spider genera are represented (1,133 genera) in 3,063 identified species. Approximately 64% of the collected specimens have been identified to species. A further 16,478 specimens have not been identified yet; of them, 78% have been identified to genus (Table 1). It should be noted that there are often multiple specimens of the same species per vial (range 1 – 62).

Families with the highest numbers of identified species are the Linyphiidae (494 species, 6,191 specimens), the Salticidae (432 species, 7,103 specimens), the Theridiidae (281 species, 5,844 specimens), the Gnaphosidae (271 species, 3,774 specimens), and the Araneidae (231 species, 2,677 specimens). The above five families have an average

Table 1. Identification status of specimens and vials at family, genus, and species ranks in the Murphy spider collection, and taxonomic representation of world spider fauna

Taxonomic level	**Identification status**	**Specimens (% of total in Murphy collection)**	**Vials (% of total in Murphy collection)**	**Number of taxa (% of world spider fauna)**
Family	Identified	44,831 (98.7%)	24,955 (99.3%)	95 (81.9%)
	Not identified	584 (1.3%)	186 (0.7%)	-
Genus	Identified	41,827 (92.1%)	23,329 (92.8%)	1,133 (27.8%)
	Not identified	3,588 (7.9%)	1,812 (7.2%)	-
Species	Identified	28,937 (63.7%)	16,069 (63.9%)	3,063 (6.5%)
	Not identified	16,478 (36.3%)	9,072 (36.1%)	-
Total (for each taxonomic level)		**45,415**	**25,141**	

Table 2. Species represented by type specimens in the Murphy collection as of October 2018, by family (nomenclature follows WSC, 2018) M = Male, F = Female.

Family	No. of species			No. of specimens
	Holotypes only	Paratype(s) only	Total	
DYSDERIDAE		5	5	14
ULOBORIDAE	2		2	2
ZODARIIDAE	2	5	7	16
Total	**4**	**10**	**14**	**32**
List of species	**Holotypes**	**Paratypes**	**Type locality**	**References**
DYSDERIDAE				
Dysdera corfuensis Deeleman-Reinhold, 1998		2 M, 2 F	Greece, Corfu	Deeleman-Reinhold and Deeleman (1988)
Dysdera dubrovninnii Deeleman-Reinhold, 1988		1 M, 2 F	Yugoslavia	Deeleman-Reinhold and Deeleman (1988)
Dysdera halkidikii Deeleman-Reinhold, 1988		1 M, 1 F	Greece, Halkidiki	
Dysdera murphyorum Deeleman-Reinhold, 1988		2 M, 2 F	Greece, Corfu	Deeleman-Reinhold and Deeleman (1988)
Dysdera punctocretica Deeleman-Reinhold, 1988		1 M	Greece, Corfu	Deeleman-Reinhold and Deeleman (1988)
ULOBORIDAE				
Miagrammopes kinabalu Logunov, 2018	1 M		Malaysia, Sabah	Logunov (2018)
Miagrammopes uludusun Logunov, 2018	1 M		Malaysia, Sabah	Logunov (2018)
ZODARIIDAE				
Mallinella denticulata Dankittipakul, Jocqué et Singtripop, 2012		2 F	Malaysia	Dankittipakul, Jocqué and Singtripop (2012)
Mallinella leptoclada Dankittipakul, Jocqué et Singtripop, 2012		1 M, 3 F	Malaysia	Dankittipakul, Jocqué and Singtripop (2012)
Mallinella microtheca Dankittipakul, Jocqué et Singtripop, 2012	1 F		Malaysia, Genting	Dankittipakul, Jocqué and Singtripop (2012)
Mallinella murphyorum Dankittipakul, Jocqué et Singtripop, 2012	1 M		Malaysia, Johor	Dankittipakul, Jocqué and Singtripop (2012)
Mallinella robusta Dankittipakul, Jocqué et Singtripop, 2012		1 M	Malaysia, Johor	Dankittipakul, Jocqué and Singtripop (2012)
Mallinella tricuspida Dankittipakul, Jocqué et Singtripop, 2012		3 M, 3 F	Malaysia, Genting	Dankittipakul, Jocqué and Singtripop (2012)
Workmania botuliformis Dankittipakul, Jocqué et Singtripop, 2012		1 F	Singapore, Bukit Timah	Dankittipakul, Jocqué and Singtripop (2012)

40% of the known genera of the world spider fauna represented in the collection, and 10% of the known species (Figure 3).

The median number of specimens per species is four, with only 25% of the species being represented by 10 or more specimens. Species with the highest number of specimens are *Tenuiphantes tenuis* Blackwall, 1852 (213 specimens from 10 countries), *Locketidium couloni* Jocqué, 1981 (159 specimens; endemic to Kenya), *Drassodes lapidosus* Walckenaer, 1802 (139 specimens; 7 countries), *Pardosa proxima* C. L. Koch, 1847 (138 specimens; 5 countries), and *Haplodrassus dalmatensis* L. Koch, 1866 (134 specimens; 11 countries).

The Murphy collection at Manchester Museum currently holds type specimens for 14 species (Table 2). Two of these species (*Dysdera murphyorum* and *Mallinella murphyorum*) were dedicated to both Frances and John Murphy for "*their pioneer work in the field of arachnology of Southeast Asia*" (Dankittipakul, Joque and Singtripop, 2012: p. 217). However, the majority of type specimens of species described before the collection arrived at Manchester Museum are held in other collections; for instance, in the American Museum of Natural History in New York (e.g., Logunov, 2000; Platnick, Ovtsharenko and Murphy, 2001; etc.), and the Natural History Museum in London (e.g., Deeleman-Reinhold and Deeleman, 1988; Wanless, 1980; etc.). The collection also

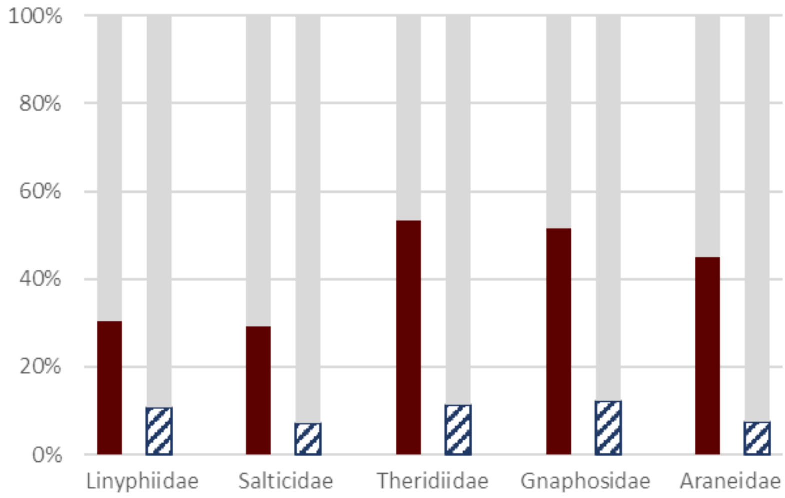


Figure 3. Proportion of world spider genera (solid bar of each family) and species (hatched bar) represented in the top five families of the Murphy collection.

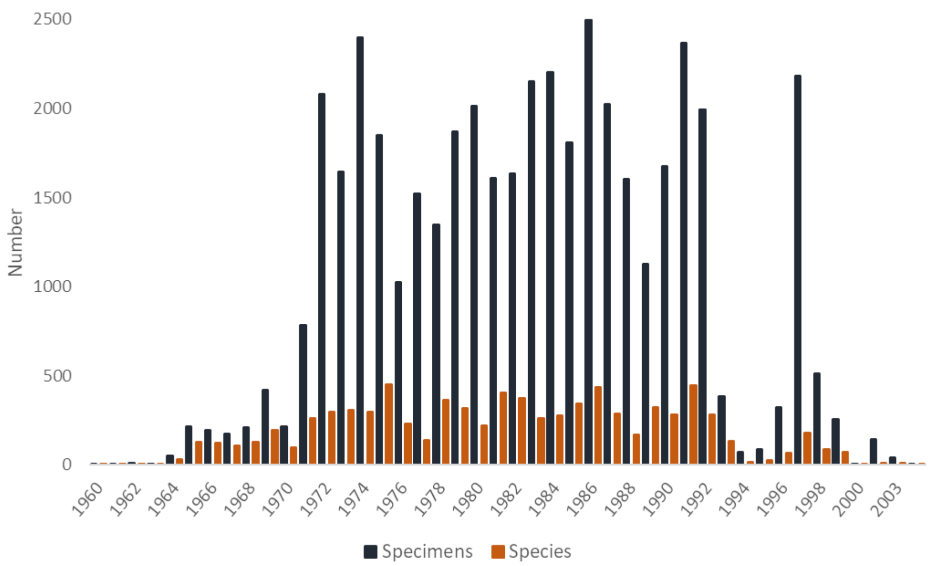


Figure 4. Number of specimens and species in the Murphy spider collection acquired per year (94 specimens were acquired before 1960, not shown here).

contains some specimens with 'museum names', i.e. prepared for descriptions of new species and even provided with new names and corresponding type labels, but not actually published, for instance, *Mallinella planotibialis* Jocque, 1990 (paratype male; family Zodariidae) from Kenya.

The Murphy spider collection comprises specimens collected from 1925 to 2004 (Figure 4), with a sustained period of active collection between 1971 and 1992. Over this 20-year period, 39,246 specimens (86% of the total collection) from 67 countries were acquired. Only 1.2% - i.e. 560 specimens and 85 species – do not have a collection date. More than a third of specimens were collected in two months of the year – April (6,980) and August (9,690), which seems to correspond to the most common holiday months in the UK. Months with the fewest number of specimens correspond to October and December, with less than 1000 specimens collected per month.

The importance of the Murphy spider collection lies not only in its extended period of collection, but also in its geographical range, with species collected from six of the world's eight biogeographic regions (cf. Olson et al., 2001) and from 72 countries (Table 3, Figure 5). The Palaearctic Region shows the highest number of specimens (21,077) and species (1,515),

Table 3. Number of specimens and taxa by biogeographic regions (only determined species)

Biogeographic region	**Number of specimens**	**Number of families**	**Number of genera**	**Number of species**	**Countries represented**
Australasia	4876	58	267	262	3 (Australia, New Zealand, Papua New Guinea)
Afrotropics	8493	63	351	394	16 (Botswana, Burkina Faso, Cameroon, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Nigeria, Saint Helena, Senegal, Seychelles, South Africa, Tanzania, Uganda, Zimbabwe)
IndoMalay	5342	59	358	291	10 (Bhutan, Brunei, India, Indonesia, Malaysia, Philippines, Singapore, Sri Lanka, Thailand, Vietnam)
Nearctic	4211	58	296	685	3 (Canada, Mexico, United States)
Neotropics	1369	48	140	119	11 (Chile, Colombia, Costa Rica, Dominica, Falkland Islands, Guyana, Jamaica, Panama, Peru, Puerto Rico, Trinidad and Tobago)
Palaearctic	21077	60	508	1515	29 (Algeria, Austria, Belgium, China, Croatia, Cyprus, Egypt, Finland, France, Greece, Guernsey, Ireland, Israel, Italy, Libya, Mongolia, Montenegro, Morocco, Netherlands, Norway, Oman, Portugal, Spain, Sweden, Switzerland, Tunisia, Turkey, United Kingdom, Yemen)
No country data	47	14	24	15	
Total	**45415**				**72**

collected from 29 countries. Spain (including Tenerife and the Canary Islands), France, UK, Portugal, and Greece are the countries with the highest numbers of collected species (Figure 5). The Neotropics is the least represented region in the collection, with the lowest number of specimens (1,369) and species (119). Neotropical specimens were mainly collected from Costa Rica and Panama. Only a small percentage of the specimens from the Murphy spider collection does not have associated country information (47 specimens, Table 3).

British spiders

The Murphy spider collection contains almost 90% (579 species) of the recorded British spider species in 34 families, following the checklist by Merrett, Russell-Smith and Harvey (2014). This does not include the Channel Island, vagrants, or those from synanthropic habitats (Table 4). The collection is missing just 70 species from 14 families; of these, nine families have between 80–99% of species represented, and four families have between 60–79%. Eresidae, with a single species recorded from the UK, is the only unrepresented family. Linyphiidae has the highest number of missing species: 41.

Recuration of the collection

Curatorial practices to date at the Manchester Museum's Entomology Collection (MMUE) include adding a unique accession number (starting with G7572) to each vial; topping up with 70% alcohol, when necessary (all specimens are spirit preserved; Notton, 2010; Simmons and Muñoz-Saba, 2005); comparing vial contents and data label to the information in the electronic catalogue (every vial is marked with the collector's personal number and in some cases more than one label is included); and removing vials containing only juveniles (for the time being, these vials will be kept as unaccessioned material, as the specimens they contain are likely to be of little or no taxonomic value). Also, empty vials with specimens on loan (from before the collection was received by the Manchester Museum) are removed, with the intention that the Curator of Arthropods will claim them back in the future, and then they will be properly accessioned. Records are being digitised in the Museum's electronic catalogue (KE-Emu). Currently 30%, equivalent to c. 11,000 records, can be searched online (http://harbour.man.ac.uk/mmcustom/narratives/). The process of documenting and cataloguing the spider collection has been possible with the help of volunteers working alongside the Curator of Arthropods.

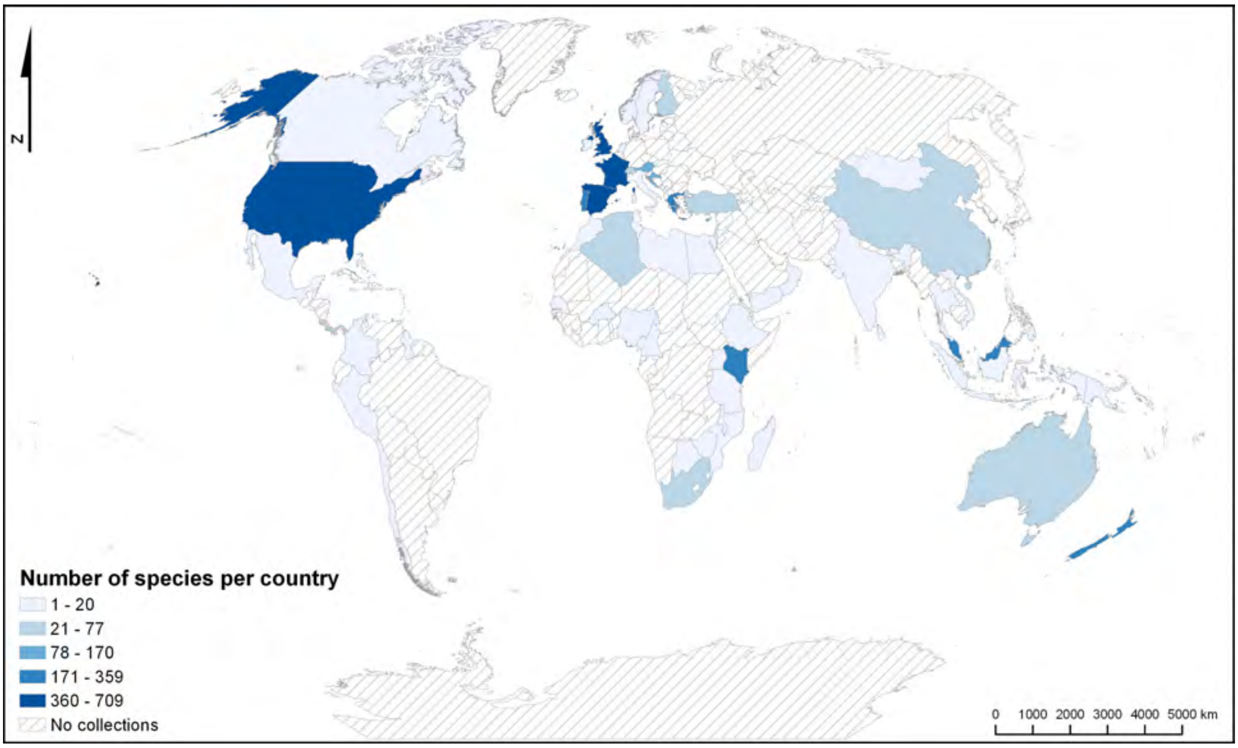


Figure 5. Global distribution and number of species per country in the Murphy spider collection.

Table 4. British spider represented in the Murphy spider collection by family. Taxonomy according to Merrett, Russell-Smith and Harvey (2014)

Family	Number of species		Total	Percentage present
	Absent	Present		
Agelenidae		13	13	100.0
Amaurobiidae		3	3	100.0
Anyphaenidae		1	1	100.0
Araneidae	1	31	32	96.9
Atypidae		1	1	100.0
Clubionidae	5	17	22	77.3
Cybaeidae		2	2	100.0
Dictynidae		14	14	100.0
Dysderidae	1	3	4	75.0
Eresidae	1		1	0.0
Eutichuridae		3	3	100.0
Gnaphosidae	4	29	33	87.9
Hahniidae	2	8	10	80.0
Linyphiidae	41	238	279	85.3
Liocranidae	1	11	12	91.7
Lycosidae	4	34	38	89.5
Mimetidae		4	4	100.0
Miturgidae		4	4	100.0
Nesticidae		1	1	100.0
Oonopidae		2	2	100.0
Oxyopidae		1	1	100.0
Philodromidae		15	15	100.0
Pholcidae		2	2	100.0
Phrurolithidae		2	2	100.0
Pisauridae	1	2	3	66.7
Salticidae	4	34	38	89.5
Scytodidae		1	1	100.0
Segestriidae		3	3	100.0
Sparassidae		1	1	100.0
Tetragnathidae		14	14	100.0
Theridiidae	2	55	57	96.5
Theridiosomatidae		1	1	100.0
Thomisidae	2	24	26	92.3
Uloboridae		2	2	100.0
Zodariidae	1	3	4	75.0
Grand Total	**70**	**579**	**649**	**89.2**

Next steps in the recuration will include rehousing the collection from the original drawers (Figure 6) by transferring specimens from plastic vials into glass tubes, arranging tubes by family and genus, and storing them in glass jars (Levi, 1966). In the future, the collection will be amalgamated with the main spider collection arranged in taxonomic order and will be easily accessible once all records have been entered in the Museum's electronic catalogue.

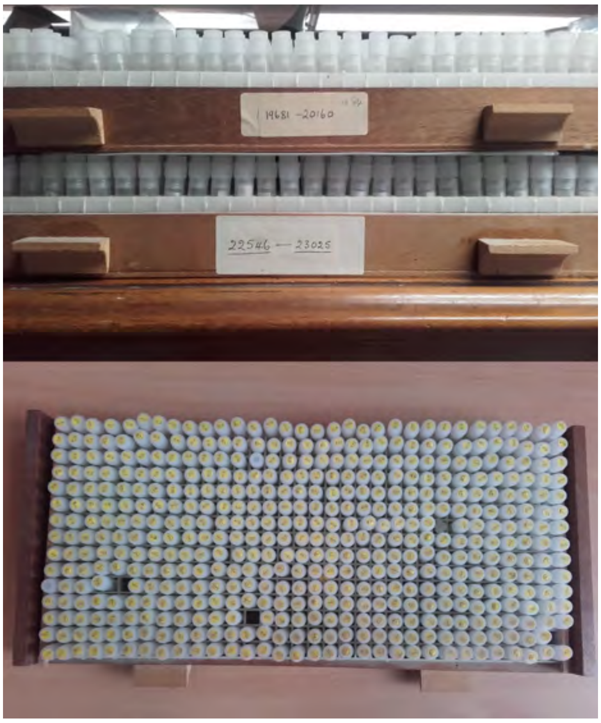


Figure 6. Some of the original drawers in which the Murphy spider collection was housed. Each drawer contains approximately 450 vials.

Making use of the collection

Over the years the collection has been used as reference material for multiple papers and books, including the description of numerous new species. Continuing the work started by Frances Murphy, John Murphy reviewed approximately 4,800 specimens from seven countries (Brunei, Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam) to write the co-authored 'An introduction to the spiders of South East Asia with notes on all the genera' (Murphy and Murphy, 2000). In this book, he also listed the species possibly new to science for the region at hand. The book includes original drawings by Michael Roberts, notes on distribution, characteristics and measurements for spiders recorded up until 1995, and a complete checklist, including some additions for southern China (Murphy and Murphy, 2000).

In a recent book, published in 2015, John Murphy and Michael J. Roberts provided an overview of the spider families of the world, emphasizing the unique structure of their spinnerets. The two-volume text, complete with illustrations and nomenclatural changes, took almost a decade to complete. In the last section, the book includes drawings and descriptions of 36 possible new species to science, encouraging other researchers to provide their formal descriptions.

Since the collection was acquired by Manchester Museum in November 2015, 16 enquiries to study specimens from the Murphy collection have been received from seven countries (including UK). Currently, 911 specimens are on loan to seven countries, including Russia (261 specimens), Israel (172), UK (141) and Germany (139), among others. Furthermore, nearly 1,100 specimens are recorded in the database as loaned (since 1978), before the collection was given to the Manchester Museum. Some examples of publications produced using these loans are 'Portuguese spiders (Araneae): A preliminary checklist' by Cardoso (2000) and the book, 'Forest Spiders of South East Asia: with a Revision of the Sac and Ground Spiders (Araneae: Clubionidae, Corinnidae, Liocranidae, Gnaphosidae, Prodidomidae, and Trochanterriidae)' by Deeleman-Reinhold (2000).

Five papers have been published since November 2015, mainly based on the specimens borrowed from the Murphy spider collection: two papers clarifying the taxonomy of a species using molecular and morphological analyses, including a re-description of type species (Oxford and Bolzern, 2018; Zonstein, Marusik and Magalhães, 2017); two reviews and notes on different genera (Logunov and Azarkina, 2018; Zonstein, 2017); and one on new species records of Gasteracanthinae from Vietnam (Williams, 2017). There are at least two more papers in press and many more in preparation using specimens from the Murphy spider collection. There are more than 16,000 specimens in the Murphy spider collection that have not been fully identified, opening up the possibility for future taxonomic research and publications.

Conclusion

The Murphy spider collection, comprising over 45,400 specimens and associated data, is an invaluable resource for taxonomy, entomology, ecology and many other disciplines. The collection has already provided much material for new species descriptions and taxonomic reviews, underlining the importance of maintaining biological collection in museums. I hope that rehousing the collection at Manchester Museum will encourage arachnologists, both professional and amateur, to use the collection and associated archives more intensively. The collection is fully accessible for anybody willing to study it. For any enquiries, including requests for the collection catalogue, please contact the Curator of Arthropods, Dr Dmitri V. Logunov (dmitri.v.logunov@manchester.ac.uk).

Acknowledgements

Many thanks to the Curator of Arthropods at the Manchester Museum, Dmitri Logunov, for his support and guidance, and the information provided to write up this paper; to Christian Devenish for his advice on the analysis and language editing; to Louise Thomas, Rachel Jennings (editor) and two anonymous reviewers for their helpful comments. Also, thank you to the volunteers for their support with the documentation and recuration of the Murphy spider collection, particularly to the undergraduate university students: Callan Denham, Louis Nicolls, Liam Solomon, Emmy Tokunaga, Robert Tracey and Roksana Wilson.

References

BAS, 2018. *British Arachnology Society*, [online] Available at: <http://britishspiders.org.uk/wiki2015/index.php?title=BAS_Bulletin_and_Newsletter_Articles> [Accessed 30 April 2018].

Breitling, R., 2018. Eric Duffey's Spider Collection in the Manchester Museum – an Update. *The Newsletter British Arachnological Society,* 141, pp.5–9.

Cardoso, P., 2000. Portuguese spiders (Araneae): A preliminary checklist. *Ekológia (Bratislava)*, 19 (3), pp.19–29.

Dankittipakul, P., Joque, R. and Singtripop, T., 2012. Systematics and biogeography of the spider genus *Mallinella* Strand, 1906, with descriptions of new species and new genera from Southeast Asia (Araneae, Zodariidae). *Zootaxa*, 3369, pp.1–327.

Deeleman-Reinhold, C.L. and Deeleman, P.R., 1988. Revision des Dysderinae (Araneae, Dysderidae), les espèces mediterranéennes occidentales exceptées. *Tijdschrift voor Entomologie*, 131, pp.141–269.

Deeleman-Reinhold, C.L., 2000. *Forest Spiders of South East Asia: with a Revision of the Sac and Ground Spiders (Araneae: Clubionidae, Corinnidae, Liocranidae, Gnaphosidae, Prodidomidae, and Trochanterriidae)*. Leiden: Brill.

Dunlop, J., 2013. Award Issued at the 19th International Congress of Arachnology, Taiwan. *The Newsletter British Arachnological Society*, 127, p.10.

GADM, 2018. *Geographic Administrative Division Map (version 2.8)*, [online] Available at: <https://gadm.org/> [Accessed 15/Feb/2018].

Stanney, J.D., 2016. Library News. *The Newsletter British Arachnological Society*, 136, p.10.

Levi, H.W., 1966. The Care of Alcoholic Collections of Small Invertebrates. *Systematic Zoology*, 15(3), pp.183–188.

Logunov, D.V., 2000. A redefinition of the genera *Bianor* Peckham & Peckham, 1885 and *Harmochirus* Simon, 1885, with the establishment of a new genus *Sibianor* gen.n. (Araneae: Salticidae). *Arthropoda Selecta*, 9(4), pp.221–286.

