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A note of thanks

A huge congratulations from all the NatSCA members to the NatSCA Chair, Clare Brown, on the safe arrival of her little baby girl. Zoe Gwyneth Brown was born on 7th February 2012, and both are doing very well.

It has been a busy time for everyone these past months, with numerous new projects, large cuts in the sector, and the recent spree of attempted rhino horns. With all of this in mind, NatSCA would like to thank everyone for their articles for this, and all issues of *NatSCA News*. I would like to thank everyone who has submitted an article for this journal, as I know that we are all so busy juggling several things at once. The articles are such useful case studies, highlighting collections and examples of good practice; they are an invaluable resource for getting together new ideas for the future.

I must thank the reviewers for spending the time to thoroughly go through each article and provide useful comments and recommendations to ensure that this journal is of a high standard. The reviewers, like the authors, have their normal job to carry out, and I am grateful for the time they have given.

NatSCA News prides itself on current curatorial and conservation projects with natural history collections. This issue houses several interesting articles of current topics, including the recent increase in rhino horn thefts in museums, examples of conservation carried out on specimens, good imaging and packing solutions, safe handling and storage of collections, and case studies of living displays in museums.

This issue also includes, for the first time, a list of publications, with abstracts, from NatSCA members which may be useful to the museum curator (page 87). There are so many different journals currently available, the aim of this addition is to highlight some publications which may be relevant to curators and possibly assist or provide ideas for projects they are working on. If you have published an article, please send me the full reference and the abstract to be included in the next issue.

Jan Freedman
12th March 2012

Contributions for Issue 23, August 2012

All articles, letters, news, adverts and other items for inclusion for the next issue of the NatSCA Newsletter should be sent to the address below by June 1st:

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View From The Acting Chair

As some of you may be aware Clare Brown – Chair of NatSCA – is on maternity leave at the moment. I am sure that you will join the committee in offering heartfelt best wishes and congratulations to the newly extended Brown family. In Clare's absence the duties of the Chair have been passed to other committee members, including myself as nominal Acting Chair.

It has been a difficult time for natural history collections recently, with a spate of rhino horn thefts from collections around the UK and Europe that have caused damage and disruption (a more detailed article on the problem can be found in the pages of this issue of NatSCA News). The funding situation has also becoming increasingly dire for some collections, as the Museums Libraries and Archives Council (MLA) handover to Arts Council England (ACE) has seen substantial changes to the way in which funds have been allocated. In light of concerns about this situation NatSCA are due to meet with Hedley Swain of ACE to discuss the future of natural history collections.

With an eye to the future, we are delighted that the trainees involved in the Heritage Lottery Fund (HLF) 'Skills for the Future' programme have been very positive about their experiences, particularly since the HLF have provided funds for the extension of the project for a further two years. NatSCA are pleased to continue our support the project, as well feel it provides a useful mechanism for transferring curatorial knowledge and experience to a new generation of natural scientists.

Of course, NatSCA also has the training needs of established natural scientists in mind, and there have been recent workshops held on 'Caring for Entomology Collections' and 'Caring for Botanical Collections'. Attendance was excellent and feedback was very positive for both seminars and due to high levels of demand an additional 'Caring for Botanical Collections' workshop is being planned. Other seminars are also in the pipeline, including 'Identification of Osseous and Keratinous Materials' and 'Taxidermy and the Law' – keep an eye on the website for more information.

Regarding the website, there are plans for a major overhaul of the content, structure and design of the site in the near future. Please let me know your thoughts on what you would like to see on the new-look site known by emailing me at P.Viscardi@gmail.com or talking to me at this year's AGM in London on 28th and 29th March. I hope to see you there!