Logunov, D.V., 2011. Eric Duffey's Spider Collection in the Manchester Museum. *The Newsletters British Arachnological Society*, 122, p.8.

Logunov, D.V., 2012. British entomology collections of the Manchester Museum. *Journal of the Lancashire and Cheshire Entomological Society*, 133–134 (2009–2010), pp.20–44.

Logunov, D.V., 2018. Three new spider species of the genus *Miagrammopes* O. Pickard-Cambridge, 1870 (Aranei, Uloboridae) from SE Asia. *Eurasian Journal of Entomology*, 17(4), pp.280-289.

Logunov, D.V. and Merriman, N. (eds.), 2012. *The Manchester Museum: window to the world*. Manchester: The Manchester Museum.

Logunov, D.V. and Azarkina, G.N., 2018. Redefinition and partial revision of the genus *Stenaelurillus* Simon, 1886 (Arachnida, Araneae, Salticidae). *European Journal of Taxonomy*, 430, pp.1–126.

Merrett, P. and Murphy, J.A., 2000. A revised check list of British spiders. *Bulletin of the British Arachnological Society*, 11(9), pp.345–358.

Merrett, P., Russell-Smith, A. and Harvey, P., 2014. A Revised Check List of British Spiders. *Arachnology*, 16(4), pp.134–144.

Murphy, F. and Murphy, J., 1976. Spider Hunting in the United State of America. *The Newsletter British Arachnological Society*, 16, pp.6–8.

Murphy, F. and Murphy, J., 1980. A spider hunting trip to Malaysia and Borneo. *The Newsletter British Arachnological Society*, 28, pp.9–11.

Murphy, F. and Murphy, J., 2000. *An Introduction to the Spiders of South East Asia with notes of all the genera*. Kuala Lumpur: Malaysian Nature Society.

Murphy, J.A., 1994. Brittany, May 1992: An Impersonal View. *The Newsletter British Arachnological Society*, 69, pp.2–4.

Murphy, J.A. 2007. *Gnaphosid genera of the world.* Volume 1 (text) & Volume 2 (plates). Cambridge: British Arachnological Society.

Murphy, J.A. and Roberts, M.J., 2015. *Spider families of the world and their spinnerets*. Volume I & Volume II. York: British Arachnological Society.

Notton, D.G., 2010. Maintaining concentration: A new practical Method for profiling and topping up alcohol-preserved collections. *Collection Forum*, 24, pp.1-27.

Olson, D.M., Dinerstein, E., Wikramanayake, E.D., Burgess, N.D., Powell, G.V.N., Underwood, D'Amico, J.A., Itoua, I., Strand, H.E., Morrison, J.C., Loucks, C.J., Allnutt, T.F., Ricketts, T.H., Kura, Y., Lamoreux, J.F., Wettengel, W.W., Hedao, P. and Kassem, K.R., 2001.Terrestrial Ecoregions of the World: A New Map of Life on Earth. *BioScience*, 51, pp.933–938.

O'Neill, G., 1995. Frances Mary Murphy (1926–1995). *The Newsletter British Arachnological Society*, 74, pp.3–5.

Oxford, G.S. and Bolzern, A., 2018. Molecules v. morphology—is *Eratigena atrica* (Araneae: Agelenidae) one species or three? *Arachnology*, 17(7), pp.337–357.

Platnick, N.I., Ovtsharenko, V.I., and Murphy, J.A., 2001. A review of the ground spider genus *Scotognapha* (Araneae, Gnaphosidae), and its radiation on the Canary and Salvage Islands. *American Museum Novitates*, 3338, pp.1–22.

Simmons, J.E. and Muñoz-Saba, Y. (eds), 2005. *Cuidado, Manejo y Conservación de las Colecciones Biológicas*. Bogotá: Universidad Nacional de Colombia y Conservación Internacional.

Wanless, F.R., 1980. A revision of the spider genera *Asemonea* and *Pandisus* (Araneae: Salticidae). *Bulletin of the British Museum of Natural History (Zoology)*, 39, pp.213–257.

Williams, S.H., 2017. New faunistic records of *Gasteracantha* Sundevall, 1833 and *Macracantha* Simon, 1864 species (Araneae: Araneidae) from Vietnam. *Arthropoda Selecta*, 26(3), pp.249–252.

WSC, 2018. *World Spider Catalog (version 19.0), Natural History Museum Bern*, [online] Available at: <http://wsc.nmbe.ch> [Accessed 15 February 2018].

Zonstein, S.L., 2017. Notes on *Nemesia* and *Iberesia* in the J. Murphy spider collection of the Manchester Museum (Araneae: Nemesiidae). *Israel Journal of Entomology*, 47, pp.141–158.

Zonstein, S.L., Marusik, Y.M., and Magalhães, I.L.F., 2017. *Labahitha* nom.n., a replacement name for *Mystes* Bristowe, 1938, with a redescription of the type species (Aranei: Filistatidae). *Arthropoda Selecta*, 26(4), pp.303–309.

Across the Continents: communicating ecology to schools in Cambridge and Southeast Asia

Sara Steele

Address: University Museum of Zoology, Cambridge, Downing Street, Cambridge, CB2 3EJ, UK

Email: sls72@cam.ac.uk

Received: 23/07/2018

Accepted: 27/10/2018

Citation: Steele, S., 2018. Across the Continents: communicating ecology to schools in Cambridge and Southeast Asia. *Journal of Natural Science Collections,* 6, pp.60-67.

Abstract

Across the Continents is an exciting pioneering project combining expertise within current species conservation research and museum learning. Taking advantage of the planned dissemination outcomes of four well-established NERC-funded projects, the team tested how the newly-renovated University Museum of Zoology could act as a stage for engagement activities and as a source of expertise in communicating with a variety of audiences.

This new way of working seeks to inform future collaborations, with a view to make a case for future grant applications to not only consider the Museum as a source of guidance in public engagement activities, but also as a partner right from the initial application stage through to evaluation and impact measuring. Here I will set out the *Across the Continents* project case study, the lessons learned and successes achieved, and consider why more museums should be seeking to promote their aptitude in sharing the unfamiliar.

Keywords: Collaboration, Research Excellence Framework, engagement, ecology, dissemination, conservation, schools, communication, training

Introduction

Museums across the UK are looking for new sources of funding (Mendoza, 2017) and strategies that will allow them to continue to prioritise critical public-facing work and combat an increased demand for curriculum-focused school visits (Museums Association, 2018).

The University Museum of Zoology is embedded within the University of Cambridge's Department of Zoology and has long had a relationship with the department and its researchers. Much to the Museum's advantage, the students and researchers associated with its curators are based within the museum itself, providing valuable, easy to access, ongoing science. Furthermore, both department and museum are increasingly looking to the Museum team to be the bridge between current research and the public, helping researchers to share their findings to as wide an audience as possible.

In an effort to go beyond displays and exhibitions as a way of reaching these audiences, the *Across the Continents* project took advantage of the dissemination activity aims of four linked Natural Environment Research Council (NERC) El Niño projects. These aims primarily focused on sharing their research methods and findings with non-specialist audiences in a sustainable way. *Across the Continents* had two strands: a 17-day study tour for scientific staff of research stations in Southeast Asia and Oceania; and a museum-led schools communication project, based in the UK and Southeast Asia.

The Projects

The effect of El Niño for much of Southeast Asia and Oceania is drought, with associated risks of fires and crop failures. Drought is predicted to have effects on ecosystem processes spanning across the land-use gradient from primary forests to logged forests and plantations, with the highly diverse forest environment being the most resilient to these effects. The projects all aim to monitor landscape responses to the most recent El Niño event, to inform resilience strategies, and to make a case for the promotion of biodiversity as part of best farming practice to increase resilience to climate events and, thus, yield.

This is especially urgent within a region where the conversion of forest to plantation is rapidly expanding, and much of the biodiversity that is supported by a rainforest landscape is being lost, with further consequences for the region's inhabitants, ranging from a crash in food supply to poor water and air quality.

Study tour

The aims of the *Across the Continents* project were threefold: to disseminate El Niño project findings around research stations in Southeast Asia and cement links between stations; to reduce dependency on support from outside of the region; and, most importantly for what I shall discuss here, to increase the capacity of the participants in communication, both in formal presentations to stakeholders, academic researchers, and industry representatives, and in informal activities for school children.

These aims were met on the ground by a study tour. Local researchers from each of the four projects joined Dr. Amy Eycott and me for 17 days, visiting three of the four project sites in turn. This enabled them to share best practice and to communicate their experiences and findings in the field. They received training in how to present their research methods and findings to different audiences and practiced their new skills on a variety of willing spectators. This included a non-specialist (and non-science) audience, research assistants (who are predominantly employees from the local community), Western researchers, conference audiences, and agricultural industry representatives. The final, and most challenging, audiences for the team were the eagerly waiting classes of school children in Pekanbaru province, Sumatra.

It is worth acknowledging that the dissemination project held an advantageous position from which to begin knowledge-sharing activities, created by the longevity of the four research projects and existing institutional reputations as sources of reliable and unbiased scientific information among the agro-industrial sector in the region. Previous close collaboration with networks such as the Southeast Asia Rainforest research Partnership (SEARRP) and organisers of the International Conference on Oil Palm and the Environment (ICOPE) allowed for existing networks to be utilised when looking for industry representative participants.

The work done through the project also aims to begin combating what is called 'parachute science' (Harris, 2004), where researchers from outside of the region gather their data, formulate their conclusions, but share the results only with their home institutions and communities. By giving local researchers the ability and authority to present on the findings and an understanding of why the data has been collected, and what it has shown us, the current science can be shared much more easily with the very people whose lives and livelihoods are impacted by El Niño events and land use change.

School project

The development of informed learning activities for primary school children began in January 2018 with the utilisation of existing connections between the University Museum of Zoology and Cambridgeshire schools. It was important that the El Niño research projects were shared with our own local communities, as well as those close to the research stations, to ensure that we covered target audience aims for all teams and institutions involved. This Cambridge-based component also provided the team with an audience with which to develop and test resources before taking them to schools in Southeast Asia.

The Museum of Zoology has identified a number of target schools as part of its audience development plan. It was important for the Museum team that the school involved within the project was on this targeted list as they are most likely to benefit from the extra activities and resources, and lead to engaging a new audience with the Museum collections and departmental research. A simple call for interest was sent to target schools, and later conversations with teachers enabled us to narrow the responses down to one that was most suitable, St Luke's Primary school.

As the project progressed, the team worked in partnership with the school's teachers to create a realistic project timetable that could be achieved alongside and within their usual teaching commitments. It was important that the project was manageable for the teachers involved in order to limit the impact of the project on their already busy schedule and prevent communication or commitment drop-off. With this in mind, curriculum themes were considered from the outset of activity design so that the effort of trialling the activities as part of the project would help rather than hinder the school's teaching aims.

In order to gain the most from their participation in the project, our partnership teachers were keen to introduce the project to the entire school cohort, to widen participation within the activities and create a general buzz around the topic of habitat change and biodiversity. Conservation plays a big part in many Key Stage curriculum aims, and getting children excited about the subject can only benefit them as they progress through their schooling (Department for Education, 2013). We began with an introductory creative writing competition, with entries being accepted from the entire school. Children would learn about the challenges that orang-utans face in their wild rainforest home from their teachers, and write an adventure story featuring and naming an orang-utan. The winning story would assign a name to an orang-utan stuffed toy to be featured in later resources.

The school's Year 4 students were to join us for the remainder of the project and were the first to receive the new school session developed as part of the dissemination goals (Figure 1). This session aimed to provide the children with some knowledge of the concepts we would be coming across during the project, and allow us to test our new activities in a 'real-life' environment.

Figure 1. Year 4, St Luke's Primary during museum-led session, February 2018 ©University Museum of Zoology, Cambridge

The session itself included several activities chosen by researcher Dr. Amy Eycott in the early stages of the project: Ecological Jenga, which demonstrates that the more we remove from an ecosystem, the more unstable it becomes, thus promoting the protection of diversity within a habitat; The Habitat Game, an oversized board game which allocated different

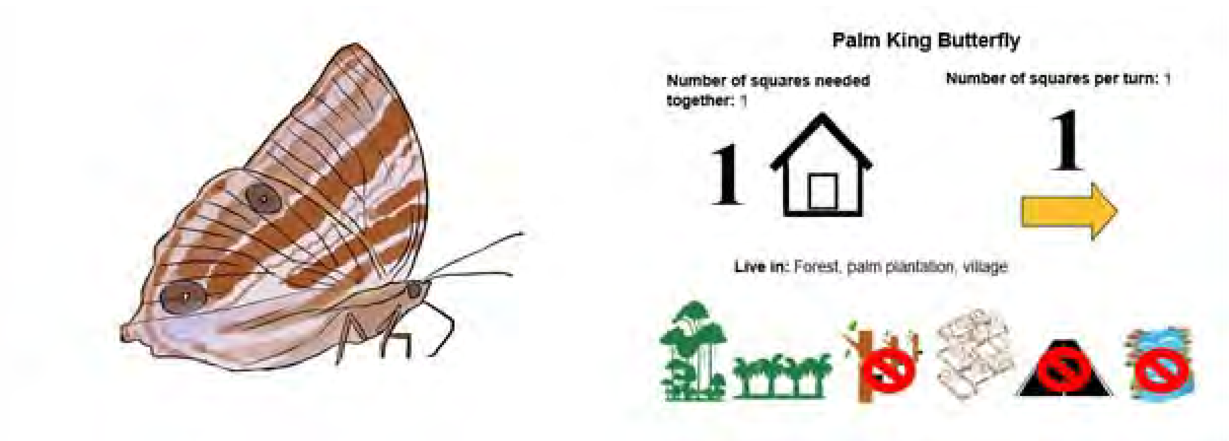


Figure 2. Player animal card for use in habitat game ©University Museum of Zoology, Cambridge

animals to each student player. The habitats would change throughout the game, with each 'animal' being able to survive or thrive depending on their individual movement rules and habitat changes (Figure 2). We finished up by comparing insects from the Museum collection, originating in East Anglia and Southeast Asia, to see how their features compare and considering the reasons behind any similarities or differences.

I found that the students were engaged and very responsive to the activities and the information being shared with them. It was a great learning opportunity for me too, as is any delivery practice using new content. The teacher and I found that the Habitat Game, for example, was attempting to share too many new concepts with students of the age range found in Year 4 (8-9 years), and that each activity would have greater success if completed with fewer children in each group. This experience and feedback was shared with our study tour participants and impacted how further sessions were planned and conducted.

St Luke's Primary would continue their involvement in the project by following the orang-utan toy's journey throughout the study tour, as we travelled to the different habitats covered in our school session, and observing the differences between the research centre sites. By repeating key themes and extending the topic throughout the project, we hoped to cement their understanding and knowledge of the impacts of landscape change and importance of biodiversity.

The children received three videos of our orang-utan toy exploring the field centre sites and thus three different landscapes. These included a rainforest habitat, a landscape going through change, and an oil palm plantation. The videos were shared with the teacher using the Museum's Facebook profile platform (University Museum of Zoology, n.d.), and via Google Drive. The twinned approach ensured that the often-poor Internet connectivity within the research centres, and difficulties with firewalls implemented at schools in the United Kingdom, did not disrupt our sharing schedule. We were also able to keep teachers and the childrens' parents in the loop via an *Across the Continents* blog (Steele, 2018). A further advantage of the blog was that it provided all those involved in the study tour with a sharable diary, further extending the project's reach by creating links between the research, study tour, and schools project in a language that is accessible for a wider audience.

Training in communication

The primary aim for the partner schools in the Southeast Asia region was to improve schoolchildren's awareness of the challenges posed by habitat and land use change, and the importance of forests for supporting biodiversity. School children are the region's future farmers, agriculturalists, land managers, and consumers. Working with children is known to be an effective way of influencing communities as a whole (Vaughan et al., 2003). By sharing these ideas with the community from an early age we hope to have a long-term impact on farming practice in our study regions.

In order for us to achieve sustainability and longevity beyond the study tour, and for the developed school session to have the widest possible scope and impact, it was important that the study tour participants acquired the skills, resources and confidence to deliver the 'habitat change' session in their local schools. We achieved this through two days of intensive training, including a number of activities and tools that many educators will have come across in their own training. We began with an activity that got the group thinking about how they would communicate their projects to anyone with a lower level of formal education or understanding of climate science (Figure 3). We talked in more general terms about how we could share the information that we learn during our research with different audiences, and underlined words that the average person may not have come across before.

Figure 3. School session training activity, March 2018 ©University Museum of Zoology, Cambridge

It was a surprise to some that terms many considered straightforward, such as what we mean by 'water supply', may not be widely understood. We furthered this by taking a look at St Luke's Primary School's creative writing competition entries. By examining the language level used by children of this age, I hoped to prepare the scientists for what to expect from children within their own communities, when speaking their first language. This task was especially useful to demonstrate that not all children of the same age will possess the same level of ability, and that it is important to remember that flexibility is key to any teaching environment.

As the training continued, we covered skills that come naturally to any museum educator. These included pitching information at the correct level for different ages and abilities, understanding how children learn through reinforced words and terms, and ensuring that sessions are made up of both energetic (Figure 4) and calm activities to aid the children's learning and concentration.

Figure 4. Participants playing habitat 'twister' to shake off afternoon fatigue, March 2018 ©University Museum of Zoology, Cambridge

Our final activity required our scientists to create bespoke insect identification worksheets, in the languages spoken in their home communities and with relevant insect species, to be used as part of the session. Inspiration was taken from the worksheets that St Luke's Primary would be using for their own insect collecting activity, produced by the Woodland Trust (Woodland Trust, 2015) and recommended by us at the Museum.

Session delivery

Working in response to experience and feedback from our partner teachers in Cambridge, the 'habitat change' session was adapted to include a rotation of the three activities (Figure 5), concluding with a full class drawing activity. The children were very engaged, despite the excitement of having different people lead their lesson. Our scientists were most surprised at how much the children learned from such simple activities.

"Anati and Austin have reported that the objectives and learning points of the Ecological Jenga game and insect collecting activity were understood and enjoyed by most, if not all of the children. It was believed that changes do not need to be made to these two activities in order to suit this age group, but that practice was an advantage and their confidence in delivering the activity grew as the session progressed." (Eycott and Steele 2018)

Figure 5. Children taking part in ecological jenga and insect collecting and identification activities, March 2018 ©University Museum of Zoology, Cambridge

All of the study tour participants said that they now feel comfortable in delivering these activities to their local schools, but that they would need to enlist the help of the schoolteachers, as they would not have the number of team members that we had during our trial sessions. This would incidentally extend the impact of the session to the teachers, with them being able to deliver some of the activities themselves to further students.

As always, with further delivery practice came further changes that needed to be made to the session. The most notable and immediate change was that with each session, the participants found that the Habitat Game was still attempting to tackle too much for the age group at hand. However, remembering the activities covered as part of the training, they remained flexible and were able to simplify the players' 'movement rules' as the session progressed.

"Ribka and Amy found that by the end of the session, they were able to simplify the game during delivery so that most children understood the wider concepts and learning objectives (i.e. that animals need different habitats to survive, with larger animals also needing more space)." (Eycott and Steele 2018)

They did, however, observe that the older children, watching the game during their break-time, understood the rules and were assisting their younger peers. A game of such scope can be used with a range of ages, something that will be considered when formatting the game as a downloadable teaching resource.

The schools' involvement, both in Cambridge and Sumatra, concluded with observational drawing of the insects they had caught and identified. These drawings were then shared between the schools, in a 'penpal pictures' scheme (Figure 6) to encourage the children to think about the differences and similarities between the two environments, and, most importantly, how habitat change can affect all creatures, no matter where you are.

Embedded evaluation

In order to ensure that thorough evaluation was conducted at every step of the study tour and schools project, I implemented the use of an impact measure or logic model (Arts & Humanities Research Council, n.d.). This ensured that we considered why and how each phase of the project was useful and meaningful, and that we could use each activity to inform the next. The expected consultation with teachers and researchers, and statistics from blog post and video views, were recorded, in addition to feedback forms completed by the students themselves. It is new but now common practice to consult project participants directly, in place of asking a representative such as a teacher to answer in their stead.

Crucially, in order to gain comparable feedback from the children, it was important that all classes completed the same form (Figure 7). An adaptable form, with images to assist with understanding and interest, was created, with our researchers translating the text for our Bahasa-Indonesia speaking schools.

Implications for museum collections

The issues tackled as part of the research projects have strong links to natural science museum collections worldwide. The consequence of a connected, shrinking world, is that we are losing much of the biodiversity represented within our collections. The potential for sharing with and informing audiences on habitat and species conservation is vast, with the results far-reaching. Museums can use their natural history collections and reputations as trusted sources of information to highlight local issues, create relevance and empower contributions. National Museum Scotland have done just that in employing digital resources to highlight Scottish wildcat conservation efforts and how pet owners can contribute to its protection (National Museums Scotland, n.d.)

The *Across the Continents* project will begin by sharing the content created as part of the schools communication project with teachers via the University Museum of Zoology website and social media platforms. Current efforts are looking to create

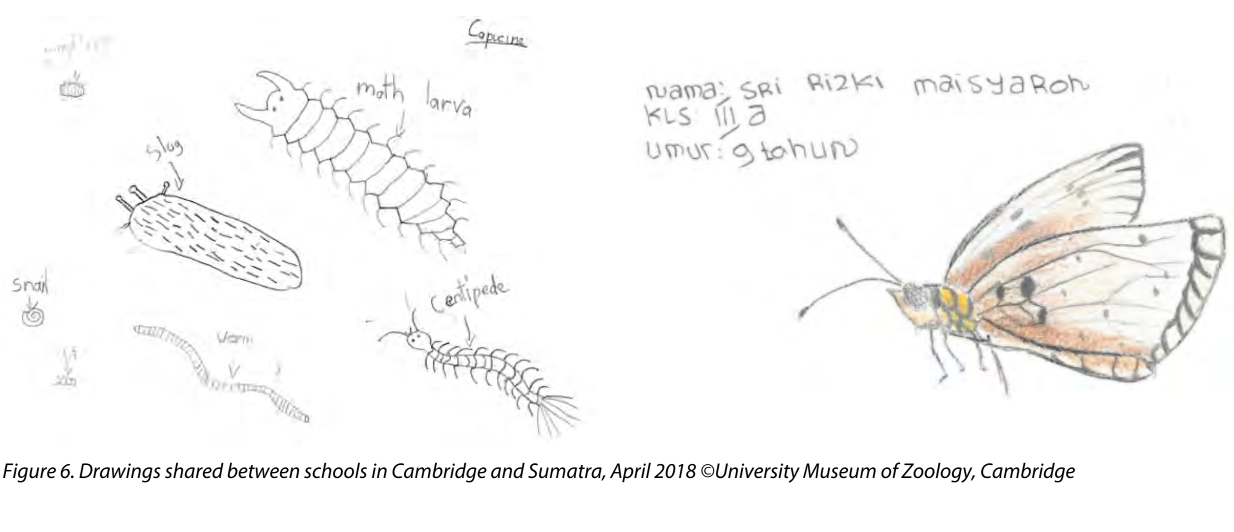


Figure 6. Drawings shared between schools in Cambridge and Sumatra, April 2018 ©University Museum of Zoology, Cambridge

a complete teachers' pack, containing activities, resource sheets, videos, and teaching tips surrounding the topic of habitat change. It is expected to be available in January 2019.

Furthermore, there is great scope to create useful, relatable resources for local schools in the United Kingdom. Moving forward, we hope to link the topics covered in this project with the dissemination goals of a collections-based research project. Funded by Arts Council England, postgraduate students and researchers are exploring what we can learn about habitat and land use change from insects collected by Leonard Jenyns in the then-wet fenlands of 1829. Combining the two projects will not only extend the reach of each dissemination activity, but also hopes to create relatable links between communities that are so easily considered to be worlds apart, promoting equality in diversity.

The University Museum of Zoology benefits greatly in collaborating with researchers on their dissemination activities and the public engagement team is using the current, relevant science to inform and create exciting new sessions, events, and resources. Museum collections, especially in natural science, are incredibly and increasingly important for research and are already constantly utilised by students, researchers, and curators. By using and speaking to researchers in a language that translates directly to the Research Excellence Framework impact measures (Nature, 2015), museums open up a gateway to potential funding and collaboration opportunities.

Conclusions: looking to the future

As a museum learning professional, being involved in the dissemination project has definitely had its benefits. I have been able to learn about, connect with, and grow as passionate about our insect collection as the researchers who study it. I have created working relationships that continue to benefit and inform my day-to-day working practice, and am now building on this experience to convince researchers that the Museum team holds the tools they need to produce beneficial resources for wider audiences. Indeed, consultation with researchers developing the *SciEd network* based in Germany is already leading to the publishing of advice for students wanting to share their research in new, innovative ways (SciEd, 2018).

While the real delivery and evaluation is still ongoing, the participants of the study tour are our biggest legacy. They have gained the confidence and skills to present their work and deliver school sessions across Southeast Asia, and to the communities that can directly benefit from the research outcomes.

The advice I would give, and the conclusions I would draw from the project, now that *Across the Continents* is reaching the end of its implementation phase, are threefold:

Where possible, be involved from the beginning. It is not unusual to find that dissemination activities are left until the end of a research grant period, with panic-stricken colleagues seeking quick evaluation outcomes. Implementing any kind of activity with external audiences takes time and consideration in order to be completed with the best possible results, and I will certainly be using this project as an example of how the Museum team can achieve real results when given the time and resources to do so.

Empower researchers to deliver the activities alongside you. I found that asking colleagues and

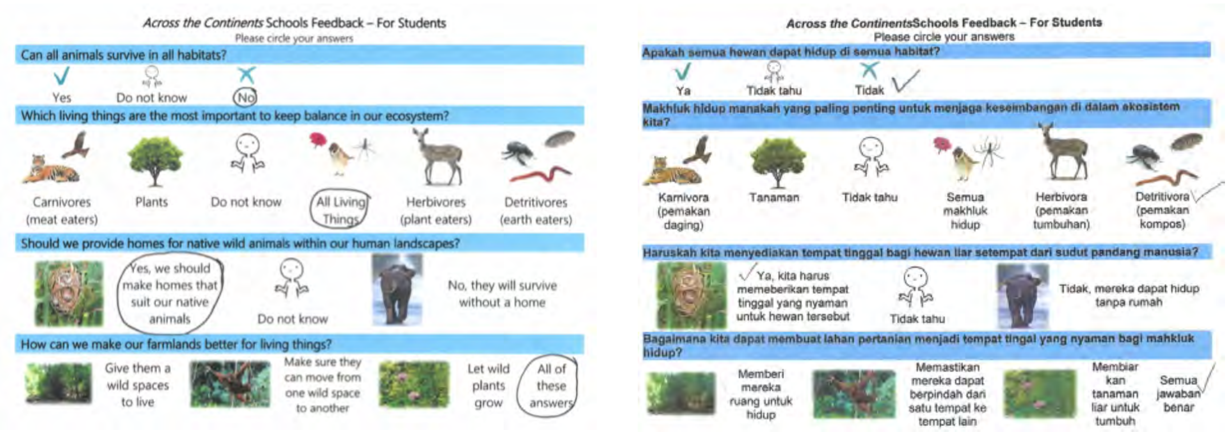


Figure 7. Completed feedback forms from schoolchildren, May 2018

researchers to join in with at least some of the dissemination activity delivery was the most effective way of creating a convincing argument for collaboration, in addition to encouraging them to share their passion for the research they are undertaking with others.

Lastly, and most importantly, make it easy. When working with school teachers, we have found that using keywords, providing ready-made, curriculum-linked content is the best way to get these time-poor professionals and their class into a museum. Researchers can also be time-poor, with pressures on fieldwork and data analysis often overshadowing the project's dissemination goals. By using the same keywords, measurement strategies, and evidence output that is required of researchers when reporting their impact, we make working together the obvious choice.

Acknowledgements

Dr. Amy Eycott, Dr. Edgar Turner, Natural Environment Research Council (NERC), Isaac Newton Trust Cambridge, Sinar Mas Agri Resources and Technology, University of Cambridge, Study tour participants: Catherine Waite, Sui Peng Heon, Anati Sawang, Ribka Sionita Tarigan, Andreas Dwi Advento, Jason Paliau, Austin Sau.

References

Museums Association, 2018. *Museums in the UK 2018 report, February 2018.* [online] Available at: <https://www.museumsassociation.org/download?id=1244881> [Accessed 7 July 2018].

Harris, E., 2004. *Building Scientific Capacity in Developing* Countries. EMBO Reports 5.1 (2004): 7–11. [online] Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1298969/> [Accessed 7 July 2018].

Department for Education, 2013. *Science Programmes of Study: Key Stages 1 and 2. National Curriculum in England.* Ref: DFE-00182-2013. [online] Available at:<https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/425618/PRIMARY_national_curriculum_-_Science.pdf> [Accessed 8 July 2018].

University Museum of Zoology, n.d. *University Museum of Zoology Facebook page*. [online] Available at: <https://www.facebook.com/ZoologyMuseumCambridge/> [Accessed 8 July 2018].

Steele, S., 2018. *Across the Continents Project Fieldwork Adventures blog, 18th February*. [online] Available at:<https://fieldworkadventures.wordpress.com/2018/02/18/across-the-continents-project/> [Accessed 8 July 2018].

Woodland Trust, 2015. *Nature Detectives Activities.* [online] Available at: <https://www.nature.com/nature/supplements/collections/npgpublications/impact/hefce1.pdf> [Accessed 5 July 2018].

Vaughan C., Gack, J., Solorazano, H., and Ray, R., 2003. The Effect of Environmental Education on Schoolchildren, Their Parents, and Community Members: A Study of Intergenerational and Intercommunity Learning. *The Journal of Environmental Education*, 34(3), pp.12-21.

Eycott, A. and Steele, S., 2018. *Biodiversity School Session Delivery Feedback*. [unpublished report].

Arts & Humanities Research Council, n.d. *Logic Models for programme planning and evaluation,* [online] Available at: <https://ahrc.ukri.org/funding/resources-for-researchers/selfevaluation/> [Accessed 11 April 2018].

Mendoza, N., 2017. *The Mendoza Review: an independent review of museums in England,* [online] Available at: <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/673935/The_Mendoza_Review_an_independent_review_of_museums_in_England.pdf> [Accessed 21 November 2018].

National Museums Scotland, n.d. *Explore our Collections: Scottish wildcat*. [online] Available at: <https://www.nms.ac.uk/scottishwildcat> [Accessed 10 November 2018].

Nature, 2015. *REF2014 Impact Case Studies.* [online] Available at: <https://www.nature.com/collections/bsrqmdyyjr> [Accessed 6 July 2018].

SciEd, 2018. *Reconnecting children to nature through multi-cultural collaboration – new insights. Blog of SciEd, 28th May 2018*. Available at: <https://networkscied.wordpress.com/blog-of-scied/> [Accessed 6 July 2018].

Movers, not shakers: challenges and solutions for relocating an entomology collection

Ana E. Herrero[1,2], Kim Chandler[1,3], and Paolo Viscardi[1]*

Address: [1] National Museum of Ireland - Natural History, Merrion Square West, Dublin 2, D02 F627, Ireland

[2] University College Dublin, Belfield Downs, Dublin, D14 YH57, Ireland

[3] Trinity College Dublin, the University of Dublin, College Green, Dublin 2, D02 PN40, Ireland

**Corresponding author: pviscardi@museum.ie*

Received: 28/08/2018

Accepted: 27/10/2018

Citation: Herrero, A.E., Chandler, K, and Viscardi, P., 2018. Movers, not shakers: challenges and solutions for relocating an entomology collection. *Journal of Natural Science Collections,* 6, pp.68-78.

Abstract

Collections moves can pose significant challenges for the care and conservation of the objects contained therein, but they also offer opportunities to improve conditions. Here we discuss our experiences of dealing with the movement of approximately 1 million dry entomological specimens held by the National Museum of Ireland – Natural History from an historic building to a modern offsite location. Protocols for the movement of specimens were devised, implemented, reviewed and improved upon in an effort to minimise the impact of agents of deterioration during the move. We raise concerns about the use of very low temperatures when treating entomology collections for pests, and conclude with recommendations on freezing protocols for Plastazote®-lined entomology drawers and carded specimens.

Keywords: IPM, integrated pest management, collections moves, entomology, protocols, freezing, insect cabinets, insect boxes, pesticide

Introduction

The National Museum of Ireland – Natural History (NMINH) has a globally significant entomology collection, with over a million specimens including thousands of scientifically and historically important figured and type specimens. For over 150 years, this collection has been housed behind the scenes in the NMINH exhibition building on Merrion Street in central Dublin (also known as the 'Dead Zoo' by locals). As part of an ongoing move of stored collections to an offsite Collections Resource Centre (CRC), and with a timetable determined by a major national development plan (Project Ireland 2040, 2018) in which the Dead Zoo is due to have a roof replacement and extension building, the dry insect collections needed to be relocated. Moving objects carries inherent risks (Waller, 1995), but it can also provide opportunities to improve collections management and address existing problems (Hall, 2012). Here we discuss the challenges faced during the move, the solutions we came up with, and the lessons learned from the process.

Challenges

Collections storage

The dry entomology collection was stored in 134 standard 10-drawer Hills-type cabinets, 41 historic cabinets ranging in capacity from 6 to 60 drawers (most with 30), and 650 insect boxes. The cabinets were stacked two or three units high in two densely packed rooms in the upper floors of the building, creating a crowded space that was difficult to access (see Figure 1). The largest room was at the very top of the building, open to the glass ceiling and roof and prone to large environmental fluctuations as it received significant solar gain during the day, especially during the summer, and extremely cold conditions during the winter (Monaghan, 2004). These diurnal and seasonal fluctuations in temperature and humidity caused the wooden furniture, drawers, and boxes housing the collection to warp and split, and the cork pinning substrate in historic drawers and boxes to shrink, posing a challenge for storage following the move. The second room was a better space for collections, located a floor below and therefore somewhat buffered from more extreme changes in climate.

Physical logistics

It was a significant challenge working within the physical constraints imposed by an historic building. The lack of lifts, old stairs, uneven floors, and the restricted exit (84cm wide, with a steep ramp) that was only accessible by passing through a public space, made moving the collection difficult. Access to the private road adjacent to the building, that leads on to the public highway, is also extremely limited since it is located within the security cordon for the Houses of the Oireachtas (Irish government buildings).

The furniture housing the collection was heavy due to the solid wood and glass construction (e.g. a 10-drawer Hills-type cabinet weighs around 56 kg), but it was also fragile due to damage caused by the poor environment. Desiccated cork in old drawers meant that many of the pinned specimens had become loose, and so drawers had to be kept level when carried. The insect boxes had similar issues with shrinkage, but it was more difficult to assess and monitor as they were sealed in plastic bags. These factors combined to exacerbate issues with manual handling.

Pest management

In the top floor room, various insect pests were able to access the collections from the roof void, including psocid booklice, *Reesa vespulae* (Milliron, 1939) and *Tineola bisselliella* (Hummel, 1823) (see Figure 2). The second room was a better space for collections, with reduced access for pests, although the presence of small numbers of *T. bisselliella* did become apparent during the move. One of the main challenges we faced in moving these collections was therefore avoiding transfer of insect pests to the CRC site.

Residual pesticides

Historic pest management for the insect collection in the NMINH relied on three main approaches: barriers, repellents, and active treatments. The barriers comprised plastic bags or flypaper and sticky plastic strips pinned around cabinets, leaving sticky residues that were a minor inconvenience to remove. Repellents included naphthalene and paradichlorobenzene, which impregnated the furniture with a pervasive sublimate that readily vaporises, causing respiratory irritation at low concentrations (National Pesticide Information

Figure 1. The top floor insect room in the NMINH Merrion Street building. Image © Paolo Viscardi, 2018

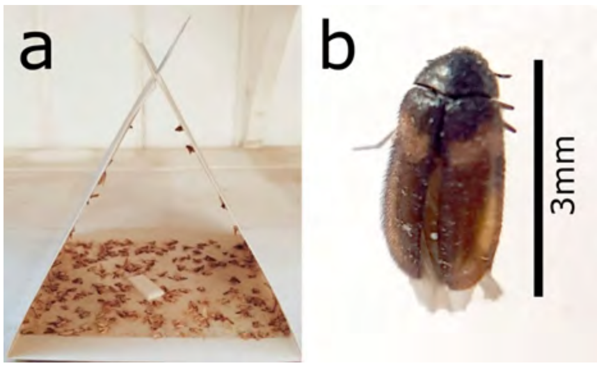


Figure 2. a) sticky trap with pheromone lure from top floor insect room containing T. bisselliella; b) specimen of Reesa vespulae found in the entomology room. Images © Paolo Viscardi, 2018

Center, 2010a; National Pesticide Information Centre, 2010b) and damage to microscope slides (Flanagan, White and Viscardi, 2018). The air quality in the room was tested on 3rd July 2013 and found to have naphthalene levels of <0.01 parts per million (ppm), well below the Occupational Exposure Limit of 10ppm (Dromgoole, 2013). As such, respiratory equipment was not deemed necessary when working in the space, although it was available if wanted. No naphthalene crystals remained in the drawers due to either prior removal or sublimation, but nitrile gloves were used when handling drawers. Active treatment with various insecticides had no doubt been in use in the past, but the most obvious was Vapona™, a brand of dichlorvos (2,2-dichlorovinyl dimethyl phosphate, also known as DDVP) dispersed from a yellow polyvinylchloride resin strip. While Vapona™ could be cut into appropriately sized blocks (Goldberg, 1996; Richter and Corcoran, 1997), it was often applied excessively in collections (Ryckman, 1969) and this was true at the NMINH (see Figure 3). Dichlorvos was banned for agricultural use in the EU in 1998 (PAN, 2008), but stockpiled supplies continued to be used in museums for many years afterwards, despite it interfering with the extraction and amplification of DNA from specimens (Espeland et al., 2010). We discovered large amounts of Vapona in parts of the NMINH insect collection, causing staining of wood, leaving residues on glass and putty, and discolouring and warping acetate mounts with specimens attached (Figure 3).

Staffing

In order to conduct the move it was essential to train a team of people physically able to carry several thousand drawers and hundreds of cabinets down multiple flights of stairs, without damaging themselves or the specimens. The NMINH has a long history of chronic understaffing (Moriarty et al., 2005) and at the time of the move the Keeper and two Assistant Keepers were the only staff in the Division. The insect move had to happen alongside normal day-to-day duties and other projects in the NMINH, including the ongoing moves of other parts of the NMINH collections.

Solutions

Staffing

In order to accommodate a move of this scale alongside a heavy workload, and to keep the physical demands of each move within reasonable limits, the project was broken into 11 moves over the course of

Figure 3. a) Large block of Vapona found in a drawer during move – note beads of fluid on the surface of the block – presumably from the breakdown of the polyvinylchloride strip; b) lid of the drawer in contact with the Vapona block – note staining of wood, reaction with putty and residue on glass; c) drawer with Vapona removed – note staining of wood and discolouration of acetate mounts; d) deformation of acetate insect mounts in close proximity to Vapona block. Images © Paolo Viscardi, 2018

a year. The Assistant Keeper for Zoology and Entomology (author PV) planned and managed the moves, facilitated by volunteers (authors AEH and KC and others mentioned in the Acknowledgements below) who played an active role in preparing sections of the collection for each move and packing the drawers on move days. To undertake the physical carrying and road transport of the collection, contracted movers William Tracey & Sons were used, a company with extensive experience of transporting objects for the National Museum of Ireland (NMI) with their own in-house Manual Handling training. Registration and security staff based at the CRC played an important role in providing access, coordinating contractors, and managing freezing protocols. The team involved in the moves received instructions in advance and the curator showed the contents of representative drawers prior to each move to explain the issues posed by particular types of specimens. The importance of minimising shocks and shakes during transport was emphasised and reinforced during moves, and all members of the moving team were instructed on how to minimise risks to themselves by using appropriate lifting techniques.

Physical logistics

When devising a moving protocol, we considered techniques implemented by other museums for moving insect collections, such as use of steel roll cages with Plastazote® cushioning between drawers and polyethylene wrap around the cage (Nicholls, 2017). However, the lack of lifts, level floors, or suitable doorways meant that wheeled solutions were impractical. Instead, we opted to use plastic crates with internal padding. For insect boxes we used our standard 80 litre (710mm x 360mm x 460mm) crates, but the insect drawers were too large so we selected 165 litre (745mm x 545mm x 425mm) crates normally used for moving computer equipment.

The smaller crates could be packed with bagged insect boxes in the insect storage room and hand-carried down the stairs, but the drawers were too large and heavy to move in this manner. Instead, they were hand-carried down the stairs by the movers, no more than three at a time (depending on the contents as assessed by the curator), and placed on tables (Figure 4a-c) for volunteers to transfer into the large crates. The crates had a 30 mm Plastazote® base layer, and a 10 mm-thick Plastazote® sheet (with a small pre-cut notch at each end) was added between each drawer to protect the glass (Figure 4d-e). Each crate was loaded with five drawers, before two 30 mm-thick Plastazote® strips were pushed vertically through the pre-cut notches in the stack of Plastazote® sheets to brace everything in position (see Figure 4f), and the crates closed.

Initially, each drawer had been sealed in polyethylene before the move, but issues arising from this (see below) led us to change our approach and the filled crates were instead covered with premade polyethylene lids, which were secured in place using polyethylene film (Figure 4g). The crates were carefully hand-carried out of the building between two contractors, loaded using a tail-lift into a truck with an air-ride suspension system (Figure 4h), and transported by road to the CRC where they were transferred directly into walk-in freezers for pest control (Figure 4i), using the freezing protocols discussed below. This process could only take place on Mondays, when Merrion Street was closed to the public and Dáil Éireann was not in session. Only a limited number of crates were available and so they were reused, meaning that the drawers had to be unloaded onto longspan shelving at the CRC (Figure 4j-k) and the crates transported back to Merrion Street for each subsequent move.

Collections storage

The CRC is an ex-electronics factory with an area of approximately 20,000 m^2, intended to house the reserve collections for all of the curatorial divisions of the NMI without relying on compression storage. The building has significant benefits when compared to the Merrion Street building: the light levels are tightly controlled, temperature and humidity fluctuate less, it is better sealed against pests, and it has zones with air handling. It also has loading bays equipped with large walk-in freezers for pest control, wide corridors and doorways, and it is built on a single storey, with no stairs or changes in level, all of which facilitates movement of collections.

The collections storage furniture used in the CRC is preferentially powdercoated or galvanised steel, in order to reduce fire risk and minimise issues with off-gassing. For storage of the entomology dry collection, there was some compromise required on this point, since the entire collection was pinned in wooden drawers and boxes and there was insufficient skilled staff available to re-pin specimens into more appropriate containers such as unit trays (Lane, 2011). We assessed the furniture and concluded that the more recent Hills-type cabinets were in good enough condition to retain, but the more historic furniture

Figure 4. Process of moving collections – see text for explanation. Images © Nigel Monaghan, 2018

was unfit for purpose due to warping and cracking of the wooden cabinet carcasses. To keep cabinets, drawers, and boxes off the ground in case of flooding and to reduce access for pests, we used steel longspan shelving. This was to permanently support the Hills-type cabinets and provide temporary storage for the historic drawers and boxes while 15 bespoke steel cabinets (with capacity for 900 drawers) were commissioned from metal fabricators Flexitech Ltd. (see Figure 5 for units and Appendix 1 for the specifications and design).

Residual pesticides

To reduce risks to human health and limit damage to the collections from volatile repellents and pesticides, the room allocated for the insect collection at the CRC had its own air extraction system, creating a small negative pressure in the room to minimise dispersal of vapour. Historic repellents or pesticides were removed prior to the collections moves by the curator wearing appropriate PPE, and sealed in plastic for later chemical disposal. The new cabinets also provided a mechanism for containing naphthalene and paradichlorobenzene vapours emitted by historic drawers.

Pest management

As part of the NMI integrated pest management (IPM) approach, all moves into the CRC follow a strict quarantine procedure. Objects unsuitable for freezing undergo a confinement process in a holding area, where they are cleaned, securely wrapped in polyethylene sheeting, and inspected after an isolation period of several months (actual duration dependent on conditions) to ensure they are pest-free before entering the main CRC collections areas. Objects that can be safely frozen are kept at -30^{0}C for at least 72 hours prior to entry to the building (although see below). When freezing objects, they should be sealed in plastic in order to prevent damage from changing humidity, condensation, frost formation and meltwater (Florian, 1990; Pinniger and Harmon, 1999). Our initial approach was to bag individual drawers prior to the moves, using polyethylene tubing and a heat sealer. This method had the advantage of being fast and allowing signs of existing damage in the drawers to be marked up on the polyethylene using a permanent pen, making it possible to assess subsequent damage occurring as a result of the move.

Figure 5. a) Hills-type cabinets on steel longspan shelving; b) bespoke steel furniture, with gaskets and compression locks for housing historic entomology drawers and boxes. Images © Paolo Viscardi, 2018

It became clear after the first move that specimens in some drawers saw significant damage, including detachment of carded specimens and loss of wings, legs, and antennae in directly pinned specimens – in some cases, even the internal wooden beading of the drawer was displaced (Figure 6). This damage was at first thought to be the result of vibration, but closer inspection revealed bent pins that could not be caused simply by vibration. We noted that this damage only occurred in drawers from Hills-type cabinets and, after consideration, we deduced that the contraction of the air volume inside the sealed drawers during freezing at -30^{0}C caused a partial vacuum that displaced beading and lifted the Plastazote® lining of the drawer, pushing the pins against the glass lid.

We tested this by using Blu Tack™ and pins to replicate specimens in a drawer, bagging it and using a vacuum cleaner to remove air. The Plastazote® lifted, pushing pins in the centre of the drawer against the lid where they bent and rotated, resulting in similar damage to that seen in the Hills drawers (Figure 7). A second experiment tested bagged drawers frozen at -18^{0}C and -30^{0}C. We found no signs of damage in the drawer frozen at -18^{0}C, but flattening of the Blu Tack and bending of pins in the drawer frozen at -30^{0}C indicated that the Plastazote® was pushing the pins against the glass. It seems likely that sealing the drawers using a heat sealer created conditions that allowed the vacuum to form at very low temperatures.

We also considered the failure of adhesive in carded specimens to be due to freezing at temperatures below those recommended in some early literature, which suggests -20^{0}C (Florian, 1990). Freezing can affect the thermoplastic properties of adhesives, causing them to "unlace" (Moore, 2007) – this was seen most often where a large amount of adhesive (probably Seccotine fish glue) had been used to attach a specimen to a card. To solve these issues, we raised the freezing temperature to -18^{0}C and extended the freezing cycle to four weeks. This allowed a minimum of two weeks at the necessary temperature to kill any pests (Florian, 1990; Pinniger and Harmon, 1999; Strang, 1992), while factoring in the time taken to fully cool down and warm up at the start and end of the process. By adapting the approach to wrapping crates for freezing (as shown in Figure 4g-i) rather than the individual drawers as we did at first, we lessened the risk of a vacuum forming and significantly reduced the time and materials used to prepare each load for transport.

Figure 6. Damage to specimens and beading in Hills-type drawer and specimen detached from card in historic drawer. Images © Paolo Viscardi, 2018

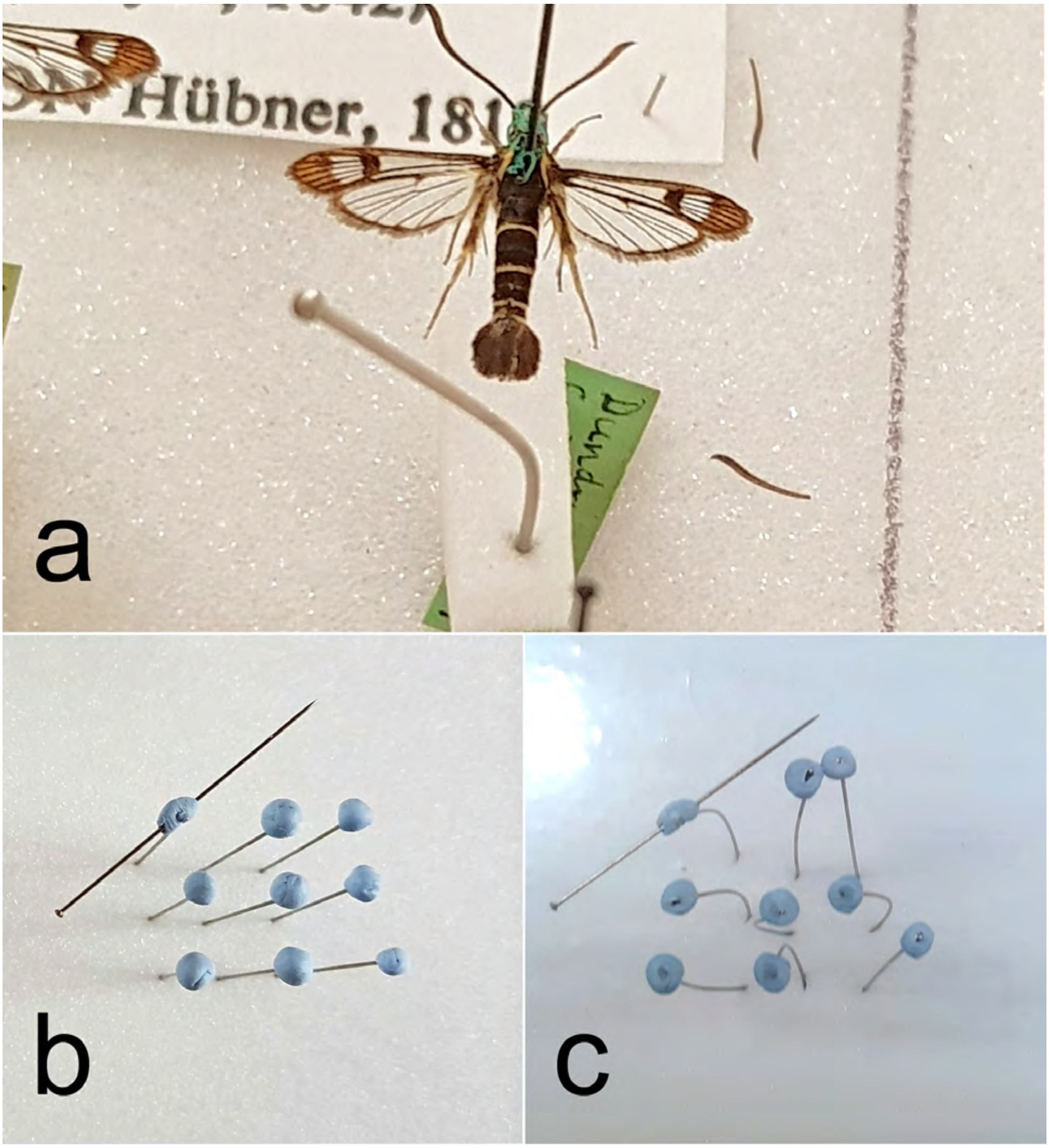


Figure 7. a) Example of pin bent during freezing process; b-c) experimental set-up using Blu Tack on pins to investigate cause of pin bending with b) prior to experiment and c) during experiment. Images © Paolo Viscardi, 2018

Lessons learned

Clear communication is essential during collections moves. We found that when communication failed, logistical problems tended to occur that increased the potential for risk to the objects – such as drawers continuing to be carried down stairs after the supply of crates had run out, meaning that the remaining drawers had to be carried back up the stairs, doubling their handling. Having a single person in charge of the process, ensuring that everyone knew what was expected and how the move was progressing, was vital.