Paolo Viscardi
14th March 2012

NatSCA Conference 2012 "Use it or Lose it"
29th and 30th March 2012

Thursday 29thMarch 2012: Horniman Museum and Gardens
Please note that the Horniman Museum is approx 1 hour from Euston

10:00 – 10:30 Registration and coffee

10:30 – 10:35 Introduction: Paolo Viscardi, Jack Ashby

10:35 – 10:50 Welcome from Janet Vitmayer, Director of Horniman Museum

10:50 – 11:10 "Gaining young Children's Perspective on Natural HistoryCollections"Elee Kirk, School of Museum Studies, University of Leicester, and independent museum researcher and educator

11:10 – 11:30 "The Giant Squid – the Making of an Iconic Specimen" Jonathon Ablett, Zoology Department, Natural History Museum

11:30 – 12:00 Coffee Break12:00 – 12:20 "How Museums can support Higher Education: Engaging Universities with Museums" Jack Ashby, Grant Museum of Zoology, UCL

12:20 – 12:40 "400 years of Collection: The use of Bryozoans for environmental and biodiversity research" Mary Spencer Jones, Zoology Department, Natural History Museum

12:40 – 13:00 "Gorillas, graffiti and Dolly Parton: An A-Z of audience engagement through Natural Science" Liz Knight and Esther Amis-Hughes, Leeds Museums and Galleries

13:00 – 14:00 LUNCH

14.00 – 14.40 AGM

14:40 – 16:10 A selection of guided tours at either;

1) Crystal Palace Dinosaurs (numbers limited – info to follow)

Or

2) Horniman Museum, visiting: Gardens, Aquarium, Natural History Galleries

Travel back to Bloomsbury / Euston

17:30 – 19:00 Reception at Grant Museum of Zoology, UCL

19:30 – 21:30 Conference Meal

Friday 30th March 2012: Grant Museum of Zoology, UCL

09:30 – 10:00 Registration and coffee

10:00 – 10:15 Welcome from Sally MacDonald, Director, UCL Museums and Public Engagement

10:15 – 10:40 "A bit of a pickle: Reassessing the spirit preserved specimens at Plymouth City Museum and Art Gallery." Jan Freedman, Plymouth City Museum and Art Gallery

10:40 – 11:05 "Connecting the dots: Natural Science Collections and the Web" Ed Baker, Entomology Department, Natural History Museum

11:05 – 11:30 “Acquiring and reviewing collections for HE teaching” Hannah Russ, Archaeology Department, University of Sheffield

11:30 – 12:00 Coffee Break

12:00 – 12:25 “How to teach with objects – a guide for convincing lecturers to use your collection” Rosalind Duhs, Centre for the Advancement of Learning and Teaching Leonie Hannan, UCL Museums

12:25 – 12:50 “How to get grant funding” Sally Colvin/Gina Evans, Museums Association

12:50 – 14:00 LUNCH

14:00 – 16:30 Two tours and a workshop, in three groups (repeated):Workshop: Collections Review Toolkit for Natural History Mark Carnall and Jayne Dunn, UCL Museums Tours of Wellcome Collections and one of UCL’s Museums

16:30 Conference end

Notes:
The main conference sessions take place on Thursday 29th March at the Horniman Museum and Friday 30th March at the Grant Museum of Zoology, UCL.

We recommend you stay at a hotel in the Bloomsbury/Euston area near the Grant Museum.

The Horniman Museum is near Forest Hill train station, 10-15 minutes from London Bridge, and trains run regularly. It takes 15-20 mins go get the Tube from Euston to London Bridge.

As well as tours as part of the main conference, optional tours of the **Hunterian Museum at the Royal College of Surgeons** will take place on **Wednesday** afternoon, and tour of the **Darwin Centre at the NHM** and **Horniman Study Collections Centre** on **Wednesday afternoon and Saturday morning**. Booking is required – details to follow. These tours are only available to delegates who have paid for at least one day of the conference.