Learning from the experience of other museum staff involved in similar moves was valuable, but it was important to tailor the lessons learned to the specific challenges of our physical spaces and resources. This sometimes meant that compromises had to be made, with best solutions not necessarily being practicable and good-enough solutions being adopted. For example, re-pinning specimens from old drawers into unit trays would be preferred, but lack of staff resources meant that transferring old drawers into new cabinets was the best available solution.

Collections moves offer significant long-term improvements in storage conditions, but they do present risks. Despite freezing being widely accepted as a suitable mechanism for controlling pests in entomology collections, it is important to note that freezing at temperatures significantly below -20^{0}C can cause problems. Besides the issue with low air pressure causing Plastazote® to lift in drawers tightly sealed with plastic, some specimens also dissociated from the cards to which they were attached, due to failure of adhesives at very low temperatures. However, after changing our freezing protocol we encountered no further problems with damage to specimens or their detachment during the move. Our experiences demonstrate the value of monitoring specimens for damage during a move and highlight the importance of changing protocols when they prove to be unfit for purpose.

Acknowledgements

We would very much like to thank the volunteers who were involved in the collections moves: Aisling Brennan, Charlotte Busch, Lyndsey Flanagan, Maximilian Fursman, Megan Gallagher, Casey Patmore, Alacoque White. We would also like to thank the team at William Tracey & Sons for enduring most of the physical work involved in the moves and the NMI staff based at the CRC and at the NMINH for their support. We would also like to thank the team at Flexitech Ltd., particularly Mindas Petrosius, for their knowledge, guidance, and support in designing our new insect cabinets. Finally, we would like to thank Melissa Viscardi and the anonymous reviewers for their helpful comments on this manuscript.

References

Dromgoole, N., 2013. *Occupational Exposure Monitoring Natural History Museum, Merrion Street, Dublin 2*. Airmid healthgroup limited, unique report number 1272b.

Espeland, M., Irestedt, M., Johanson, K.A., Akerlund, M., Bergh, J.E., and Källersjö, M., 2010. Dichlorvos exposure impedes extraction and amplification of DNA from insects in museum collections. *Frontiers in Zoology*, 7(2), pp.1-7.

Flanagan, L., White, A., and Viscardi, P., 2018. Clean and Constrain: a pest management protocol and an overview of some collections management considerations for microscope slide collections. *Journal of Natural Science Collections,* 6, pp.TBC.

Florian, M. L., 1990. The effects of freezing and freeze-drying on natural history specimens. *Collection Forum,* 6, pp.45–52.

Goldberg, L., 1996. A history of pest control measures in the anthropology collections, National Museum of Natural History, Smithsonian Institution. *Journal of the American Institute for Conservation,* 35(1), pp.23-43.

Hall, G., 2012. Collections moves at Leicestershire Museums' Natural Life Collections: practical hints and the importance of volunteers. *NatSCA News,* 23, pp.50-58.

Lane, S., 2011. Re-organising the Coleoptera Collection at Leicestershire County Council Service. *NatSCA News,* 21, pp.75-88.

Monaghan, N., 2004. Victorian Natural History Galleries in the 21st Century - Keeping a Victorian Gallery Alive. *NatSCA News,* 3, pp.26-28.

Moore, S., 2007. Overview of the NatSCA Biochemistry Seminar. *NatSCA News,* 11, pp.25-27.

Moriarty, C., Myers, A.A., Andrew, T., Bolger, T., Breen, J., and Parkes, M.A., 2005. *The Natural History Museum – Present status and future needs.* Dublin: Royal Irish Academy.

National Pesticide Information Center, 2010a. *Naphthalene General Fact Sheet*. Oregon State University and the U.S. Environmental Protection Agency (U.S. EPA, cooperative agreement # X8-

83458501) [online] Available at: <http://npic.orst.edu/factsheets/naphgen.pdf> [Accessed 22 August 2018].

National Pesticide Information Centre, 2010b. *Paradichlorobenzene General Fact Sheet*. Oregon State University and the U.S. Environmental Protection Agency (U.S. EPA, cooperative agreement # X8-83458501) [online] Available at: <http://npic.orst.edu/factsheets/PDBgen.pdf> [Accessed 22 August 2018].

Nicholls, E.-L., 2017. *Horniman Museum moves – coping with short notice*. The 44th AGM of the Geological Curators Group - Making the most of a move. Dublin.

PAN, P. A. N., 2008. *Which pesticides are banned in Europe?*, [online] Available at: <https://www.pan-europe.info/old/Resources/Links/Banned_in_the_EU.pdf> [Accessed 25 July 2018].

Pinniger, D. and Harmon, J., 1999. Pest management, prevention and control. In: Carter, D., and Walker, A.K. (eds), 1999. *Care and Conservation of Natural History Collections.* Oxford: Butterworth Heinemann, pp.152-176.

Project Ireland 2040, 2018. *National development plan 2018-2027*. Government of Ireland, p.71, [online] Available at: <https://www.per.gov.ie/wp-content/uploads/NDP-strategy-2018-2027_WEB.pdf> [Accessed 25 July 2018].

Richter, P. and Corcoran, J., 1997. *Toxicological profile for dichlorvos*. Agency for Toxic Substances and Disease Registry: U.S. Department of Health and Human Services, 248pp, [online] Available at: <http://www.bvsde.paho.org/bvsapud/i/fulltext/profile/dichlorvos.pdf> [Accessed 25 July 2018].

Ryckman, R.E., 1969. Vapona for the control of museum pests. *Journal of Medical Entomology*, 6(1), p.98.

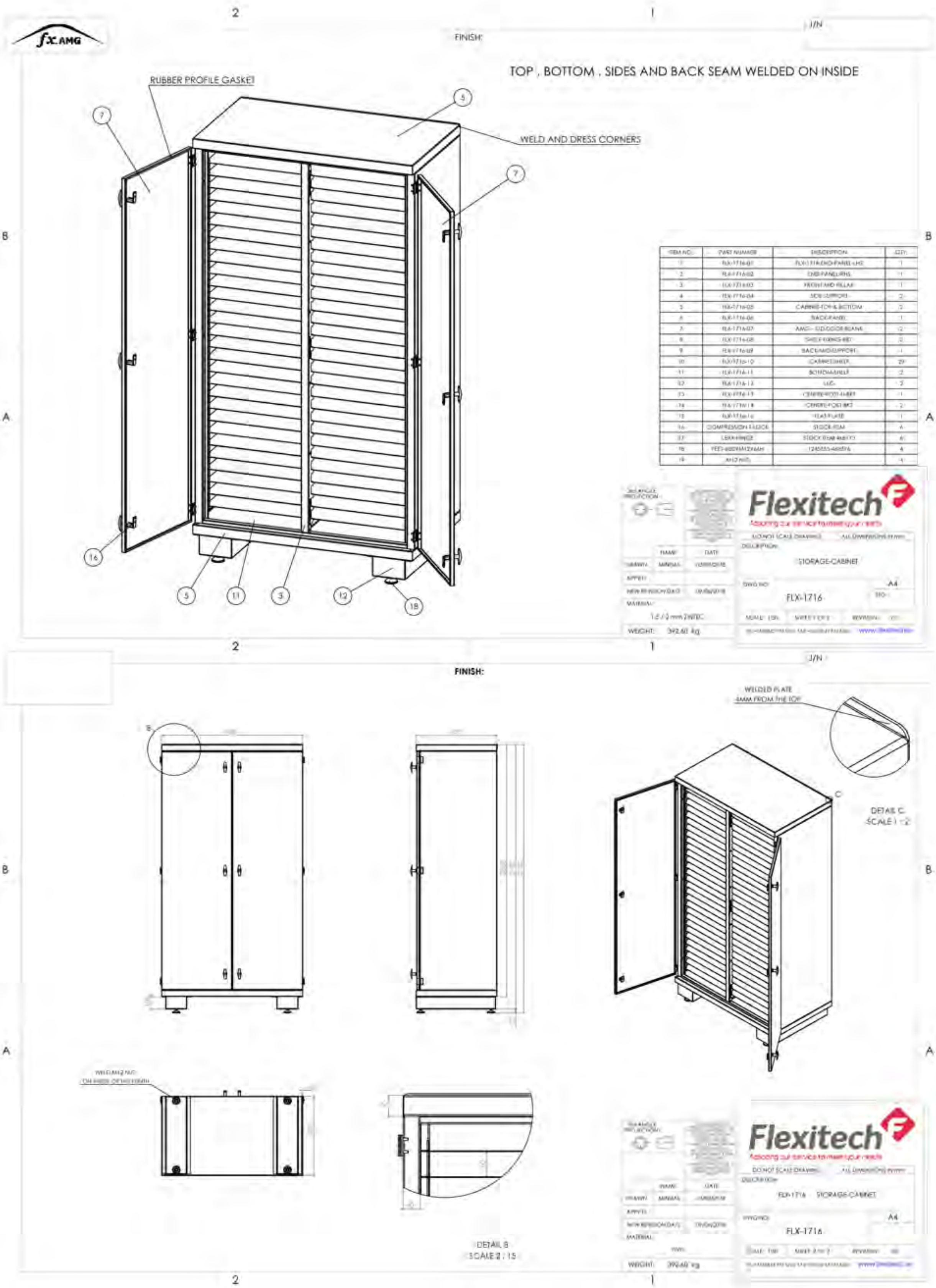
Strang, T.J.K., 1992. A Review of Published Temperatures for the Control of Pest Insects in Museums. *Collection Forum*, 8(2), pp.41-67.

Waller, R.R., 1995. Storage of natural history collections: a preventive conservation approach. In: Rose, C.L., Hawks, C.A., and Genoways, H.H. (eds), 1995. *Storage of natural history collections: a preventive conservation approach.* Pittsburg, Pa: SPNHC, pp.21-27.

Appendix 1. Specifications for insect cabinets

The specification for the cabinets was as follows:

- Powder coated 1.5 / 2mm Zintec (mild steel with zinc incorporated using electrolysis);
- Seam-welded on five sides to ensure a secure seal;
- Double doors with three compression locks and gaskets around the internal frame to reduce the risk of pests getting inside, or volatile compounds from the historic drawers escaping.
- 1100mm wide (to take widest drawers or two, or three Historic drawers side-by-side, depending on their dimensions) x 630mm deep (to accommodate deepest historic drawer) x 2102mm high (to maximise vertical storage space while still fitting through internal doors when on a pallet truck);
- Internal Zintec shelves spaced 60mm apart (to accommodate most historic drawer heights) with removable front brace to allow shelves to be removed to accommodate oversize drawers and insect boxes);
- Two 100mm raised box supports with space between to allow movement using a pallet truck;
- Adjustable feet to enable levelling of the cabinet once in situ;
- 4mm lip at back of top of unit to act as a stop for empty insect boxes stored on the top of the cabinets.



Appendix 1. Plans for steel cabinet, designed in discussion with Mindas Petrosius. Copyright Flexitech Ltd. 2018. Reproduced with permission.

Clean and Constrain: a pest management protocol and an overview of some collections management considerations for microscope slide collections

Lyndsey Flanagan[1,2], Alacoque White[1,3], and Paolo Viscardi[1*]

Address: [1] *National Museum of Ireland - Natural History, Merrion Square West, Dublin 2, D02 F627, Ireland*

[2] *Claremont McKenna College, 888 N Columbia Ave, Claremont, CA 91711, USA*

[3] *Trinity College Dublin, the University of Dublin, College Green, Dublin 2, D02 PN40, Ireland*

**Corresponding author: pviscardi@museum.ie*

Received: 13/08/2018

Accepted: 03/11/2018

Citation: Flanagan, L., White, A., and Viscardi, P., 2018. Clean and Constrain: a pest management protocol and an overview of some collections management considerations for microscope slide collections. *Journal of Natural Science Collections,* 6, pp.79-86.

Abstract

Integrated Pest Management is an essential tool in safeguarding museum collections, even for objects normally considered inedible, since pests may be present in and on furniture housing the collection. Here we describe an unexpected infestation in microscope slide cabinets and we outline a protocol for controlling pests in collections that cannot be frozen, while touching on additional issues relating to the use and management of microscope slide collections.

Keywords: IPM, integrated pest management, collections moves, microscope slides, protocols, freezing, storage furniture, pesticide

Introduction

Many natural science collections hold microscope slides representing specimens from every biological and geological discipline. These slides are often neglected in collections, but they may represent important scientific specimens (Justine et al., 2013) and can play a valuable role in exhibition (Tybjerg, 2018). The National Museum of Ireland – Natural History (NMINH) has in the region of 100,000 slides, including hundreds of type specimens in a range of Orders (see Appendix 1 for some of the groups represented). During the summer of 2018 a significant portion of these collections were moved from the NMINH display building on Merrion Street to the National Museum of Ireland (NMI)'s offsite Collections Resource Centre (CRC) in order to clear space for building development work, and to improve storage conditions and access to the collection (see Herrero, Chandler and Viscardi, 2018 for more details). This provided an opportunity to assess issues relating to the slide collection and address some of the more urgent problems discovered.

Microscope slides

Specimens can be mounted for microscopy in a variety of ways, depending on the type of microscope that is to be used and the size and shape of the specimen intended for examination. Three-dimensional specimens may be adhered to a card or placed in a prepared cavity (or cavities) on a slide. Generally, such specimens are examined using direct light from above or to the side of the specimen, rather than being lit from beneath. As such, the slides used for them tend to be opaque. Very small and flat specimens will tend to be viewed using light transmitted through the specimen from beneath, necessitating use of a transparent – usually glass – slide (see Figure 1).

Figure 1. Slide drawer from the NMINH collection, showing a selection of type specimens of corals mounted onto card, cavity slides, and glass slides with coverslips. Image © Paolo Viscardi, 2018

Securing specimens to slides allows manipulation during examination and helps prevent movement or loss of the specimen. For opaque slides, this will often have been achieved using whatever adhesive was at hand, but for glass slides specimens need to be secured using a method that does not interfere with the transmission of light. For short-term work, it may be enough to sandwich a specimen between a glass slide and coverslip, sometimes with a drop of water or oil to hold the coverslip in place using surface tension. However, for slides intended to be held in collections, an appropriate mounting medium is required, that will keep the specimen affixed to the slide indefinitely. Historically, a variety of mounting media have been used, including glycerine, wax, phenol, and even saliva (Allington and Sherlock, 2007). However, when keeping specimens permanently in collections it is recommended that a stable, non-aqueous mounting medium is used, such as Permount™ or Canada balsam (ibid.; see Figure 2). It is also recommended that coverslips on slides are sealed with an appropriate sealant, which can reduce issues of crystallisation and discolouration by limiting the area of exposed medium at the margins, reducing the opportunity for desiccation and chemical reaction (Allington and Sherlock, 2007).

While there is a useful body of literature discussing the aging and subsequent restoration of microscope slides (Brown, 1997; Allington and Sherlock, 2007; Neuhaus, Schmid and Riedel, 2017), there is very little written about pest management of slide collections, since they are not considered particularly vulnerable to pest attack. The main reported concern relating to slides and pests is the use of paradichlorobenzene as an insect repellent around microscope slides, due to a reaction that causes darkening and opacity of Canada balsam (see Figure 2) (Halliday, 1994; Neuhaus, Schmid and Riedel, 2017).

Figure 2. Slide drawer showing discolouration of Canada balsam mounting medium due to the presence of paradichlorobenzene in adjacent historic insect cabinets. Note that the intensity of the discolouration is greater in slides that have not been sealed. Image © Paolo Viscardi, 2018

Glass slides are typically safe from pest attack, although their paper labels are not and may be grazed by Psocidae (booklice), Oniscidea (woodlice), and Zygentoma (silverfish and firebrats). In some cases, the furniture that houses slides can provide a source of food for pests. At the NMINH, microscope slides are stored in a variety of ways, including folded card holders, bespoke wooden furniture, and steel cabinets, but there has been a move towards storage in standard cabinets. These measure 45cm high x 40cm wide x 34cm deep and are made from wood with a lockable glass-panelled door. They contain 28 wooden drawers, giving a capacity of 1000 slides per unit (see Figure 3). These cabinets allow accessible arrangement of the slides, which lie flat in shallow drawers that prevent displacement of mounting media and loss of any coverslips, labels, or specimens that become detached from slides. The drawers have

Figure 3. Standard cabinets with evidence of pest infestation. Image © Paolo Viscardi, 2018

a white plastic lining that offers contrast against which slides can be clearly seen, making it easier to see specimens and read labels. However, as with most wooden furniture, these units can warp and crack when stored in fluctuating environmental conditions, such as those experienced in Merrion Street (Monaghan, 2004; Herrero, Chandler and Viscardi, 2018). They also suffer from a design issue that we discovered has implications for pests - the cabinets each have a vertical wooden bar on the inside of the door, near the hinge, which prevents movement of the drawers when the cabinet doors are closed. This restraining bar has a strip of wool felt down the centre that acts as a buffer (see Figure 3). This wool felt is particularly attractive to the webbing clothes moth *Tineola bisselliella* (Hummel, 1823) and, on inspection, we discovered significant infestations in some of the cabinets (Figure 3). We also discovered adult brown house-moth *Hofmannophila pseudospretella* (Stainton, 1849), *Reesa vespulae* (Milliron, 1939) and some unidentified Psocidae.

The pest issue was identified during preparation for the movement of microscope slide cabinets from the entomology collections space to the CRC. The integrated pest management (IPM) protocols for these moves are described elsewhere (see Herrero, Chandler and Viscardi, 2018), but primarily they involve prophylactic treatment by freezing or cleaning, wrapping, and quarantining objects before inspecting them for signs of pest activity. However, when approaching the move of microscope slides, we were unable to use freezing as a preventative control measure, since slides can be damaged by ice formation (Florian, 1990; Brown, 1997; Allington and Sherlock, 2007). Furthermore, the materials comprising slides expand and contract at different rates, which can compromise the seal between slide, mounting medium, and coverslip (Allington and Sherlock, 2007). Therefore, we adopted an alternative approach to pest control involving manual removal of pests and treatment with a pesticide.

Materials and methods

The microscope slides in the NMINH collection are organised taxonomically, and to maintain their arrangement we drew a template of a standard slide drawer onto a sheet of 10mm thick Plastazote®, allowing the slides from one drawer to be laid out in the same sequence as they were stored. The drawer was inspected for signs of pests, with any evidence collected using a pair of fine entomology forceps and saved for further investigation. The drawer was carefully cleaned using a small nylon brush micro adapter on a Museum Vac® with HEPA filter and treated with pesticide if there was any sign of pest activity, then allowed to dry before the slides were returned in their correct sequence. The pesticide selected was Constrain™, which is a water-based permethrin formulation applied using a trigger spray, created specifically for use in a museum environment to control a wide range of insect pests (Pinniger et al., 1994). The outside of the cabinet was inspected and wiped down with paper towels; the inside of the cabinet was vacuumed and also sprayed with Constrain™, with special attention paid to the felt strip. The cabinet was allowed to air out until fully dry before the drawers were returned. Each slide was gently dusted with a small, soft paintbrush prior to re-storage (Figure 4). All work was conducted in a ventilated space using appropriate personal protective equipment (nitrile gloves and a 3M 8822 particulate respirator).

Figure 4. Slides being laid out on a Plastazote® template while empty drawer is cleaned. Image © Paolo Viscardi, 2018

Discussion

Use of pesticides is generally avoided in modern museum practice in order to reduce issues of contamination of objects with toxic residues that may impact upon the health of staff and the integrity of specimens (see Herrero, Chandler and Viscardi, 2018). When pesticides are used, pyrethroids and particularly permethrins are the usual choice because they have relatively low toxicity to mammals and birds (Imgrund, 2003) but high toxicity to invertebrates (Pinniger et al., 1994; Pinniger and Harmon, 1999). Permethrins are considered safe enough to be used in topical applications for treatment of human ectoparasites such as scabies (Rosumeck, Nast and Dressler, 2018) and present a relatively low risk to staff when used in collections, although some studies have suggested there may be some impact on male mammal reproduction when administered orally (Patrick-Iwuanyanwu, Udowelle and Okereke, 2016). Despite the toxicity of Constrain™ to target organisms, it has some limitations as a pesticide since permethrins do not readily vaporise (Imgrund, 2003). This means that it must come into direct contact with pests to be effective. Therefore, permethrin treatments such as Constrain™ may not eliminate eggs and larvae hidden inside holes and cracks in furniture that are not exposed to direct application (Querner, 2015). Permethrins also break down with exposure to sunlight and through bacterial action (Imgrund, 2003), meaning that they may not provide sufficient residual insecticidal effect to kill new adult insects as they emerge from untreated areas. Therefore, following the move of slide cabinets to the CRC they were wrapped in polyethylene, quarantined, and will be inspected at three month intervals for a year to ensure that all pests have been eradicated. In order to help prevent future infestations, we intend to replace the edible felt with a conservation-grade inedible material, such as Plastazote®, or consider alternative furniture.

Replacing the cabinets currently in use would provide the advantages of materials that are less attractive to pests and less prone to distortion, splitting, and detachment of drawer linings; all problems that we encountered. Rehousing the slides in new furniture would also present an opportunity to review the collection in a more comprehensive and systematic way than has been possible here, in what has been a time-sensitive response to a need to move. For the time being, however, the wooden cabinets have been moved onto steel shelving in a room at the CRC with no history of paradichlorobenzene use and a comparatively stable temperature and humidity, which represents a significant improvement from their previous storage environment. Fluctuating temperature and humidity is likely to have contributed to the detachment of labels and possibly to the discolouration and crystallisation of mounting media on some slides. Restoration of these may be possible with an appropriate understanding of the chemistry and causes of crystallisation and discolouration (Brown, 1997; Allington and Sherlock, 2007; Neuhaus, Schmid and Riedel, 2017), but it will require an appropriately trained member of conservation or technical staff to undertake the work.

Pests and other conservation issues are more likely to be recognised in a timely fashion in collections that are regularly used. With a collection of around 100,000 microscope slides, very few with unique museum numbers assigned, there is a real need for comprehensive curation and documentation to encourage use. It is important that a review of types, figured specimens and other important material is carried out and data made accessible if the collection is to fulfil its scientific potential (Notton, 1995). A list of putative type specimens of Acari from J. N. Halbert has previously been published (O'Connor, 1980), and many Orders with types represented in the collection are noted below (see Appendix 1), but there are a large number of zoological and geological microscope slides that have yet to be thoroughly examined. Furthermore, we have only been able to recognise type material that is labelled as such, making it important to encourage access by researchers specialising in the material, who may identify further important specimens. There are many specimens recorded as types in hard catalogues, but that information can be difficult to relate back to the specimens since many labels on slides are difficult to read due to grazing by Psocidae, fading, poor choice of writing materials (such as use of thick markers or inks that deteriorate), and poor penmanship. We found that badly faded slides were illegible when backlit or on a darker surface, but a white background greatly improved legibility and taking a photograph of the label allowed image-processing software to enhance legibility (Figure 5). With modern mobile devices and freely available software applications, this can be a quick and simple solution to deciphering faded text on labels.

Conclusion

IPM is an essential consideration even for collections not normally considered at risk of infestation. It is important that we undertake processes to prevent transmission of pests between collection spaces, and those processes should seek to minimise risks to people, collections, and the environment. We recommend that slide collections are included in IPM activity, and if wooden slide cabinets are used, we suggest removing wool felt if it is present. Slides should be stored in a stable environment away from

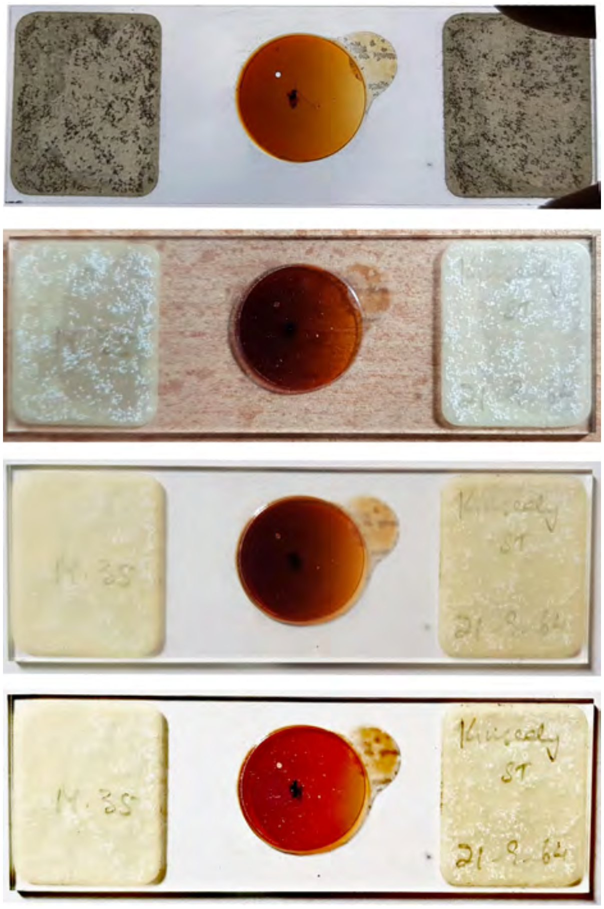


Figure 5. Top to bottom: backlit slide, slide on table, slide on sheet of white paper, slide photographed and image enhanced using image processing software. Image © Paolo Viscardi, 2018

old furniture with traces of residual paradichlorobenzene. Preferably, slides should be laid flat rather than stored on their side or end to limit the risk of displacement of labels and specimens that may become detached over time. Slide collections can hold important scientific information or have significant interest for a variety of audiences and should be appropriately curated and documented in order to make them accessible, as with any other collection.

Acknowledgements

We would like to thank Ana Esmeralda Herrero and Kim Chandler for their input to the work on this project and their input on this paper.

References

Allington, L. and Sherlock, E., 2007. Choosing a microscope slide sealant: A review of aging characteristics and the development of a new test, using low oxygen environments. *NatSCA News,* 12, pp.4–14.

Brown, P., 1997. A review of techniques used in the preparation, curation and conservation of microscope slides at the Natural History Museum, London. *The Biology Curator*, 10 (Supplement), pp.1–33.

Florian, M.L., 1990. The effects of freezing and freeze-drying on natural history specimens. *Collection Forum,* 6, pp.45–52.

Halliday, R., 1994. *Microscope slide mounting media. Results of informal survey.,* s.l.: Archives of Acarology List.

Herrero, A. E., Chandler, K., and Viscardi, P., 2018. TBC. *Journal of Natural Science Collections,* 6, pp.TBC.

Imgrund, H., 2003. *Environmental Fate of Permethrin*. Sacramento: California Department of Pesticide Regulation.

Justine, J.L., Rahmouni, C., Gey, D., Schoelinck, C., and Hoberg, E.P., 2013. The Monogenean which lost its clamps. *PLOS ONE,* 8(11), pp.1-18.

Lane, S., 2011. Re-organising the Coleoptera Collection at Leicestershire County Council Service. *NatSCA News*, 21, pp.75-88.

Monaghan, N., 2004. Victorian Natural History Galleries in the 21st Century - Keeping a Victorian Gallery Alive. *NatSCA News*, 3, pp.26-28.

Neuhaus, B., Schmid, T., and Riedel, J., 2017. Collection management and study of microscope slides: Storage, profiling, deterioration, restoration procedures, and general recommendations. *Zootaxa,* 4322(1), pp.1-173.

Notton, D.G., 1995. B.P. Beirne Microscope Slides of Ichneumonidae at the Natural History Museum, London. *The Biology Curator,* 2, pp.15-17.

O'Connor, J.P., 1980. J.N. Halbert: Notes on His Collection of Acari (Arachnida) Housed in the National Museum of Ireland, with a List of Contained Putative Types. *The Irish Naturalists' Journal,* 20(2), pp.75-76.

Patrick-Iwuanyanwu, K.C., Udowelle, N.A., and Okereke, C.J., 2016. Testicular toxicity and sperm quality. *Journal of Interdisciplinary Histopathology,* 4(1), pp.13-16.

Pinniger, D. and Harmon, J., 1999. Pest management, prevention and control. In: Carter, D. and Walker, A.K. (eds), 1999. *Care and Conservation of Natural History Collections.* Oxford: Butterworth Heinemann, pp.152-176.

Pinniger, D., Morgan, C., Child, R., and Lankford, W., 1994. *A novel microemulsion formulation of permethrin for the control of museum insect pests*. Studies in Conservation, 39(1), p.24.

Querner, P., 2015. Insect Pests and Integrated Pest Management in Museums, Libraries and Historic Buildings.. *Insects,* 6(2), pp.595-607.

Rosumeck, S., Nast, A. & Dressler, C., 2018. Ivermectin and permethrin for treating scabies (Review). *Cochrane Database of Systematic Reviews,* Issue 4, pp. 1-74.

Tybjerg, K., 2018. Exhibiting Epistemic Objects. *Museum and Society,* 15(3), pp.269-286.

Appendix 1. Some collectors and taxa with type specimens held on slides in the collections of the NMINH.

Collector	**Taxa**
Ashe, P.	Diptera, Hymenoptera
Barnes, W.V.	Phthiraptera
Bullock, E.	Acari
Cabot, D.	Parasitic worms (various)
Carpenter, G.H.	Collembola
Conroy, J.C.	Acari
Donovan, O.	Phthiraptera
Evans, G.O.	Acari
Gertrude, C. and Fr. Joseph	Collembola
Halbert, J.N.	Acari
Haliday, A.H.	Diptera, Thysanoptera, Hymenoptera
Healy, B.	Annelida
Hopkins, G.H.E.	Phthiraptera
Huxton, M.	Acari
Hyatt, K.H. and Benson, E.M.	Acari
Jackson, D.F.	Copepoda
Langton, P.H.	Diptera
Lawrence, P.N.	Collembola
Leske, N.G.	Lepidoptera
Malcomson, S.M.	Ostracoda
Melvin, A.D.	Collembola
Mitchell, M.	Diplopoda
O'Mahony, E.	Phthiraptera, Siphonaptera, Zygentoma
O'Mahony, E. and Hopkins, G.H.E.	Sternorrhyncha
Perkins, R.C.L.	Collembola
Peters , J.U.	Psocoptera
Purvis, G.	Acari
Purvis, G. and Evans, G.O.	Acari
Rousselet, C.F.	Rotifera
Schmitz, H.	Diptera
Theobold, F.V.	Sternorrhyncha
Walker, T.M.	Hymenoptera, Sternorrhyncha
Walton, G.A.	Auchenorrhyncha
Williams, C.	Diptera
Wright, E.P.	Cnidaria
Surveys (Including Challenger, BIOMAR, Royal Irish Academy)	Marine invertebrates (various)

Driggsby the fin whale's museum ecosystem: the collection, conservation, and installation of a new museum icon

Simon Jackson[1]* and Nigel R. Larkin[2]

Address: [1] Tullie House Museum and Art Gallery Trust, Castle Street, Carlisle, CA3 8TP, UK
[2] Cambridge University Museum of Zoology, Downing Street, Cambridge CB2 3EJ, UK

**Corresponding author: Simon.Jackson@tulliehouse.org*

Received: 29/06/2018

Accepted: 04/11/2018

Citation: Jackson, S. and Larkin, N.R., 2018. Driggsby the fin whale's museum ecosystem: the collection, conservation, and installation of a new museum icon. *Journal of Natural Science Collections,* 6, pp.87-98.

Abstract

A 12-metre long juvenile fin whale (*Balaenoptera physalus* (Linnaeus 1758)) skeleton, named Driggsby, was installed in the Tullie House Museum and Art Gallery in January 2018. The specimen was washed up on the West Cumbrian coast in February 2014. It represents a very rare find for the area and is also significant in terms of its near-completeness, juvenile status, and potential to inspire the public about endangered marine species. This unique project has involved four years of collaboration, working with many people from different sectors which make up Driggsby's 'museum ecosystem'. Most significantly, this included work with the second author in cleaning, conserving, mounting, and installing the specimen. Specialist methods were needed to clean the bones, as the specimen was very fresh. It also involved working with the local community from the outset, in terms of collecting the specimen and then beginning its preparation for display. Tullie House collaborated with the local Carlisle Natural History Society and engaged with museum volunteers. Working with local media has resulted in a plastic-free campaign led by Carlisle City Council. Driggsby's museum ecosystem continues to grow as Tullie House integrates the specimen into work with schools and universities.

Keywords: Fin whale, skeleton, collaboration, conservation, mounting, installation, community, volunteers

Introduction

The discovery of a 12-metre long fin whale *Balaenoptera physalus* (Linnaeus, 1758) carcass on the west Cumbrian coast at Drigg Point near Ravenglass caused quite a stir when the news broke in February 2014, immediately attracting the attention of a local paper (News and Star, 2014). The news quickly reached the attention of staff at Tullie House Museum and Art Gallery (TH) in Carlisle. A campaign began at the Museum to collect and display the specimen's skeleton, the goal being to create a major museum centrepiece. However, at the time, the full scale of the project and huge logistical challenges involved were not fully appreciated.

The collection, curation, preparation, conservation, and mounting of the specimen (named Driggsby), took almost four years. The project was achieved through collaboration with a number of people from different disciplines and sectors. This paper will focus on five particular types of people that TH collaborated with (Figure 1), which broadly charts the most significant chronological episodes of the story: (1) working with the local community in collecting, preparing, and naming the specimen; (2) working with specialist contractors including the conservator, Nigel Larkin (NL) to conserve, mount and install the specimen; (3) working with traditional and social media; (4) working with other museums; (5) working with schools and universities.

In January 2018 the skeleton was installed in the public reception area (Atrium) of Tullie House Museum and Art Gallery (TH) as a major museum centrepiece, to greet and inspire current and future generations of visitors.

Significance of the specimen

Fin whales are the largest extant animal species after the blue whale. The species has a worldwide distribution, and in the northern hemisphere (including the North Atlantic) reaches up to 50 tonnes in mass (Berta, 2015). Fin whales are regular visitors to British waters. The species is distributed at various localities around the British coast, including the west coast of Scotland (NBN Atlas Partnership, 2017). Sightings are particularly common south of Ireland and in the Western Channel Approaches, where part of the population overwinters and breeds (Reid, Evans and Northridge, 2003), resulting in sightings and strandings of young calves or pregnant females (ibid).

Whale strandings on the West Cumbrian coast, as occurred in this case, (Figure 2) are rare. According to unpublished biological database records (Cumbria Biodiversity Data Centre, 2016) there has only been one other occurrence of a dead fin whale on the Cumbrian coast (Silloth) in the last 100 years, although this represents an underestimate as there is at least one more known from Arnside in 2009 (BBC News, 2009). However, it is almost certain that the 2014 specimen was washed inland from further out, likely during the extreme storms in the winter of 2013/2014 (BBC News, 2013), given the state of

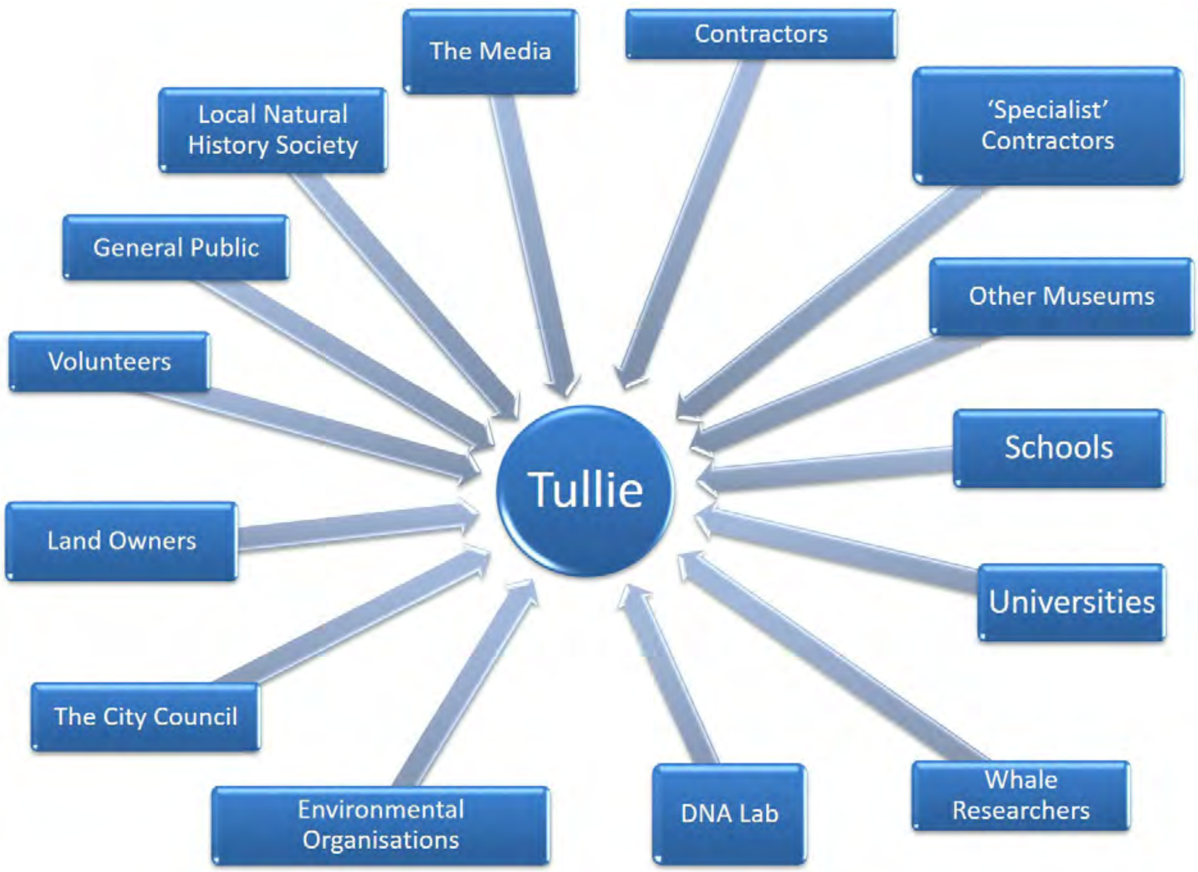


Figure 1. Diagram showing the network of collaboration or 'Museum ecosystem' of the fin whale project at the Tullie House Museum and Art Gallery.

decomposition and loss of colouration which indicates that the specimen had been dead already for a month before it was washed up on the beach (Baxter, 2016).

In the UK, very few fin whale carcasses have been recovered and become museum specimens. Examples include the University of Cambridge Museum of Zoology specimen (from Pevensey, Sussex, 1865), the National Museums Scotland specimen (from the Island of Coll, Scotland, 2004), the National Museum of Ireland specimen (from Bantry Bay, 1802), and seven individuals at the Natural History Museum, London (from the British Isles).

Furthermore, the TH specimen is of scientific significance because it is fairly complete. The specimen also represents a juvenile, and so could potentially provide invaluable information for the study of whale growth, about which very little is known (El Adli, 2016). The extent of fusion in different parts of the skeleton potentially provides a window into this animal's growth and a single ontogenetic (developmental) stage of the species.

Working with the community

The collection of the skeleton

When the carcass was found in February 2014, a Cumbria Wildlife Trust Conservation Officer undertook a brief examination of the carcass and suggested several possible causes of death, including ingestion of marine litter; the exact cause is still unknown and no autopsy was undertaken. The examination tentatively identified the specimen as a sub-adult sei whale (*Balaenoptera borealis* Lesson 1828*)*. (SJ later sent a sample to the DNA laboratory at Swift Ecology, where it was conclusively identified as a fin whale.) The remains quickly became a tourist attraction, with some people walking 4 km along the beach to see it (Figure 3).

Figure 2. Map showing the location of Drigg Point, West Cumbria, where the specimen was discovered, relative to Tullie House in Carlisle.

Figure 3. The animal as it was discovered in February 2014 on the west Cumbrian coast. Photograph reproduced with permission of Cumbria Wildlife Trust.

A campaign began at the Tullie House Museum to collect the specimen for display. The campaign was initially led by the (then) Curator of Natural Sciences, Stephen Hewitt, who recognised a gap in the collection in terms of cetacean material, and who proposed that a locally provenanced whale skeleton in the central foyer (Atrium) area would make a bold statement about the building as a museum. The Museum and its Trustees got behind the campaign and were very supportive.

From the outset, it was vital to work with the community in order to recover the specimen. Firstly, permission was required from the landowners, Muncaster Estate. Negotiations were facilitated successfully through one of the TH Trustees, Paul Croft, whose involvement paved the way for further discussions. Permission was also required from Copeland District Council and the Marine Management Organisation in order to 'dispose' of the carcass (in this case, remove the skeleton from the beach). As vehicular access was needed along the Drigg Coast, which is a Site of Special Scientific Interest (SSSI), permission was also required from Natural England.

There were also logistical challenges in terms of collecting the skeleton. The Tullie House Museum is very fortunate in having a good relationship with the local natural history society. For 125 years, the Carlisle Natural History Society has held its meetings at the museum. Indeed, the collecting activities and donations of the Society's members underpins the museum's collection and its significance. The Society includes all sorts of different specialists and prominent county recorders. From this expertise, a team of knowledgeable and keen volunteers was assembled (see *Acknowledgements*).
The negotiations for permissions and planning the logistics took several months, and it was not until 1 August 2014 that the team was able to return to the site to inspect the specimen. The hot summer weather had assisted in the decay of soft tissue, exposing many of the bones. In particular, the skull and vertebrae were now visible.

The team returned two weeks later, on 14 August, to recover the skeleton. However, the whale was nowhere to be seen. The specimen had been transported further around the point into the estuary towards Ravenglass by summer storms, which had also broken up much of the carcass. Some of the bones were subsequently recovered individually, though many of the caudal and lumbar vertebrae were still articulated and attached by tendons and skin. A veneer of soft tissue remained on many of the ribs and vertebrae, though at this stage the carcass was so well decayed that the team did not need to remove any excess flesh.

Unfortunately, due to this disarticulation, some of the bones were now missing. However, about two-thirds of the skeleton was recovered, including: a near-complete cranium with right maxilla, right mandible, hyoid, sternal plate, both scapulae and humeri, one ulna, 43 vertebrae, 15 pairs of ribs, and 14 chevrons. Due to the sub-adult status of the specimen, the epiphyseal discs had not fused to the ends of the vertebral centra and these were collected as separate and scattered elements. Additionally, some of the vertebral neural spines were incomplete, lacking their distal expansions, and some of these were recovered as individual elements. There were no external signs of injury visible, apart from a small, square cut on the left flank. It is likely that the breakages to the bones occurred during their transport across the beach.

Thanks to Society members and friends, TH had access to the resources to collect and start preparing the specimen. This included the use of a pickup truck to collect and transport the bones, and the use of private property at Birkmere Wood, near Penrith, for the preparation of the bones through burial in raised beds of sand and compost. This method was the most economical and practical way to prepare such a large carcass, allowing the soft tissue to decompose through the action of heat, microbes, and invertebrates. The specimen was left for 18 months before being fully excavated.

Enter Driggsby the whale: naming the skeleton

Whilst the specimen was buried, SJ took over leading the project and fundraising began. The original goal was to raise £50,000 (the total cost of the project is now around £86,000). As part of this campaign, TH devised a 'Name the Whale' competition, launched in Spring 2016. For a £1 donation, people could submit their suggestions on an envelope within the outline of a cartoon whale, which could then be posted in the Museum. Many entries were received, including predictable ones such as Moby, and some that were topical of the time, such as Boney McWhaleFace, after 'Boaty McBoatface', the 2016 winner of the popular vote to name a British Antarctic Survey research vessel (Ellis-Petersen, 2016). However, variations on Drigg, after where it was found at Drigg Point, were most popular, and the name Driggsby was selected by a TH panel from the shortlist.

The main purpose of the campaign was to create a sense of ownership of the whale within the local community, and was underpinned by a key objective of the (then) new TH Manifesto (Tullie House Museum and Art Gallery, 2016), to work and co-create with the community. The name Driggsby has fondly been accepted and has become a popular social media hashtag in its own right (#Driggsby). Furthermore, the adoption of the name Driggsby was key to gaining the support of the local Drigg Parish, who provided funding towards the project (via The Drigg Charity Board) and helped to organise work with local schools (see *Working with schools and universities*, below).

Working with volunteers

After the bones had been exhumed and transported back to Tullie House, preliminary cleaning was undertaken to remove the sand and compost which coated the bones after their long burial. Museum volunteers undertook this work (Figure 4). At TH, volunteers are a vital part of the workforce and are involved in a large number of collections projects. The fact that a volunteer team was already in place meant that cleaning could start immediately. In addition, due to the media attention and high profile of the project, it was relatively easy to recruit more volunteers to join the project workforce.

Volunteers can also come from unexpected places. Carlisle Scaffolding built outdoor shelving for the bones. In order to support the project, as a form of in-kind sponsorship, the company were able to provide (at no extra cost) a flatbed truck vehicle in order to collect the whale from the Penrith wood, and a driver to transport the material and also help with the packing.

Figure 4. Tullie House volunteers cleaning the sand and compost off the whale bones, following their burial for 18 months in a Penrith wood.

In addition to cleaning, the volunteers helped with documentation and photography of the bones. Many of them were university students studying courses such as Zoology and Wildlife and Media. As volunteers they learned about whale anatomy and marine wildlife, thus enriching their studies. During the summer of 2016, 86 hours of volunteer labour were recorded. Without this assistance, the project would have taken months longer.

Working with specialist contractors

It was clear at an early stage of the project that TH would need to work with a specialist conservator to fully clean the bones, mount them, and then install them at the Museum. The Natural Sciences Collections Association mailing list and forum was consulted for recommendations, and Nigel Larkin (NL) was chosen for the project. At the time, in 2016, NL was completing a project to disassemble, clean, conserve, and reinstall the famous 21-metre long adult fin whale skeleton at the University of Cambridge Museum of Zoology (Larkin, 2015).

The whale bones were transported to NL's rented workshop in Shropshire for cleaning, conservation, and mounting. This included removing sand which still covered some bones, particularly the fragile skull elements, using soft brushes, a vacuum cleaner and compressed air (Figure 5), and removing remains of soft tissue, including gristle, with scalpels and tweezers. A more detailed description of the cleaning and conservation work will be published in a future paper by the authors.

Many of the bones still retained a very bad odour. Some of the vertebrae from the rear half of the skeleton were still quite oily, black, and foul-smelling, with white adipocere on their surfaces. Conventional methods such as using poultices of ethanol and 3% ammonia in water (1:1:1) (e.g. Turner-Walker, 2012) did little to remove the oils or improve the smell or appearance of the bones tested. Discussions with colleagues in the field of natural history conservation led to dialogue with John Ososky, a specialist at the Smithsonian Institution who has successfully cleaned and mounted many whales (Ososky, 2012). Ososky buries his whale bones in elephant dung for weeks or months depending on need. It is not essential that elephant manure is used; the dung of any large herbivore should work (Ososky, 2017), as long as the manure is kept moist or even quite wet. Burial in manure appears to clean bones of oils, fats and adipocere. It is not known if this is through microbial or invertebrate action or high temperature, or a combination of these. This methodology was very successfully applied to the worst-smelling bones of Driggsby, using horse manure (Figure 6) as elephant dung was not available. These included all the caudal and lumbar vertebrae and associated chevrons, the two humeri, the ulna and sternum, amounting to about 120 pieces of bone as epiphyses were not fused. They were all placed on a deep layer of horse manure within large containers, and covered with another 18 inches of horse manure.

During burial, the temperature at depth was mostly in the 20°C to low 30°C range, with brief periods at around 50°C. After five months, the bones were removed. They were rinsed with water, then soaked in ammonia hydroxide at 4% in water for a minimum of a week to kill any bacteria and reduce the strong odour. The large lidded polypropylene tubs containing the ammonia solution were kept outside and under cover, to reduce risk of ammonia fumes affecting health. Goggles, rubber gloves, and an apron were worn at all times when making up the ammonia solution and when submerging and removing the bones.

At least 17 vertebrae were never recovered from the beach (the number of vertebrae in fin whales varies between 60 and 63 (Gambell, Ridgeway and Harrison, 1985). If all of the missing vertebrae were replicated, the whale would not fit into the tight exhibition space. 13 vertebrae were successfully recreated by NL, by moulding the vertebra adjacent to the gap in each instance and then making Jesmonite acrylic and glass fibre casts, which were painted to match the bones. However, as both of the lower forelimbs were

Figure 5. N. Larkin cleaning the skull of Driggsby (CALMG:2016.70), which is upside-down with the anterior end to the left and the posterior end to the right. The white spots in the middle are patches of adipocere yet to be removed. Adipocere is a greyish waxy substance formed by the decomposition of soft tissue in dead bodies subjected to moisture, and besides being unsightly can stain bones over the long term.

Figure 6. N. Larkin placing some caudal vertebrae and associated epiphyseal discs into a large tub of fresh horse manure to clean them of oils and fats. These were covered with another 18 inches of manure before the lid was replaced.

missing (apart from one ulna), an alternative method of replication was necessary for these elements. The University Cambridge Museum of Zoology fin whale skeleton was being disassembled during the autumn of 2016, just before conservation of Driggsby began, so the complete articulated forelimbs were accessible and permission was kindly given to copy them. Stephen Dey of ThinkSee3D (a 3D printing and photogrammetry company specialising in working with museums) has worked with NL on many osteological and palaeontological projects (Larkin et al., 2016; Lomax et al., 2017) and was available to scan the complete forelimb of the Cambridge specimen using photogrammetry and convert the data to create a detailed 3D digital model. This enabled all the bones of the forelimb below the 'elbow' to be 3D printed at the correct size to match the skeleton of Driggsby, using the preserved ulna as a size guide. The models were made using a 3DS x60 3D Printer with a core powdered material consisting mostly of gypsum. The same methodology was also used to 3D print the missing pelvis bones, also based on those of the Cambridge specimen.