Hotels near the Grant Museum (these are largely untested)
There are many – see the link on the right of this page:
http://www.tripadvisor.co.uk/Attraction_Review-g186338-d638483-Reviews-Grant_Museum_of_Zoology-London_England.html

Imperial Hotels Group
Six local hotels of varying standard – the County starts at £45 per night, the less budget Tavistock from £69.
http://www.imperialhotels.co.uk/

Ridgemount Hotel, Gower Street
Rooms from £50 per night
http://www.ridgemounthotel.co.uk/prices
http://www.tripadvisor.co.uk/Hotel_Review-g186338-d187680-Reviews-Ridgemount_Hotel-London_England.html

Jesmond Hotel, Gower Street
Rooms from £50 per night
http://www.tripadvisor.co.uk/Hotel_Review-g186338-d559783-Reviews-Jesmond_Hotel-London_England.html
http://www.jesmondhotel.org.uk/budget-room-prices

Gower House Hotel
Rooms from £55 per night
http://www.gowerhousehotel.co.uk/tariff.html
http://www.tripadvisor.co.uk/Hotel_Review-g186338-d806087-Reviews-Gower_House_Hotel-london_England.html

2012 CONFERENCE & AGM BOOKING FORM
Part 1

London, Thursday 29 – Friday 30 March 2012

Please complete this booking form and send to Tony Irwin at Norwich - address below.

Keep a copy of your form for reference. Deadline for bookings is 9th March 2012.

Name…… ……

Organisation……..…….

Address…….
……..

E-mail:……..…… **Tel**: ……..…

CONFERENCE COSTS
(Please tick as appropriate. All lunches & refreshments included.)

	2 day rate		Thurs only		Fri only	
Early-bird member (by Jan 31st):	□	£75	□	£40	□	£40
Early-bird non-member (by Jan 31st):	□	£90	□	£50	□	£50
Member:	□	£85	□	£50	□	£50
Non-Member:	□	£100	□	£60	□	£60

Institutional members please note that this category of membership entitles you to two member rate places at conference.

Please note any special dietary requirements: … …….

……..……..……..

Please note that the dinner is an additional charge

I will be attending the Conference dinner on Thursday evening - cost £16 per person □

Payment total = £…….

Any queries: Jack Ashby, Grant Museum of Zoology, UCL. 020 3108 2052. j.ashby@ucl.ac.uk

Continued…

NatSCA
Natural Sciences Collections Association

CONFERENCE & AGM BOOKING FORM - Part 2

PAYMENT

Name…….

Payment total £……

I enclose a personal cheque for £……..…

This is for the conference fee only / meal only / both

Please send me a receipt for this amount □

Cheques should be made payable to the **'Natural Sciences Collections Association'**

My institution will pay by cheque □

Send me an invoice for £……..…..

My institution will pay my fee into the NatSCA bank account by BACS transfer. □

Send me an invoice for £…….……..

Order number (if required on invoice) ……

Please send booking forms and payments to:
Dr A.G. Irwin,
47 The Avenues
Norwich,
Norfolk NR2 3PH

Phone: 01603 453524
Mobile: 07880707834
E-mail:tony.irwin@btinternet.com

The Horns of a Dilemma: The Impact of the Illicit Trade in Rhino Horn

Paolo Viscardi

Deputy Keeper, Horniman Museum and Gardens

Email: pviscardi@horniman.ac.uk

Abstract

Rhinoceros horn has recently become highly sought after on the black market for use in Traditional Asian Medicine. Demand has increased levels of poaching and has led to the theft of material from collections across Europe through 2011. This article provides background to the situation and reiterates guidance on protecting both rhinoceros horn and staff in natural science collections.

Keywords

Rhinoceros, rhino, horn, poaching, security, theft, auction, legislation, threat, CITES, DEFRA, AHVLA

Introduction

It has been a bad year for rhinoceros and for natural history collections holding their horn. The international black market dealing in rhino horn has been particularly active recently, following a rumour that Traditional Asian Medicine (TAM) containing powdered horn could successfully treat and prevent cancer.

This has led to demand for rhino horn, driving up prices and increasing the risks criminals are willing to take in order to obtain it. Poaching of rhinoceros has increased dramatically and black market interest in taxidermy and cultural artefacts made from rhino horn has led to auction prices increasing by as much as tenfold and has ultimately resulted in the theft of material from collections.

The Natural Science Collections Association (NatSCA) has been active in monitoring the growing issue of theft from natural science collections and during the year we have issued guidance and liaised with media and government bodies in relation to the problem. This article is intended to contextualise and summarise the state of the rhinoceros horn situation at the end of 2011.