Frequent communication was integral to the success of the project. At the start, this included on-site meetings between NL, the structural engineer (Bingham Yates), and TH staff, to discuss the most appropriate method of installation. An early plan by SJ to suspend the specimen in the centre of the Atrium had to be rejected, as all of the missing bones could not be recreated within the budget. SJ's alternative proposal was chosen instead: to suspend the right side of the specimen only, in order to conceal the missing left elements (maxilla, mandible, lower forelimb), next to the Atrium wall directly above reception. A decision was reached, using the engineer's advice, to hang the specimen from a beam connected to a central rafter in the ceiling (able to support up to 4 tonnes). We also followed the advice of NL regarding the need to use steel brackets between the skeleton and the wall, to hold the ribs in place and mitigate the sideways torsion of the asymmetrical skull and mandible.

The dynamic curvature seen in the specimen now on display in TH was achieved thanks to collaboration between the authors. In order to achieve a realistic diving pose, SJ first studied photographic material of diving whales available online and existing museum specimens, and ultimately sought the advice of whale experts. Jerry Herman (Senior Curator of Vertebrates at National Museums Scotland) was consulted, and he also recommended whale specialist Christian Ramp, who was able to provide more distinct parameters on what was realistic. SJ then created an authentic and ambitious curvature in a 2D schematic at a 1:20 scale, working with a design company (Vincent and Bell Graphic Design) (Figure 7), after which NL went through the complicated process of recreating it in 3D, in a series of sections. Collaboration with the structural engineer included superimposing an

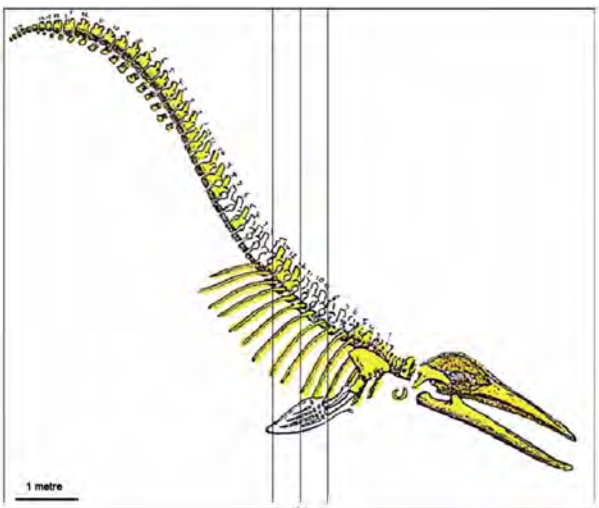


Figure 7. The 2D schematic produced by S. Jackson, which was reproduced in 3D by N. Larkin in his Shropshire workshop.

Figure 8. N. Larkin with one of the four sections of the vertebral column, consisting of vertebrae and replica vertebrae mounted on a shaped steel bar, with hanging points welded in place.

outline of the skeleton over the schematic building plans, to ensure that the curved skeleton would fit in the space. There was no room for error in the curvature: the skeleton was 12 metres long when lying flat, and the space in which it was to be installed was only 9.5 m wide. A hollow, square cross-section steel beam was shaped by NL, to follow the curvature envisaged, and was then threaded through a hole (25-50 mm diameter) drilled into the centre of each centrum (Figure 8) using a wide 'spade' drill bit. 50 mm holes were necessary for the front portion of the vertebral column to accommodate the thicker bar that had to take more weight. Towards the rear of the vertebral column, as vertebrae decrease in size, the metal bar required for support and articulation needed to be thinner and therefore increasingly smaller holes were required in the centra (Figure 8).

Working with traditional and social media

During the course of the project, TH was assisted by extensive media coverage. The Cumberland Newsgroup produced six newspaper articles (e.g. News and Star, 2017) after the initial announcement of the discovery. At certain landmarks of the project, a press release was presented to the media and then TH responded to visiting journalists and photographers. The media interest grew from local to regional via BBC Radio Cumbria, and included a visit from a radio presenter in May 2016 to inspect the outside storage of the bones and interview SJ. In May 2016, BBC Look North covered the story, including an interview and also filming the volunteers undertaking some of the preliminary work. Undoubtedly, this helped to maintain their enthusiasm and engagement with the project.

During the second night of the seven-day installation, BBC Look North returned to TH to do an on-site live broadcast. This was excellent footage to promote the project. However, even though it was only a five-minute broadcast, it took about an hour to carefully choreograph the sequence of the footage. This did not present a major delay, but this sort of potential interruption needs to be borne in mind and ideally incorporated into the installation programme.

The media coverage culminated in an announcement by the Carlisle City Council that they were launching a 'Plastic-free Carlisle' campaign (News and Star, 2018a). This followed a News and Star (2018b) interview with SJ, and then a one-to-one discussion between the Leader of the Council, Mr Colin Glover, and SJ in the new Tullie House whale gallery during the January 2018 Driggsby launch event. Mr Glover was particularly moved by the possibility that Driggsby had been killed by plastic pollution. The Council are pushing to entirely eliminate the use of single-use plastics across all City Council bases and operations, and are urging local businesses and organisations to follow suit. The Council has also had discussions with local environmental charities, who are keen to help with the challenges presented by plastics. Subsequently, Tullie House has promoted this campaign through national events, including Green Great Britain Week.

Social media was used throughout the project. Facebook and Twitter were used in the community competition to name the whale (#namethewhale). Many Twitter posts were also released to coincide with broader hashtags, including #WhaleWednesday. #Driggsby and #Tulliewhale were also used for many posts and were adopted by NL and the 3D printing/scanning company, ThinkSee3D. They have now also been adopted by the general public. The importance of using consistent hashtags was learnt early on in the project, and choosing a name for the specimen helped with this. In the six months leading up to the January 2018 installation, Facebook, Twitter and Instagram were used to build excitement about the project; for instance, a slideshow of NL doing mounting work was created in one Instragram post, which was then automatically posted through Twitter. The greatest interaction with posts (in terms of likes and re-tweets) occurred during the installation week. TH continues to target relevant hashtag events (e.g. #WorldOceansDay (8 June), which is a global celebration of the world's oceans) to promote Driggsby.

Working with other museums

The whale installation was accompanied by a new, small, permanent gallery, exploring the story of Driggsby, whale evolution and whale conservation. The gallery contains a viewing window looking onto the skeleton. Manchester University Museum provided two loans, which included the skull of a minke whale (*Balaenoptera acutorostrata* Lacépède, 1804) and also a cast of the skull of the fossil ancient whale, *Dorudon atrox* Andrews, 1906. These objects greatly strengthen the exhibition: the minke whale skull contains baleen (most of which unfortunately was not recovered with Driggsby) and is a useful resource for school teaching to explain how whales feed (see below). The fossil whale skull is part of the display on the evolution of whales, entitled 'Rise of Driggsby', which explains how whales became adapted to a completely aquatic existence (for instance, almost completely losing the hindlimbs). It was planned from an early stage in the project to have an associated gallery, and approximately £5,000 was allocated towards this. (It was delivered for £4,500.)

Working with schools and universities

TH has an award-winning schools programme, which worked with over 14,000 children in 2017. Driggsby is a great addition to this programme, because it provides new natural history content with a local connection to the subject. Sessions for Key Stage 1 and 2 have been developed, as well as a workshop for Early Years children focusing on Driggsby, including its life, anatomy, whales in general, and the process we went through to preserve the specimen. These sessions include a series of practical experiments aimed to reproduce the preparation steps undertaken. The sessions, provided for Gosforth and Seascale Primary Schools, aim to promote awareness of how our actions impact the environment, particularly bearing in mind that Driggsby may have been killed by plastic pollution. Subsequently, the children have created a small whale artwork made from plastic, inspired by Driggsby. This work with the schools was set up in direct collaboration with the Drigg Parish, who provided funding towards the delivery of the sessions.

The skeleton has also provided new content for teaching zoology to undergraduate students from the University of Cumbria. One in-house practical session uses TH specimens to investigate adaptations of tetrapod forelimbs. The new whale skeleton increases the range of species present that can be studied and drawn by students, to investigate how the forelimb has evolved to adapt to different ecological niches.

Conclusions

Whilst there are several other whale skeleton displays in the UK, the combination of the conservation challenges we faced with such a fresh specimen, the highly dynamic and ambitious posture of the whale, and the large amount of collaboration with the community and other organisations make this project unique. As such, there are many things we have learnt that can be shared with the wider museum and heritage community.

Working with the local community was vital to the success of the project. Allowing the public to name the whale created a sense of ownership, whilst helping to raise vital funds for the project. Furthermore, the naming of the whale after its location at Drigg facilitated the financial support of the local Parish (via the Charity Board), who helped to organise Driggsby-based school sessions with local West Coast schools.

One of the TH Trustees paved the way in obtaining permission from the landowners of the Muncaster Estate to access the site. However, it still took several months to complete negotiations with organisations for permission to dispose of the carcass and make preparations to collect the specimen. During this time, the specimen had decayed considerably, causing disarticulation of many elements and the loss of around a third of the skeleton. This demonstrates that such negotiations and logistical planning should ideally be completed within a shorter timeframe. In theory, this would have allowed virtually all of the specimen to be collected and would have significantly reduced costs incurred through replication of missing elements.

The skills and resources of the Carlisle Natural History Society were vital, and without their assistance the project would not have even started. The work of the volunteer team saved a huge amount of Museum staff labour, and they also benefited, gaining knowledge relevant to their university degrees.

Working with specialist contractors, particularly NL, allowed this highly ambitious project to be completed. Many museums do not have in-house conservators and must turn to external expertise; in this case we needed a contractor to undertake the conservation, mounting, and installation of the whale. Good communication between the conservator, engineer, and TH was also vital to the project, including the selection of an appropriate method for suspending the whale. On-site meetings at TH and in the conservation workshop in Shropshire facilitated this communication and ensured that the whale fittings met the specific requirements of the beam.

In an age that can seem dominated by social media, this project has proved that traditional media (local newspapers, radio, and TV) can still be a very powerful vehicle to promote museum work. The Carlisle City Council's 'plastic-free' campaign came about, at least in part, as a result of the project, demonstrating that it had a considerable impact. However, working with the media can be timeconsuming, and this needs to be factored into project planning.

The total project cost approximately £86,000. This covered the conservation, mounting, and installation of the whale and the replication of missing parts. It also included the design and installation of the beam by the structural engineers, the modification of the Atrium including solar films in the windows above, and a cooling air conditioning system. It also included the costs associated with the new whale gallery, including design and printing of panels. Following the discovery of the whale, the total project costs could only be crudely estimated. Unfortunately, as stated previously, one third of the specimen was not collected, which considerably increased the total project costs. This reiterates the importance of the point above in collecting specimens whilst they are complete in order to avoid replication costs.

TH has been able to so far cover about half of these costs through fundraising. This included grants from public funding (Arts Council England (ACE)), local organisations, a charitable trust and a small amount from the Name the Whale community campaign. The total project cost was also spread over 4 financial years which also helped to plan and absorb the costs. The whale is seen as a long-term investment, and we are striving to cover the remaining costs through increased visitor numbers and secondary spending in the shop; our visitor numbers have increased by 27,109 people in 2018 (comparing 16 January - 13 November 2018 to the same period in 2017). However, there have been other major exhibitions at the museum, making it hard to attribute specific numbers to the success of the whale. We are also using the whale to secure grants from other bodies for related projects. For instance, 'Whale Tales' is a major HLF-funded engagement programme aimed at early years pupils from the West Coast of Cumbria, which will see children, parents and teachers tell the story of Driggsby the Whale through developing their own exhibition, illustrated book, and events programme from February 2019 – June 2020.

Figure 9: The skeleton of the fin whale, Driggsby (CALMG:2016.70), at Tullie House Museum and Art Gallery in Carlisle, Cumbria, UK.

Large vertebrate specimens, known as 'charismatic megafauna', make fantastic displays to inspire the public to care about endangered animals and their natural world. The exhibit raises awareness of issues around whaling and the importance of caring for our environment. The associated interpretation in the TH galleries was greatly strengthened by the loan of Manchester Museum specimens. Driggsby's museum ecosystem continues to grow, as TH is now integrating the skeleton into university and school teaching and, in so doing, inspiring future generations (Figure 9).

Acknowledgements

Simon Jackson would like to thank: Muncaster Estate, Copeland District Council, The Marine Management Organisation, and Natural England for permission to access, collect and display the skeleton; Tullie House Trustee Paul Croft for helping facilitate negotiations with the landowners; Carlisle City Council for permission to install the whale in the Council building; Stephen Hewitt for his significant contribution in leading the initial campaign to collect the specimen; Carlisle Natural History Society for their contribution in helping to collect the whale (in particular, Arthur Walby, John Parker, and Bernard Parker); at TH, Technical Officer Gavin Campbell for helping plan the logistics and installation; all TH staff for their assistance at various times of the project, including unloading the skeleton before the installation; the team of TH volunteers for helping to prepare the whale, including Georgia Burns, Rebecca Gibson, Will Higgs, Lequane Jason Johnson, 'Scarlet', Zahrah Vawda, and John Winder; Cumbria Wildlife Trust, particularly Emily Baxter, for permission to use an image and also for initial information about the specimen; Manchester University Museum for the loan of specimens; whale specialists Peter Evans (Director, Sea Watch Foundation) and Joseph El Adli (University of Michigan) for information in order to help determine the significance of the specimen; researcher Christian Ramp (Mingan Island Cetacean Study), and Jerry Herman (Senior Curator of Vertebrates, NMS) for providing guidance on parameters for creating a realistic curvature; Richard C. Sabin (Principal Curator, Mammals at NHM) for providing general advice on whale anatomy; James Vincent (previously Vincent and Bell Graphic Design) is thanked for helping to prepare the Cumbrian map figure and the 2D schematic of the whale.

I would like to thank Chris Walters of Bingham Yates for the design of the structural beam and for helpful discussions around its installation; PMS Fabrications for the installation of the beam; HSS Hire for the hire and use of the scaffolding tower; Richard Walters of Commendium for some early experimentation scanning bone elements; Georg Hantke of National Museums Scotland for advice on cleaning whale bones early in the project; Swift Ecology for their help with the analysis of the DNA samples.

Special thanks are also due to funding organisations: The Arts Council England (PRISM), The Binks Trust, The Drigg and Carleton Community Benefit Fund, and the Cumberland Newsgroup Charitable Trust. Carlisle Scaffolding are also thanked for their staff-in-kind sponsorship. The local Carlisle and Cumbrian community are thanked for their generous donations during the Name the Whale campaign.

Nigel Larkin would like to thank John Ososky at the Smithsonian Institution for helpful discussions; Mathew Lowe and other staff at Cambridge University for permission to record and replicate bones of their fin whale; Phil Rye for assistance with transporting and installing the skeleton; and Stephen Dey of ThinkSee3D for useful discussions, photogrammetry and 3D printing.

Finally, the two anonymous reviewers are thanked for reviewing the manuscript.

References

Baxter, E., 2016. Personal communication [6 January 2016].

BBC News, 2009. *Dead whale washed up at Arnside.* [online] Available at: <http://news.bbc.co.uk/local/cumbria/hi/front_page/newsid_8403000/8403100.stm> [Accessed 28 June 2018].

BBC News, 2013. *UK Storm: Damage disrupts travel as more severe weather hits*. [online] Available at: <https://www.bbc.co.uk/news/uk-25502730> [Accessed 28 June 2018].

Berta, A. (Ed.)., 2015. *Whales, dolphins, and porpoises: A natural history and species guide*. Chicago: University of Chicago Press.

Cumbria Biodiversity Data Centre (CBDC), 2016. Personal communication [15 August 2016]

El Adli, J., 2016. Personal communication [10 August 2016].

Ellis-Petersen, H., 2016 *Boaty McBoatface wins poll to name polar research vessel. The Guardian*, 17 April 2016. [online] Available at: <https://www.theguardian.com/environment/20

16/apr/17/boaty-mcboatface-wins-poll-to-name-polar-research-vessel>.

Gambell, R., Ridgeway, S.H., and Harrison, R., 1985. Handbook of marine mammals. *The sirenians and baleen whales*, 3, pp.155-170.

Larkin, N.R., 2015. Recording, dismantling, cleaning and packing Cambridge University's 70ft-long Finback Whale skeleton. *PDF poster for NatSCA's 'Bone Day' seminar 2015: 'Bone collections: using, conserving and understanding osteology in Museums', Cambridge University Museum of Zoology, 8th September 2015*. [online] Available at: <www.natural-history-conservation.com/CambridgeFinbackWhaleSkeleton.pdf>.

Larkin, N.R., Lomax, D.R., Meehitiya, L, Dey, S and Porro, L., 2016. The discovery in a museum collection of the largest known skeleton of Ichthyosaurus in the world and its redisplay, including 3D printing missing bones. *Programme and Abstracts 64th Symposium on Vertebrate Palaeontology and Comparative Anatomy & 25th Symposium on Palaeontological Preparation and Conservation & Geological Curators' Group meeting, August 2016*. [online] Available at: <http://www.natural-history-conservation.com/ThinktankIchthyosaurPoster.pdf>.

Lomax, D.R., Larkin, N.R., Boomer, I., Dey, S., and Copestake, P., 2017. The first known neonate *Ichthyosaurus communis* skeleton: a rediscovered specimen from the Lower Jurassic, UK. *Historical Biology*, pp.1-10.

NBN Atlas Partnership, 2017. *National Biodiversity Network Atlas.* [online] Available at: <https://species.nbnatlas.org/species/NBNSYS0000005160> [Accessed 21 November 2018].

News and Star, 2014. *Whale washed up on Cumbrian beach*. [online] Available at: <http://www.newsandstar.co.uk/news/Whale-washed-up-on-Cumbrian-beach-e8714314-2f26-4c26-9fc2-88933e6f3397-ds> [Accessed 28 June 2018].

News and Star, 2017. *Driggsby the whale set for grand unveiling*. [online] Available at: <http://www.newsandstar.co.uk/Driggsby-the-whale-set-for-grand-unveiling-0f273823-f12f-4563-933a-43757d8e827b-ds> [Accessed 29 June 2018].

News and Star, 2018a. *Carlisle aims to go 'plastic free' - prompted by ill-fated Driggsby whale*. [online] Available at: <http://www.Newsandstar.co.uk/news/Carlisle-aims-to-go-plastic-free-prompted-by-ill-fated-Driggsby-whale-86640796-d164-41b7-8e73-9d3f7963ba11-ds> [Accessed 19 November 2018].

News and Star, 2018b. *Driggsby the whale set to make a big splash*. [online] Available at: <https://www.newsandstar.co.uk/news/16745762.driggsby-the-whale-set-to-make-a-big-splash/> [Accessed 19 November 2018].

Ososky, J., 2012. History of Collecting, Preparing and Degreasing Whale Skeletons at the Smithsonian Institution. *Conference: La conservation des squelettes gras: méthodes de dégraissage*.

Ososky, J., 2017. Personal communication [4 April 2017].

Reid, J.B., Evans, P.G., and Northridge, S.P., 2003. *Atlas of cetacean distribution in north-west European waters*. Joint Nature Conservation Committee.

Tullie House Museum and Art Gallery, 2016. *Manifesto.* [online] Available at: <http://www.tulliehouse.co.uk/sites/default/files/attachments/pages/tullie_house_manifesto.pdf> [Accessed 28 June 2018].

Turner-Walker, G., 2012. The nature of cleaning: physical and chemical aspects of removing dirt, stains and corrosion. In: *Proceedings of the International Symposium on Cultural Heritage Conservation. Tainan, Taiwan: 6th-8th November 2012, Tainan*.

Using theatre skills in a science exhibition: Dinosaurs of China in Nottingham

Martin Nunn* and Adam S. Smith

Address: Nottingham City Museums and Galleries, Nottingham, UK

*Corresponding author: martin.sciencegeek@gmail.com

Received: 16/07/2018

Accepted: 02/10/2018

Citation: Nunn, M. and Smith, A.S., 2018. Using theatre skills in a science exhibition: Dinosaurs of China in Nottingham. *Journal of Natural Science Collections,* 6, pp.99-111.

Abstract

Dinosaurs of China was a world-exclusive temporary exhibition of iconic, mostly feathered dinosaur fossils, which have revolutionised our understanding of dinosaur appearance and biology over the last 20 years. Hunter the *Sinraptor* was a puppeteer-operated semi-animatronic theropod dinosaur costume. Hunter, accompanied by Dinosaur Rangers, publicised the exhibition within Nottingham and beyond, visited schools to explore dinosaur ecology, and interacted with visitors to the exhibition. The process of putting this element of the exhibition into place included procurement of the costume, 'Dino-Factor' auditions to find a skilled puppeteer, and recruitment of volunteer Rangers. Hunter and the Rangers contributed towards exhibition marketing and the public learning experience. There is an extensive body of literature on the value of integrating dramatic arts into schools and museums, and our findings add to this body of evidence. Hunter inspired engagement with science in formal and informal settings. However, the dinosaur had mixed impacts on visitor expectations, with some anticipating animatronics to feature within the exhibition itself. In conclusion, we show that if used with care, theatre and performance skills can boost marketing and enhance scientifically rigorous learning experiences.

Keywords: dinosaurs, puppets, theatre, drama, China, animatronic, Nottingham, science education

Introduction

From July to October 2017, Nottingham City Museums and Galleries (NCMG) hosted an exhibition of iconic dinosaurs and Mesozoic birds from China. The specimens on display spanned from the Early Jurassic to Late Cretaceous, and told a story of our changing understanding of dinosaurs and their relationship to living birds (Smith and Qi, 2017; Smith and Qi, in prep.). On display were dinosaur species known from the early expeditions of Roy Chapman Andrews (Granger and Gregory, 1923; Osborn, 1924; Andrews, 1932), species discovered during the early days of Chinese palaeontology by C.C. Young (Sekiya and Dong, 2010; Young and Zhao, 1972), and stunning recent discoveries of feathered dinosaurs (Chen, Dong, and Zhen,1998; Xu, Wang, and Wu, 1999; Xu , Zhou, and Prum, 2001; Xu et al., 2003; Xu and Norell, 2004; Xu et al., 2007; Xu et al., 2015; Zhang et al., 2008).The latter have radically changed our understanding of dinosaur appearance and biology over the past 20 years (Benton et al., 2008; Zhou, Barrett and Hilton, 2003; Zhou, 2006; Zhou and Wang, 2010; Zhou, 2014; Pan et al., 2013; Zhang et al., 2010; Smithwick et al., 2017).

Two key messages of the exhibition were: (a) many dinosaurs were feathered, and (b) the dinosaur origin of birds (Chiappe, 2004; Zhou, 2004; Hone, 2010; Chatterjee and Templin, 2012; Smith and Qi, 2017). Consequently, many of the fossils in the exhibition were feathered dinosaurs, including holotypes (e.g. real fossils of *Microraptorgui* Xu et al., 2003 and *Caudipteryx dongi* Xu and Wang, 2000) and other scientifically significant specimens (e.g. *Sinosauropteryx prima* Ji and Ji, 1996; *Yanornis martini* Zhou and Zhang, 2001; *Confuciusornis sanctus* Hou et al., 1995).

As part of the planning for the Dinosaurs of China exhibition, NCMG decided to purchase an animatronic dinosaur puppet as a promotional tool. This 'animal' became known as Hunter (Figure 1). Once in operation, it became clear that as well as being an excellent marketing tool, Hunter possessed considerable potential as an educational resource.

Figure 1. Hunter outside Wollaton Hall. (image NCC 2017)

The efficacy of the dramatic arts in science education

There is an extensive literature on the impact of drama-related activities and theatrical performances on science literacy in school and museum environments. Many of these are anecdotal and non-qualitative regarding the efficacy of the techniques used, yet all point towards positive outcomes and benefits to the approach. A number of authors (Bicknell and Fischer, 1994; Baum and Hughes, 2001; OkurBerberoglu et al., 2014) have attempted to provide qualitative and/or quantitative evidence, and they all show a strong positive impact for theatre programmes.

Classroom environments

According to Dorion (2009), there is a long history of using cross-curricular drama activities in education, possibly dating back over 300 years, but such approaches have only been applied to science education since the 1980s. One of the earliest exponents was Cornell (1979; 1989) who popularised the use of play in environmental education. Since then, many approaches and artistic forms have been used within the classroom environment, such as shadow puppets (Tselfes and Paroussi, 2009), role-play (McSharry and Jones, 2000), magic and role-play (Papalaskari et al., 2006), along with traditional theatre plays (Odegaard, 2003; Dorion, 2009). These studies all agree that theatre is an effective way to engage children of various ages with science, but there is little evidence to support the development of factual knowledge through these techniques. Overviews of a range of techniques broadly support this view (Bruner, 1992; Mesure, 2005; Kind and Kind 2007). These works agree that there is a need for high quality quantitative studies to support anecdotal reports of efficacy.

Out of classroom environments

The situation for out of classroom environments is similar. A Centre For Advancement of Informal Science Education (CAISE) report (McCallie et al., 2009), and work by Ledgard (2008) and Peleg and Baram-Tsabari (2011), all agree that people can learn through theatre and become emotionally engaged. Peleg and Baram-Tsabari (2011) stressed the importance of theatre for early exposure to scientific ideas and principles with primary school children. Ledgard (2008) focused on the usefulness of these techniques for tackling social and societal issues, especially with potentially contentious questions, where it can act as a springboard for debate. McCallie et al. (2009) recognised the value of drama as one of many tools that informal science education facilities can use for public engagement with, and understanding of, science. They also noted that the dramatic arts can play a role in building a more scientifically literate society with a population better able to contribute towards reasonable decision making. Chemi and Kastberg (2015) evaluated different approaches and demonstrated that, in general, performances that actively engage the audience into becoming a part of the performance are the most effective. This is something that we attempted to achieve with Hunter. Again, the majority of literature examined on this matter agrees that further research is needed.

Museums

The picture within the museum environment is somewhat more robust. There is a longer history of using theatre-inspired interpretation activities to support museum learning (Alsford and Parry, 1991). The origins of this approach appear to be linked closely with living history and outdoor sites, with a slower uptake amongst indoor museums (ibid). Museums need a slightly different approach to more formal educational establishments, as they are destinations for leisure as well as educational outings. Consequently, both the educational and entertainment value of performances needs to be high (ibid). Due to this long history, there are a number of studies that have produced quantitative evidence for the efficacy of this approach. Bicknell and Fisher (1994) found that most visitors - and especially children - enjoy these shows, and this results in an increased engagement with the museum environment. Further, they state that performances are a "...success in communicating information, complexity, content and clarify detail..." (Bicknell and Fisher, 1994: p.86). Similarly, Baum and Hughes (2001) found drama approaches to be good for exploring complex ideas, developing emotional connections, and often led to deeper, more nuanced thoughts on a topic. OkurBerberoglu et al. (2014) conducted a statistical analysis on the effectiveness of a theatre performance compared to a lecture, and found that audiences who watched the theatre show had better retention of knowledge than those who attended the lecture.

School field trips

There are also a number of evaluations of school field trips. Behrendt and Franklin (2014) noted that "experiential learning at formal and informal field trip venues increases students interest, knowledge and motivation" (ibid: p.235), but went on to note that the teacher's role in planning implementation and reflection after the visit are essential for a worthwhile field trip. Whitesell (2016) analysed the impact of field trips on long-term knowledge retention and performance in standardised science test scores. The statistical analysis found a small positive impact for disadvantaged children, which may be down to them getting limited educational enrichment opportunities outside of the school environment.

Other examples

We can also look beyond academic literature to see impacts of drama on science learning. The eminent physicist Stephen Hawking co-authored an excellent children's adventure novel to communicate cosmological ideas to a young audience (Hawking and Hawking, 2008). Children's book author Jonathan Emmett has produced a wonderful introduction to the process of evolution for preschool and 'early years' children (Emmett, 2018). Palaeontologist Steve Brusatte has credited the original *Jurassic Park* movie with inspiring an interest in palaeontology: "So many of my colleagues, people of my age, my generation, would tell you point-blank that *Jurassic Park* made them want to be a scientist, and it's true that a lot of museums and a lot of universities started to hire palaeontologists right after that film, because dinosaurs exploded." (Anthony, 2018). The value of literature and film for exploring science has also been espoused by Klein (2006).

Consequently, there is strong justification for the use of a dinosaur puppet in an appropriately considered theatrical performance as a mechanism for enlightening people of all ages on the wonders of the Mesozoic world.

Design and Purchase

The first stage in realising the vision to have a dinosaur mascot for the exhibition was to acquire a puppet or costume. A number of companies in China manufacture these types of puppets as off-the-peg items. NCMG wanted a puppet that would represent one of the dinosaur skeletons in the exhibition, and a feathered dinosaur puppet would have been ideal for pre-empting and reinforcing key messages from the exhibition. From a marketing perspective, something large and eye catching was desirous. To be functional and realistic-looking, choices were limited to large bipedal dinosaurs, allowing an operator to climb inside the costume. Unfortunately, most feathered dinosaurs are small (under a metre long in most cases), and no convincing feathered dinosaur puppets were available.

Due to these constraints, the choice was narrowed down to the large, non-feathered, predatory theropod *Sinraptor*, from the Jurassic (Currie and Zhao,1993). A seven-metre-long sub-adult skeleton of *Sinraptor dongi* Currie and Zhao, 1993 was a star attraction in the exhibition (Figure 2). A small (i.e. juvenile) *Sinraptor* puppet was selected as the most appropriate mascot to represent the exhibition.

Figure 2. Sinraptor dongi *replica skeleton in the Great Hall. (image NCC 2017)*

A *Sinraptor* puppet was also relatively cost-effective to manufacture. At the request of the exhibition curator (author AS), Chinese company Ocean Arts were able to make bespoke modifications to one of their off-the-peg *Tyrannosaurus rex* Osborn, 1905 puppets. These modifications included a larger and longer *Sinraptor*-like arm, a three-fingered hand, and a custom paint finish. The result was a unique 3.5-metre-long stylised representation of a juvenile *Sinraptor*.

Recruitment and character development

A puppeteer was selected via an audition process that we called 'Dino-Factor' in a parody of the well-known television talent show X-Factor. This was judged by a panel of people from the Dinosaurs of China Project Executive Group, and also included a Simon Cowell (a member of the X-Factor panel) lookalike (Figure 3a). The panel were looking for people possessing the physical ability and skills to bring the puppet to 'life' in the eyes of an audience. This genuine recruitment process was also a part of the overall pre-publicity and marketing strategy, and generated a lot of interest from local media (ITV, 2017; Johns, 2017). It also allowed NCMG to recruit a highly skilled puppet operator, Izzy Hollis (Figure 3b), who gave Hunter his own individual character and behavioural quirks, which were key to making him come to life in the eyes of the audience.

The character of Hunter that developed was predominantly that of a mischievous puppy, for a number of reasons. Firstly, some young children found the costume frightening, so it was important to make Hunter friendly while still a bit edgy and naughty. Secondly, at a little over three metres long, Hunter was considerably smaller than an adult *Sinraptor*. Ascribing an actual numerical age to Hunter was difficult (see 'Educational appearances' below), but a very young animal is certainly within the bounds of plausibility for an allosauroid of this size. Thirdly, it gave a light-hearted, comedic element to performances and appearances, making the overall experience less threatening for audiences in general. This is a factor for some adults who feel intimidated by performances in a non-theatre environment (Bicknell and Fisher, 1994). The naughty puppy persona was observed by the team responsible for Hunter to go down well with a wide range of audiences. However, no formal evaluation was conducted for Hunter the dinosaur.

Hunter's antics included such set pieces as dancing the 'Hunter Shuffle'; stealing the Dinosaur Ranger's hat; back-scratching against any convenient tree, post, or person; attempting to steal people's lunches; and urinating while cocking his leg (with the help of a water bottle carried by the puppeteer). Hunter's interactions with the Dinosaur Rangers were also a key element in the performance.

Making Hunter 'real' was a complicated and skilled achievement, and is an area where cutting costs would have been highly detrimental to the whole venture. A professional puppeteer was able to bring in skills and techniques to enhance Hunter in ways

Figure 3.(A) Dino-Factor interview panel, (B) Puppeteer Izzy Hollis (image NCC 2017)

that a layperson operating the dinosaur would struggle to achieve.

A team of volunteer 'Dinosaur Rangers' (including author MN) were also recruited to accompany Hunter (Figure 4). Hunter visits occurred on an almost daily basis over a seven-month period. There was a core team of about ten regular Dinosaur Rangers, but 80 volunteers worked alongside Hunter in total. Their role was intended to ensure the safety of Hunter and onlookers in crowds and to distribute publicity materials and information about the exhibition. This included protecting the public from a half-blind dinosaur – there was very limited visibility from within the puppet, and the tail was unwieldy and at head height. Crowd control was the main priority for Rangers to ensure people didn't push, pull, or try to jump on Hunter, and to provide directions for the puppeteer, making them aware of hazards, uneven surfaces, and little children wanting to meet the dinosaur. Rangers would also answer questions and encourage people to visit the exhibition. The Rangers also assisted the puppeteer with getting in and out of the costume and transporting it to the performance location.

Figure 4. Volunteer Dinosaur Rangers preparing for an appearance at Trent Bridge Cricket Ground. (image NCC 2017)

The normal minimum number of Rangers was two, but it was possible for a single experienced Dinosaur Ranger to accompany Hunter on some occasions. Up to five Rangers were needed for crowd control at busy locations, so that one Ranger could still hand out leaflets and engage with people. It became apparent very quickly that the Dinosaur Rangers also had a valuable role to play in creating the character of Hunter, by performing as animal handlers/trainers, and trying to make a mischievous, yet highly dangerous, 'puppy' behave in public. This role-play element became even more important while accompanying Hunter on school and other educational visits (see below).

Maintenance

A number of repairs were required over the seven months of use, particularly to the soles of the feet and the cables operating the jaw. The only way to repair the cabling was to cut open the head and peel back the outer silicone rubber 'skin' and inner high-density sponge 'flesh' of the costume, to reveal the metal frame and mechanical workings inside the 'skull' (Figure 5). Replacement cables had to be custom made and installed. NCMG are indebted to a local classic motorbike enthusiast, John Birtles (Figure 5c), for assisting with these repairs for free. Most professional puppeteers make their own puppets, and this was an unexpected benefit of the 'Dino-Factor' recruitment process; our puppet operator was able to carry out all cosmetic repairs and to resole the feet of Hunter. By the end of a gruelling seven months of almost daily use, other areas of the body were also showing signs of wear-and-tear, indicating that we were close to the end of Hunter's useful lifespan (without major refurbishment).

Figure 5. Clockwise from top left, (A) Inside the 'skull', (B) MN learning dinosaur brain surgery, (C) John Birtles manufacturing custom built cables, (D) Izzy Hollis (puppeteer) completing cosmetic repairs. (images Martin Nunn 2017)

Additionally, there was wear-and-tear on the puppeteer. Being encased in a heavily-insulated 40kg foam structure placed a considerable physical strain on the operator, in terms of the weight and the temperature inside the costume (especially on hot summer days). In order to combat the heat strain, an ice-pack-filled waistcoat was purchased. However, in summer these could all melt during the first performance slot. Consequently, performance times were limited to a maximum of four 30-40 minute slots per day.

Marketing

Marketing efforts for the exhibition started in early 2016, well in advance of the 1 July 2017 opening, and continued until the close of the exhibition at the end of October 2017. Hunter made his first appearances for the marketing campaign in April 2017, alongside Chris Packham (television presenter and naturalist), who endorsed Dinosaurs of China (Figure 6).

Figure 6. Television presenter and naturalist Chris Packham with Hunter (image NCC 2017)

Between April and October 2017, Hunter appeared at 129 marketing events. These were mostly focused in Nottinghamshire, but there were wider regional appearances in Leicestershire, Derbyshire, and South Yorkshire, visiting cities, towns and villages between Leicester and Sheffield (north to south), as far east as Melton Mowbray and as far west as Derby.

Types of venues included shopping centres, museums, adult education venues, sports venues and events, theatrical events, fun days and carnivals, and many others (e.g. East Midlands Airport, Nottingham University) (Figure 7).

The specific activities during these appearances varied depending on the venue. Some locations such as shopping centres, carnivals, festivals, and museums revolved around Hunter mingling with crowds, and interacting with members of the public and the Rangers. At venues such as sports stadiums, or the Lord Mayor's parade, the public were mostly separated from Hunter. On these occasions, the focus was on Hunter performing and interacting with the Rangers, and when possible meeting audience members in the front row, especially children.

Hunter was popular, and generated a significant interest among the public and media. BBC Radio Nottingham posted a video of Hunter that received 14,000 views (EDEN, 2018). Hunter's social media presence on Facebook and Twitter was high, with regular updates. Hunter's most popular Facebook post reached 5,459 people (EDEN, 2018). Visitor surveys (University of Nottingham, 2017) conducted during the exhibition showed that 37% of those questioned had heard about the exhibition on social

Figure 7. (A) Hunter at Nottingham Forest FC Stadium on match day. (B) Hunter visiting a carnival. (Images NCC 2017)

media, with only 14% having heard about the exhibition through more traditional news sources and advertising. This clearly shows the growing importance of social media for the promotion of exhibitions, and Hunter influenced NCMG's utilisation of these new media outlets. However, word of mouth was the biggest awareness factor, at 49% (Figure 8). The survey also demonstrated that people were visiting from across the country (Table 1). Some visitors to the exhibition certainly attended as a direct result of an encounter with Hunter (MN pers. obs.).

Marketing leaflets and banners also capitalised on Hunter, and featured an artist's recreation of *Sinraptor* and feathered dinosaurs as they may have been in life (Figure 9). However, few fossil skeletons were depicted in the promotional material, as the marketing team believed that lifelike depictions of dinosaurs would be more likely to attract greater numbers of visitors.

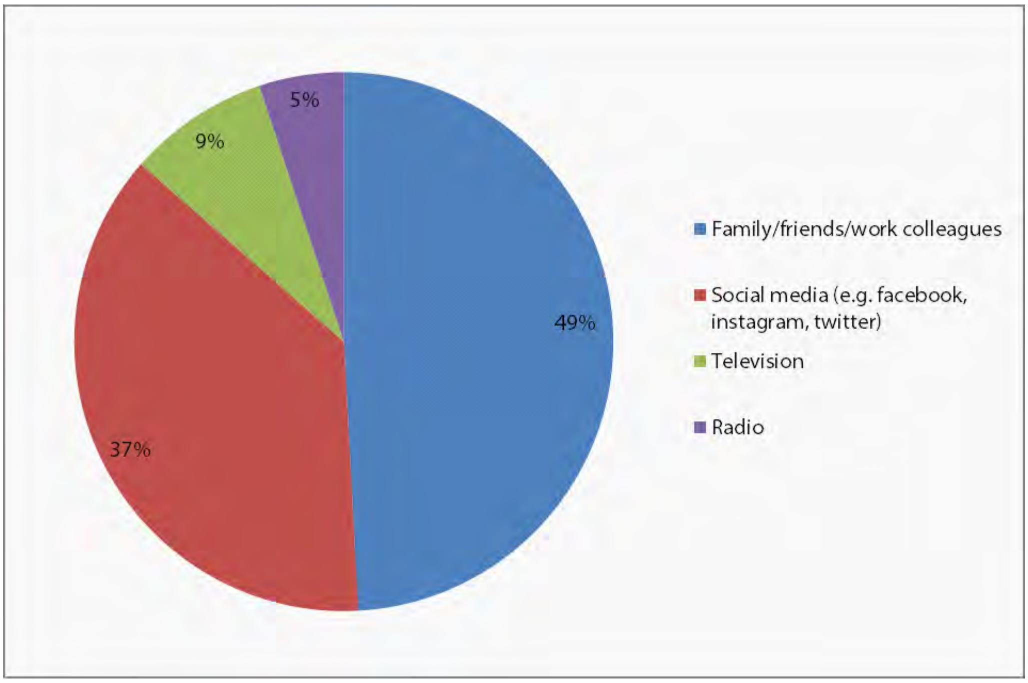


Figure 8. Visitor Survey responses to the question, 'How did you hear about the exhibition (tick all that apply)?'. Total count 118. Adapted from University of Nottingham, 2017.

Table 1. Visitor Survey, responses to the question 'Where have you travelled from today?'. Adapted from University of Nottingham, 2017.

Answer	**%**	**Count**	
Nottingham	50.68	75	
Derbyshire	23.65	35	
Leicestershire	10.81	16	**Other**
Lincolnshire	1.35	2	Milton Keynes
Cambridgeshire	2.03	3	Blackpool
Yorkshire	5.41	8	Birmingham
London	1.35	2	Hampshire
Other	4.73	7	Hertfordshire
			Gloucestershire
Total	100	148	Germany

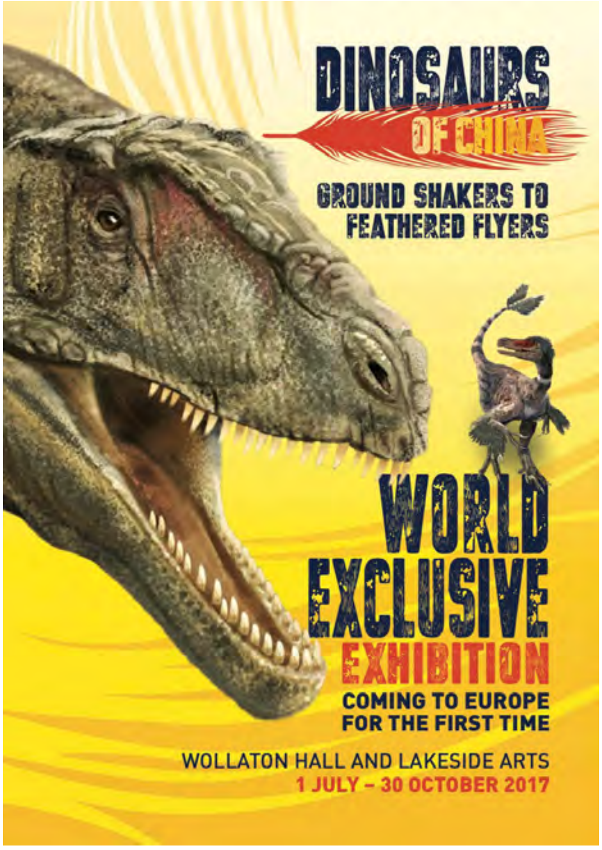


Figure 9. Example of marketing leaflet distributed by Dinosaur Rangers. (image NCC 2017)

Educational appearances

Primary school visits were initially viewed as a marketing tool aimed at the child demographic. Engagement with Hunter and the Rangers was high, and it soon became apparent that these visits were also an ideal opportunity to explore a range of biological and ecological topics. To enhance the connection between Hunter and the fossils in the exhibition, some Rangers adopted a dress and persona reminiscent of Roy Chapman Andrews (plus a little bit of lion tamer). This created a storyline and rationale for the school visits. A familiarity with Roy's life and his expeditions to China and Inner Mongolia was essential (Andrews, 1918; 1921; 1932). It also required a familiarity with non-avian dinosaurs in general, particularly theropods and the primary literature pertaining to *Sinraptor* (Yuhui 1992; Currie and Zhao, 1993; Currie, 2006; Carabajal and Currie, 2012; Fastovsky and Weishampel, 2012; Naish and Barrett, 2016; Paul, 2016). The person carrying out this role also needed to be a competent actor or role-player. It is quite a specific skill set, one described by Alsford and Parry (1991: p.18) as "actor-interpreters". Our experience concurs with those of Alsford and Parry (ibid), who assert that roles of this kind require research time and training.

The interaction between Hunter and 'Roy' often became a springboard for wider discussions and interactive Q&A sessions. Common topics covered in these sessions included predator-prey relationships, predator adaptations, dentition and dental growth, evolution of feathers, birds as dinosaurs, and ontogenetic change and growth rates. One of the most common questions during school visits was"how old is Hunter?", asked in the context of whether he is an adult or a baby. In other words, how accurate is the puppet? This was actually one of the hardest questions to answer honestly and accurately.

Calculations from the published literature (e.g. Currie and Zhao, 1993; Christiansen and Farina 2004; Bybee, Lee and Lamm, 2006; Foster and Chure, 2006; Therrien and Henderson, 2007; Hendrickx and Mateus, 2012) demonstrate that Hunter's proportions are not consistent with those of a juvenile. Based on the puppet's measured height, skull length, and femur length, Hunter is close to a six-year-old animal. However, a six-year-old allosauroid would have a body length almost double that of the puppet, and would weigh about the same as a small racehorse. Based on body length, Hunter would be around three years old, but would only stand around a meter tall and would weigh about the same as a large dog. Overall, Hunter's size and proportions are closest to a heavily foreshortened six-year-old sub adult animal. However, we chose to represent Hunter as a three-year-old juvenile, characterised as a naughty puppy, which was an engaging narrative, especially with younger children. This was consistent with his length, but not his body proportions or height. In any case, the whole concept requires a suspension of disbelief, as Hunter was anthropomorphised a lot, and we ignored the fact that a real *Sinraptor* would likely rip apart and consume any Dinosaur Ranger and audience members at the drop of a hat.

24 primary schools were visited in the build-up to and during the exhibition. Most of these visits were one-off extended assemblies; however, a few schools did incorporate Hunter's visit into a wider programme of study on dinosaurs. Some schools followed up Hunter's visit with a trip to see the fossils at the Nottingham Natural History Museum (Wollaton Hall). Hunter's visits to schools were enjoyed by the children (Figure 10) and appreciated by the teaching staff.

Figure 10. Positive reactions to a school visit. (image NCC 2017)

Hunter at Wollaton Hall

Limited space and the risk of damaging the exhibits meant that Hunter was unable to appear inside the museum. However, a Dinosaurs of China educational activity marquee was operational each day outside the museum, and so Hunter made regular appearances there (Figure 11). Visitors and schools who interacted with Hunter around the education marquee reported that it heightened their enjoyment and made the visit more memorable for them (MN pers. obs.). Hunter's performances in this area increased over time as external marketing decreased, and as it became apparent that many visitors came to the exhibition hoping or expecting to see animatronic dinosaurs. In total, Hunter made 136 separate performances outside Wollaton Hall.

Impact on visitor expectations

The response to Hunter was overall positive (except for a few dogs!), and it helped raise awareness about the exhibition (EDEN, 2018). Volunteers unanimously reported that Hunter was great for 'creating a buzz', and he was very popular for photo opportunities with the press and the public (EDEN, 2018).

Using a large theatrical prop is certainly an approach that NCMG would utilise with future exhibitions. However, care needs to be taken with marketing, as a few visitors did come expecting to see a theatrical extravaganza of animatronic dinosaurs and were disappointed when confronted with the actual dinosaur fossils. Hunter may have contributed to these erroneous expectations. A greater emphasis on fossils and skeletons, with collections at the forefront of marketing, could result in a more balanced and realistic set of expectations.

Lessons for the future

The educational potential of Hunter was not initially recognised, but was applied as much as possible later during the Dinosaurs of China project. It would be

Figure 11. (A) Hunter at Wollaton Hall outside the activity marquee (image NCC 2017) (B) Children enjoying hands on extension activities to the Dinosaurs of China exhibition. (image Martin Nunn 2017).

beneficial for similar endeavours to look closely at how marketing and educational objectives can both be met early in the planning phase. There is a wide array of potential educational uses for puppetry in a science exhibition that could be investigated in any future projects. For example, longer school visits to allow a deeper dive into the subject matter, and encouraging schools (through the supply of teaching resources and lesson plans) to incorporate the topic into their teaching and not view a visit as a one-off activity. As noted above, Behrendt and Franklin (2014) stressed how important this ongoing engagement of teachers is, from planning to reflection, for the beneficial attributes of a field trip to be maximised.

Furthermore, advanced planning for educational content during school visits would have allowed for key learning objectives to be incorporated into these activities. For example, key messages in the exhibition related to our changing understanding of dinosaur ecology, in particular the prevalence of feathers and the relationship with birds. These could have been formalised into a school visit through the use of a second small feathered dinosaur puppet, accompanying Hunter. This would have helped reinforce the latest developments in palaeontological research in this area. The feasibility of conducting formal evaluations of these visits should also be considered.

Another possible approach would be using the puppet or other theatrical techniques with museum visitors to complement the interpretation within the exhibition. The goals would be to stimulate a deeper engagement and interest in the scientific questions, lengthen gallery dwell times, and encourage a more detailed examination of the museum exhibits. Based on previous studies and our own experience, such a balance is achievable with careful planning and allocation of resources.

A human companion (the role of our Dinosaur Rangers) is key to engaging with an audience when a character, like the puppet Hunter, is unable to communicate verbally with the audience. When engaging in an educational setting, this person needs to have a high level of detailed scientific knowledge on the subject matter, a high proficiency in science communication, and an ability to interact naturally and realistically with the puppet. In short, they need to be able to fulfil the role of actor interpreter as defined by Alsford and Parry (1991: p.18). Recruitment of a suitable person would best be carried out at the same time as recruitment of the puppeteer.

It is clear that there is a strong role for drama in science education, and NCMG's use of Hunter is therefore another example of a successful integration of these two paradigms.

Acknowledgements

We thank Wang Qi for being the inspiration behind the exhibition; Izzy Hollis for bringing Hunter to life; all of the volunteers who accompanied Hunter on visits; Rebecca Wilson and Karen Lushy for coordinating Hunter's appearances; Rachael Evans for her help supplying data, clarifying issues, and proof reading; Graham Armitage and all of the heritage assistants at Wollaton Hall; and John Birtles for making Hunter roar again!

References

Alsford, S. and Parry, D. 1991. Interpretive theatre: a role in museums*? Museum Management and Curatorship*, 10, pp.8-23.

Andrews, R.C., 1918. *Camps and Trails in China. A narrative of exploration, adventure and sport in little known China*. New York: D. Appleton and Company. [online] Available at: <https://archive.org/details/campsandtrailsi00unkngoog/page/n6> [Accessed 16 November 2018].

Andrews, R.C., 1921. *Across Mongolian Plains. A naturalist's account of Chinas great northwest*. New York: D. Appleton and Company. [online] Available at: <https://archive.org/details/acrossmongolianp00andr/page/n9> [Accessed 16 November 2018].

Andrews, R.C., 1932. *The new conquest of Central Asia. A narrative of the explorations of the Central Asiatic expeditions in Mongola and China, 1921-1930*. New York: The American Museum of Natural History. [online] Available at: <https://archive.org/details/newconquestofcen00andr/page/n9> [Accessed 16 November 2018].

Anthony, A., 2018. *Palaeontologist Steve Brusatte: we owe Jurassic Park a debt of gratitude*. [online] Available at: <https://www.theguardian.com/science/2018/may/13/steve-brusatte-palaeontologist-debt-gratitude-jurassic-park> [Accessed on 16 November 2018].

Baum, L. and Hughes, C., 2001. Ten Years of evaluating science theatre at the Museum of Science Boston. *Curator, The Museum Journal*, 44(4), pp.355-366.

Behrendt, M. and Franklin, T., 2014. The review of research on school field trips and their value in education. *International Journal of Environmental & Science Education*, 9, pp.235-245.

Benton, M.J., Zhou, Z., Orr, P.J., Zhang, F., and Kearns, S.L., 2008. The remarkable fossils from the Early Cretaceous Jehol Biota of China and how they have changed our knowledge of Mesozoic life. *Proceedings of the Geologists' Association*, 119, pp.209-228.

Bicknell, S. and Fisher, S., 1994. Enlightening or embarrassing? Drama in the Science Museum, London, UK. *Visitor Studies*, 6(1), pp.79-88.

Bruner, J., 1992. Science education and teachers: a Karplus Lecture. *Journal of Science Education and Technology*, 1(1), pp.5-12.

Bybee, P.J., Lee, A.H., and Lamm, E-T., 2006. Sizing the Jurassic theropod dinosaur *Allosaurus*: Assessing growth strategy and evolution of ontogenetic scaling of limbs. *Journal of Morphology*, 267, pp.347-359.

Carabajal, A.P. and Currie P.J., 2012. New information on the braincase of *Sinraptor dongi*. *Vertebrata Pal. Asiatica*, 50(10), pp.85-101.

Chatterjee, S. and Templin, R.J., 2012. Palaeoecology, aerodynamics, and the origin of flight. In: Talent, J.A. (ed). *Earth and Life*. Heidelberg: Springer-Verlag. pp.585-612.

Chemi, T. and Kastberg, P., 2015. Education through theatre: typologies of science theatre. *Applied Theatre Research*, 3(3), pp.53-65.

Chen, P.J., Dong, Z.M., and Zhen, S.N., 1998. An exceptionally well preserved theropod dinosaur from the Yixian Formation of China. *Nature*, 391, pp.147-152.

Christiansen, P. and Farina, R.A., 2004. Mass prediction in theropod dinosaurs. *Historical Biology*, 16(2-4), pp.85-92.

Chiappe, L.M., 2004. The closest relatives of birds. *Ornitologica Neotropical*, 15(Suppl.), pp.101-116.

Cornell, J.B., 1979. *Sharing nature with children*. Nevada City, US: Dawn Publications.

Cornell, J.B., 1989. *Sharing the joy of nature*. Nevada City, US: Dawn Publications.

Currie, P.J., 2006. On the quadrate of *Sinraptor dongi* (Theropoda: Allosauroidea) from the late Jurassic of China. In: Cziki, Z., (ed.). *Mesozoic and Cenozoic vertebrates and paleoenvironments. Tributes to the career of Prof. Dan Grigorescu*. Bucharest: Editura Ars Docendi. pp.111-115.

Currie, P.J. and Zhao, X.J., 1993. A new carnosaur (dinosaur, Theropoda) from the Jurassic of Xinjiang, People's Republic of China. *Canadian Journal of Earth Sciences*, 30(10), pp.2037-2081.

Dorion, K.R., 2009. Science through drama: a multiple case exploration of the characteristics of drama activities used in secondary science lessons. *International Journal of Science Education*, 31(16), pp.2247-2270.

EDEN Public Relations Consultants, 2018) Campaign review. [unpublished report]

Emmett, J., 2018. *How the Borks became*. Burley Gate: Otter-Barry Books Ltd.

Fastovsky, D.E. and Weishampel, D.B., 2012. *Dinosaurs: A Concise Natural History (2nd Edition)*. Cambridge: Cambridge University Press.

Foster, J.R. and Chure, D.J., 2006. Hind limb allometry in the Late Jurassic theropod dinosaur Allosaurus, with comments on its abundance and distribution. In: Foster, J.R. and Lucas, S.G. (eds). *Paleontology and Geology of the Upper Jurassic Morrisson Formation. New Mexico Museum of Natural History and Science Bulletin 36*. pp.119-122.

Granger, W. and Gregory, W.K., 1923. *Protoceratops andrewsi*, a pre-ceratopsian dinosaur from Mongolia. *American Museum Novitates*, no.72.

Hawking, L. and Hawking, S., 2008. *George's secret key to the universe*. Corgi Children's.

Hendrickx, C. and Mateus, O., 2012. Ontogenetical changes in the quadrate of basal tetanurans. In: Royo-Torres, R., Gascó, F., and Alcalá, L., (coord). *10th Annual Meeting of the European Association of Vertebrate Palaeontologists. ¡Fundamental!*, 20, pp.101–104.

Hone, D., 2010 Dinosaurs of a feather. *Bulletin of the Chinese Academy of Sciences*, 2, pp.92-94.

ITV, 2017. *Casting call for city's dinosaur - do you have the 'Dino-Factor'?* ITV Report 20 March at 1:30pm. [online] Available at: <http://www.itv.com/news/central/2017-03-20/casting-call-for-citys-dinosaur/> [Accessed 16 November 2018].

Johns, B., 2017. *Dinosaur handlers being recruited for Wollaton Hall exhibition*. Notts T.V. April 26. [online] Available at: <https://nottstv.com/dinosaur-handlers-recruited-wollaton-hall-exhibition/> [Accessed 16 November 2018].

Kind, P.M., and Kind, V., 2007. Creativity in science education: Perspectives and challenges for developing school science. *Studies in Science Education*, 43, pp.1-37.

Klein, P.D., 2006. The challenges of Scientific Literacy: from the viewpoint of second generation cognitive science. *International Journal of Science Education*, 28(2-3), pp.143-178.

Ledgard, A., 2008. Visiting Time and Boychild: site-specific pedagogical experiments on the boundaries of theatre and science. In: Parry, S., Matterson, C., Nicholson, H., Winston, J., Caccavale, E., Reiss, M., Lotto, R.B., Downham, S.J., Strudwick, D., Heppell, S., Pinching, A., Teare, J., Turley, S., Ledgard, A., Levinson, R., Barton, A.C., O'Neill, T., Chappell, K., McNamara, C., and Rooke, A., 2008. *Creative Encounters: New conversations in science, education and the arts*. London: Wellcome Trust.

McCallie, E., Bell, L., Lohwater, T., Falk, J.H., Lehr, J.L., Lewenstein, B.V., Needham, C., and Wiehe, B., 2009. Many Experts, Many Audiences: Public Engagement with Science and Informal Science Education. A CAISE Inquiry Group Report. Washington, D.C.: Center for Advancement of Informal Science Education (CAISE). [online] Available at: <http://caise.insci.org/uploads/docs/public_engagement_with_science.pdf>.

McSharry, G., and Jones, S., 2000. Role-play in science teaching and learning. *School Science Review*, 82(298), pp.73-82.

Mesure, S., 2005. Creativity in science: the heart and soul of science teaching. *Education in Science*, 214, pp.12-14.

Naish, D. and Barrett, P., 2016. *Dinosaurs: How they lived and evolved*. London: Natural History Museum.

Odegaard, M., 2003. Dramatic science. A critical review of drama in science education. *Studies in Science Education*, 39, pp.75-102.

Osborn, H.F., 1924. Three new theropoda, Protoceratops zone, Central Mongolia. *American Museum Novitates*, 144, pp.1-12.

OkurBerberoglu, E., Ozdilek, S.Y., Sonmez, B., and Olgun, O.S., 2014. Theatre and sea turtles: an intervention in biodiversity education. *International Journal of Biological Education,* 3(1), pp.24-40.

Pan, Y., Sha, J., Zhou, Z., and Fursich, F.T., 2013. The Jehol Biota: Definition and distribution of exceptionally preserved relics of a continental Early Cretaceous ecosystem. *Cretaceous Research*, 44, pp.30-38.

Papalaskari, M.A., Hess, K., Kossman, D., Metzger, S., Phares, A., Styer, R., Titone, C., Way, T., Weinstein, R., and Wunderlich, F., 2006. PIVOTS: Service learning at the science, theatre & magic boundary. *Proceedings of the 36th ASEE/IEEE Frontiers in Education Conference.*

Paul, G.S., 2016. *The Princeton Field Guide to Dinosaurs, 2nd Edition*. Princeton: Princeton University Press.

Peleg, R., and Baram-Tsabari, A. 2011. Atom Surprise: using theatre in primary science education. *Journal of Science Education and Technology*, 20(5), pp.508-524.

Sekiya, T. and Dong, Z., 2010. A New Juvenile Specimen of *LufengosaurusHuenei* Young, 1941 (Dinosauria: Prosauropoda) from the Lower Jurassic Lower Lufeng Formation of Yunnan, Southwest China. *Journal of the Geological Society of China*, 84(1), pp.11-21. [online] Available at: <https://doi.org/10.1111/j.1755-6724.2010.00165.x> [Accessed 16 November 2018].

Smith, A. and Qi, W., 2017. *Dinosaurs of China: ground shakers to feathered flyers*. Nottingham: Nottingham City Council.

Smith, A. and Qi, W., In prep.. From China to Nottingham: The Making of Dinosaurs of China. *Journal of Natural Science Collections*. (Accepted for publication January 2019).

Smithwick, F.M., Nicholls, R., Cuthill, I.C., and Vinther, J., 2017. Countershading and stripes in the theropod dinosaur *Sinosauropterix* reveal heterogeneous habitats in the Early Cretaceous Jehol Biota. *Current Biology*, 27, pp.1-7.

Therrien, F. and Henderson, D.M., 2007. My theropod is bigger than yours...or not: body size from skull length in theropods. *Journal of Vertebrate Paleontology*, 27(1), pp.108-115.

Tselfes, V. and Paroussi, A., 2009. Science and theatre education: A cross-disciplinary approach of scientific ideas addressed to student teachers of early childhood education. *Science and Education*, 18(9), pp.1115-1134.

University of Nottingham, 2017. *Dinosaurs of China Wollaton Hall Visitor Survey, 8th-17th August*. [unpublished report]

Whitesell, E.R., 2016. A day at the museum: the impact of field trips on middle school science achievement. *Journal of Research in Science Teaching*, 53(7), pp.1036-1054.

Xu, X. and Norell, M.A., 2004. A new troodontid dinosaur from China with avian-like sleeping posture. *Nature*, 431, pp.838-841.

Xu, X., Tan, Q., Wang, J., Zhao, X., and Tan, L., 2007. A gigantic bird-like dinosaur from the Late Cretaceous of China. *Nature*, 447, pp.844-847.

Xu, X., Wang, X.L., and Wu, X.C., 1999. A dromaeosaurid dinosaur with a filamentous integument from the Yixian Formation of China. *Nature*, 401, pp.262-266.

Xu, X., Zheng, X., Sullivan, C., Wang, X., Xing, L., Wang, Y., Zhang, X. O'Connor, J.K., Zhang, F., and Pan, Y., 2015. A bizarre Jurassic maniraptoran theropod with preserved evidence of membranous wings. *Nature*, 521, pp.70-73.

Xu, X., Zhou, Z., and Prum, R.O., 2001. Branched integumental structures in *Sinornithosaurus* and the origin of feathers. *Nature*, 410, pp.200-203.

Xu, X., Zhou, Z., Wang, X., Kuang, X., Zhang, F., and Du, X., 2003. Four-winged dinosaur from China. *Nature*, 421, pp.335-340.

Young, C.C. and Zhao, X., 1972. *Mamenchisaurus*. *Institute of Vertebrate Paleontology and Paleoanthropology Monograph Series I, No 8* (in Chinese). Translation available at: <http://doc.rero.ch/record/31573/files/PAL_E844.pdf>.

Yuhui, G., 1992. *Yangchuanosaurus hepingensis* - a new species of carnosaur from Zigong, Sichuan. *Vertebrata Pal Asiatica*, 30, pp.313-324 (in Chinese). Translation available at: <https://paleoglot.org/files/Gao_92a.pdf>.

Zhang, F., Kearns, S.L., Orr, P.J., Benton, M.J., Zhou, Z., Johnson, D., Xu, X., and Wang, X., 2010. Fossilized melanosomes and the colour of Cretaceous dinosaurs and birds. *Nature*, 463, pp.1075-1078.

Zhang, F., Zhou, Z., Xu, X., Wang, X., and Sullivan, C., 2008. A bizarre Jurassic maniraptoran from China with elongate ribbon-like feathers. *Nature*, 455, pp.1105-1108.

Zhou, Z., 2004. The origin and early evolution of birds: discoveries, disputes, and perspectives from fossil evidence. *Naturwissenschaften*, 91, pp.455-471.

Zhou, Z., 2006. Evolutionary radiation of the Jehol Biota: chronological and ecological perspectives. *Geological Journal*, 41, pp.377-393.

Zhou, Z., 2014. The Jehol Biota, an Early Cretaceous terrestrial Lagerstatte: new discoveries and implications. *National Science Review*, 1, pp.543-559.

Zhou, Z., Barrett, P.M., and Hilton, J., 2003. An exceptionally preserved Lower Cretaceous ecosystem. *Nature*, 421, pp.807-814.

Zhou, Z. and Wang, Y., 2010. Vertebrate diversity of the Jehol Biota as compared with other lagerstatten. *Science China Earth Sciences*, 53(12), pp.1894-1907.

NatSCA 2017 AGM Minutes

Thursday 26-27 April 2018
Leeds City Museum, Leeds
14:10 - 15:00

Agenda

Attendees: Paolo Viscardi (PV), David Gelsthorpe (DG), Jan Freedman (JF), Miranda Lowe (ML), Roberto Portela Miguez (RPM), Jack Ashby (JA), Maggie Reilly (MR), Clare Brown (CB), Rachel Jennings (RJ), Holly Morgenroth (HM), and Donna Young (DY).

1. Apologies for absence

Paul Brown (PB) and Isla Gladstone (IG).

2. Minutes of AGM Thursday 26 April, 2018. Leeds City Museum, Leeds

There were no issues raised by members at the meeting. These were signed as a correct record of that meeting by the chair.

Proposed: Rachel Jennings Seconded: Maggie Reilly

3. Chairman's Report

Welcome to Leeds City Museum, I am glad you made it along to this year's AGM and conference on the theme of *The museum ecosystem: exploring how different subject specialisms can work more closely together*.

NatSCA has been representing our membership on the UK Taxonomy and Systematics Committee and in government consultation, such as the recent consultation on the ivory trade.

We have been engaging with the wider UK museums sector through the emerging consortium of Subject Specialist Networks (SSNs). This forum provides an opportunity for SSNs to share information and coordinate efforts to address issues such as collections at risk, which we continue to monitor and challenge within our limited power. As part of this, we are talking about how the training SSNs provide can feed into the wider training environment in the sector with the UK Museums Professional Development Group.

We also been in discussion with the Home Office to find a solution to the problems museums are facing with regard to expensive licenses for specimens held in collections that are controlled by drugs legislation. We hope that the eventual outcome will be Antiques Exemption certificates for accredited museums.

Last year we ran *Bringing the dead to life: how to display museum natural science* at UCL, which was a really valuable day of talks and discussion about a wide range of issues relating to displaying our collections and the peripheral activities and work required to make the most of these exhibitions.

Later this year we have the *Skeleton Preparation Workshop* in Portsmouth on the 4th July and the *Caring for Natural Science Collections* one day conference on 17th October in Oxford.

The last year has been exciting with regard to developments in the Journal, but I will let the Editor Rachel tell you about that.

In 2017 we funded two projects under the Bill Pettit Memorial Award; Manchester Museum's *Taking wing: Curation of a Venezuelan hawkmoth collection* and Tullie House's *A Virtual Flora of Tullie: "Sowing the Seeds" to Digitise a Nationally Significant Herbarium*.

On a more negative note, we have had to deal with more collections at risk, with letters to Hampshire County Council and UCL Culture, defending the role and value of collections and the staff that work with them. We are hoping that our developing partnership with other SSNs will allow us to present a more united and stronger front when dealing with similar issues in the future.

Vote of thanks:
I would like to wish Isla Gladstone all the very best as she takes a break from the committee to have her second child and I wish a heartfelt farewell to Paul Brown who is stepping down after over a decade on the NatSCA committee, after fulfilling the role of Chair, Secretary and most recently Archivist. Paul has helped shape the organisation as it emerged from the union of the Biological Curator's Group and Natural Sciences Conservation Group in 2003. We're fortunate to be keeping that font of knowledge close at hand as Paul will continue in his Archivist role in an ex officio capacity.

On the other side of things, I would like to welcome Emma-Louise Nicholls onto the committee as a co-opted member representing GCG in Isla's absence, while she is on maternity leave. I would also like to welcome Jen Gallichan and Tivvy - Yvette Harvey to the committee - we are delighted to have some new blood to keep things fresh.

Finally, I would very much like to thank our volunteers, who keep things running, namely Glenn Roadley, Gina Allnatt, Sam Barnett and the indispensable Justine Aw.

4. Treasurer's report

	Natural Sciences Collections Association			1098156	
CHARITY COMMISSION FOR ENGLAND AND WALES	**Receipts and payments accounts**				**CC16a**
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	1,810	–	–	1,810	2,230
Personal subscriptions	4,435	–	–	4,435	3,533
Workshops	840	–	–	840	885
Conferences	15,359	–	–	15,359	10,678
Bank interest	5	–	–	5	7
Sub total (Gross income for AR)	22,449	–	–	22,449	17,333

A2 Asset and investment sales (see table)					
	–	–	–	–	–
	–	–	–	–	–
Subtotal	22,449	–	–	22,449	17,333
Total receipts	22,449	–	–	22,449	17,333
A3 Payments					
Running costs	2,558	–	–	2,558	2,177
Workshops	217	–	–	217	863
Conferences	7,056	–	–	7,056	6,546
Publications and information provision	2,310	–	–	2,310	1,896
Bill Pettit Memorial Fund	733	–	–	733	1,500
ACE grant - Network Improvement Project	–	–	–	–	149
Bursaries	315	–	–	315	373
Other (e.g. stationary)	–	–	–	–	37
Subtotal	13,189			13,189	13,541
A4 Asset and investment purchases (see table)					
	–	–	–	–	–
Subtotal	–	–	–	–	–
Total Payments	13,189	–	–	13,189	13,541
Net of receipts/ (payments)	9,260	–	–	9,260	3,792
A5 transfers between funds	–	–	–	–	–
A6 Cash funds last year end	28,136	–	–	28,136	–
Cash funds this year end	37,396	–	–	37,396	3792
Section B Statement of assets and liabilities at the end of the period					
Categories	Details		**Unrestricted funds**	**Restricted funds**	**Endowment funds**
			To the nearest £	To the nearest £	To the nearest £
B1 Cash funds			37,396	–	–
Total cash funds			37,396		
		(agree balances with receipts and payments account(s))	OK	OK	OK

B2 Other monetary assets	Conference income		35	–	–
			Fund to which asset belongs	**Cost (optional)**	**Current value (optional)**
B3 Investment assets			–	–	–
B4 Assets retained for the charity's own use			–	–	–
			Fund to which liability relates	**Amount due (optional)**	**When due (optional)**
B5 Liabilities	Running costs		Unrestricted	286	
	Bill Pettit		Unrestricted	1,200	
	Early 2018/19 subscriptions		Unrestricted	120	

Proposed: Jan Freedman Seconded: Lucie Mascord

5. Membership Secretary's Report

The year ended with 298 entries on the database, this number arrived at after a major clean up of the data base to remove all members who were in two years or more arrears, duplicate entries, retirals and resignations. Of this 298 the numbers break down as follows:
8 FOC as per previous years therefore 290 paying members
Paid institutional subs: 47
Paid personal: 235
Unpaid: 6 institutional, 2 personal

Renewal notices for personal memberships were sent out in February and institutions are individually invoiced. Therefore numbers remain more or less stable – the institutional memberships hover around 50 and the personals around 230 or so. The remaining unpaid institutional subs may yet pay. There were a welcome 53 new members joining in 2018 but of course this is counterbalanced by those not renewing so the net result is number stability in membership.

Membership remains predominantly UK based with 254 of our members, the remaining 36 are 'overseas' members.
The new general Data Protection Regulations (GDPR) come into force on 25/05/2018. These have implications for all organisations big and small that hold personal data. NatSCA holds names, addresses, email addresses and telephone numbers for members, used solely for contacting members on NatSCA business. The new regulations are fairly complex to get a grip on but what it comes down to for NatSCA is that we may have to seek the membership's explicit consent to hold their data. We are investigating how we should proceed. Past consent or membership forms are invalid. It is likely members are already familiar with this through memberships of other similar societies approaching for similar consent. NatSCA will also be putting up a revised privacy policy on the website.

I would like to thank Justine Aw for continuing technical support and back up.

Proposed: Glenn Roadley Seconded: Neal Owen

6. Editor's Report

Journal of Natural Science Collections:

23 submissions to Volume 5, of which 14 were published. This was the highest number of submissions to a single volume yet.

An Editorial Board was set up to help establish new protocols and to improve the quality of peer review. This has been enormously successful, and I wish to offer my thanks to the Editorial Board members for their enthusiasm and knowledge.

Following a survey of the membership, the Committee has decided to offer a 'digital only' option for those who would prefer not to receive a print copy of the Journal. This will add a new offer for our members, and will save some money on print costs that can contribute to other areas of our operation, to the benefit of members. The deadline for submissions to the Journal has been moved up to the end of June instead of the end of July to allow more time in preparing the Journal for publication, as the schedule is very tight. The deadline for submission from Conference speakers will be in July to allow more time for writing up of talks.

NatSCA Notes & Comments:

Due to commitments with the Journal, I have been unable to process submissions to Notes & Comments. I must apologise for this, and will attempt to get these prepared as soon as I can.

7. Election of Ordinary Members of NatSCA Committee

Post	Nominee	Institution	Proposed	Seconded
OM 2018-2020	Maggie Reilly	Hunterian Museum, Glasgow	Jeanne Robinson	Edward Hancock
OM 2018-2020	Clare Brown	Leeds City Museum, Leeds	Rebbecca Machin	Roberto Portela Miguez
OM 2018-2020	Donna Young	World Museum, Liverpool	Stephen Judd	Wendy Atkinson
OM 2018-2020	Rachel Jennings	Horniman Museum, London	Jo Hatton	Emma-Louise Nicholls
OM 2018-2020	Jan Freedman	Plymouth Museum	Sophie Stevens	Erica McAlister
OM 2018-2020	Jennifer Gallichan	National Museum of Wales, Cardiff	Clare Brown	Harriet Wood
OM 2018-2020	Yvette Harvey	Royal Horticultural Society, Wisley	Rachel Webster	Jo Hatton

Already in post:

Post	Name	Institution
Chair 2017-2020	Paolo Viscardi	National Museum of Ireland, Dublin
Membership Secretary 2017-2020	Roberto Portela Miguez	Natural History Museum, London
Treasurer 2016-2019	Holly Morgenroth	RAMM, Exeter
OM 2017-2019	Jack Ashby	Grant Museum of Zoology, London
OM 2017-2019	David Gelsthorpe	Manchester Museum
OM 2017-2019	Miranda Lowe	Natural History Museum, London
OM 2017-2019	Isla Gladstone	Bristol Museum & Art Gallery
OM 2017-2019	Lucie Mascord	Lancashire County Council Museums Service

Proposed: Lucie Mascord Seconded: Simon Jackson

8. Any other business

Archivist Report

Paolo Viscardi presented this on behalf of Paul Brown.

Paul Brown has the archives still at NHM, London, having box-filed all the BCG stuff and has not got them into the Museum Archives as yet. Paul Brown will try to do so soon if and when he can get the time and when he can convince the NHM Archivist to take them (as NatSCA is an associated organisation as recognised by the NHM).

Conservation Report

Lucie Mascord took over as committee conservation representative at the 2017 AGM. The Society would all like to thank Vicky Purewal for her years of commitment to this role.

Conservation working group

A conservation working group has been set up consisting of 10 natural science conservators. They will work within a semi-formal, advisory capacity and will report to the committee via the conservation representative. The group aims are to improve professionalism, training and promotion of natural science conservation. The first meeting was held on the 31 October 2017 at OUMNH.

Conservation Conference

The first activity of the conservation working group will be to organise a NatSCA conservation conference to showcase innovative conservation projects working with natural science collections. Thanks to Julian Carter and Bethany Palumbo who have volunteered to a lead on this. The conference will be held on the 17 October 2018 at OUMNH.

Other activities

Lucie Mascord has taken a position as a Trustee of the Institute of Conservation.
The conservation working group are discussing future plans for researching the viability of "off the shelf" products used in natural science conservation.

9. Vote of thanks

Thanks to Jan Freedman and Clare Brown for organising the conference and to Isla Gladstone and Emma Nichols for acting as our GCG co-opted members. As always our volunteers are key to our success, so special thanks to Justine Aw, Glenn Roadley, Gina Alnatt, and Sam Barnett.

Without the sterling work of our treasurer, we would have never been able to manage either, so thank you Holly Morgenroth for your time, effort and support for the society.

Special thanks to Paul Brown who after long years of service in committee for the society has now decided to step down. Paul has been a great advocate for natural history, integral to the formation of NatSCA and has helped steer the society as chair and secretary through different periods.

10. Next committee meeting

Grant Museum of Comparative Zoology, 6 July 2018, 11:00.

Meeting closed at 15:00 26/04/2018.