Uses of rhino horn

Rhinoceros horn is often described as being made of compacted hair, but it is more accurately described as being formed of partially mineralised keratin tubules embedded in an intermittently melanised keratin matrix (Hieronymus et al. 2006). This structure is secreted by highly vascularised tissue often supported by an osseous protuberance of the nasal bones of the rhino. The most commonly cited use of rhino horn is as an aphrodisiac in TAM, which is a misconception[1]. There have been a few suggestions of the horn being used for this purpose in parts of Africa, but traditionally in TAM the horn has been used to treat fever and a variety of conditions including gout and rheumatism[2].

There is no mention of rhinoceros horn in relation to cancer before 2009 and the earliest articles citing a link refer to claims that a 'prominent Vietnamese official' (who goes unnamed) was apparently cured of liver cancer using rhino horn. Official representatives for TAM have distanced themselves from these claims, stating that they no longer support the use of rhino horn in TAM and they have made it clear that the use of horn as a cancer treatment has no traditional or evidential basis[3]. Nonetheless, the increasing wealth in Asia and the wide acceptance of the cancer cure rumours in China, Vietnam and Taiwan have created a booming illegal trade.

Prior to the emergence of the cancer cure rumour, the illicit trade in rhino horn had been decreasing. The main market for horn previously had been in Yemen, where it was used to make handles for traditional daggers called *jambiya* (Martin et al., 1997). Since Yemen became a member of CITES in 1997, the trade for *jambiya* handles has significantly decreased and Yemen no longer appears to be a major destination for illegal horn (Milliken et al., 2009). This reduction in illegal trade to Yemen had been reflected in the population figures for African rhino species, where numbers in the wild increased substantially from the mid 1990s to 2007 (Milliken et al., 2009).

Rhinos in the wild

The Indian Rhinoceros *Rhinoceros unicornis* Linnaeus, 1758 have been recovering from overhunting and habitat loss for the last 100 years, resulting in a population of almost 3,000 individuals where there were just 200 a century ago. Poaching is a problem, but so far the Indian rhino population still seems to be increasing, thanks to conservation efforts supported by the Indian government (Talukdar et al., 2008).

The Vietnamese Javan Rhinoceros *Rhinoceros sondaicus annamiticus* Heude, 1892 is now considered extinct after the last individual was found dead with its horn removed in 2010 (Brook et al., 2011). This leaves just 44 of the nominate subspecies of Javan Rhinoceros *R. sondaicus sondaicus* Desmarest, 1822 in the world, all of which are restricted to one Indonesian National Park.

The Sumatran Rhinoceros *Dicerorhinus sumatrensis* (Fischer, 1814) has also suffered considerably at the hands of poachers. No more than 230 individuals remain in total, with the Northern subspecies *D. sumatrensis lasiotis* probably extinct and fewer than 50 individuals left of the Eastern subspecies *D. sumatrensis harrissoni* (van Strien et al., 2011).

The Western Black Rhinoceros *Diceros bicornis longipes* (Zukowsky, 1949) subspecies was declared extinct this year (Emslie, 2011). Populations of the other three subspecies of Black Rhinoceros *D. bicornis bicornis* Linnaeus, 1758, *D. bicornis michaeli* Zukowsky, 1965 and *D. bicornis minor* Drummond, 1876 have been slowly increasing after extensive conservation efforts in the past few decades, so they now number approximately 4,800 individuals in total. However, there have been regular reports of Black Rhinoceros being poached that will impact on this past conservation success.

The Northern White Rhinoceros *Ceratotherium simum cottoni* (Lydekker, 1908) is now probably extinct in the wild (Emslie, 2011), with just 4 individuals left in captivity. In contrast, the Southern White Rhinoceros *C. simum simum* (Burchell, 1817) has a healthy population at present, with over 20,000 individuals in the wild and a further 750 in captivity (Emslie, 2011).

Despite the past conservation success stories for the Black and Southern White Rhinoceros, poaching in South Africa has rocketed in the last two or three years, with 333 animals killed in 2010 and 448 in 2011[4]. On average at least one rhinoceros is killed by poachers every day to supply the black market for horn.

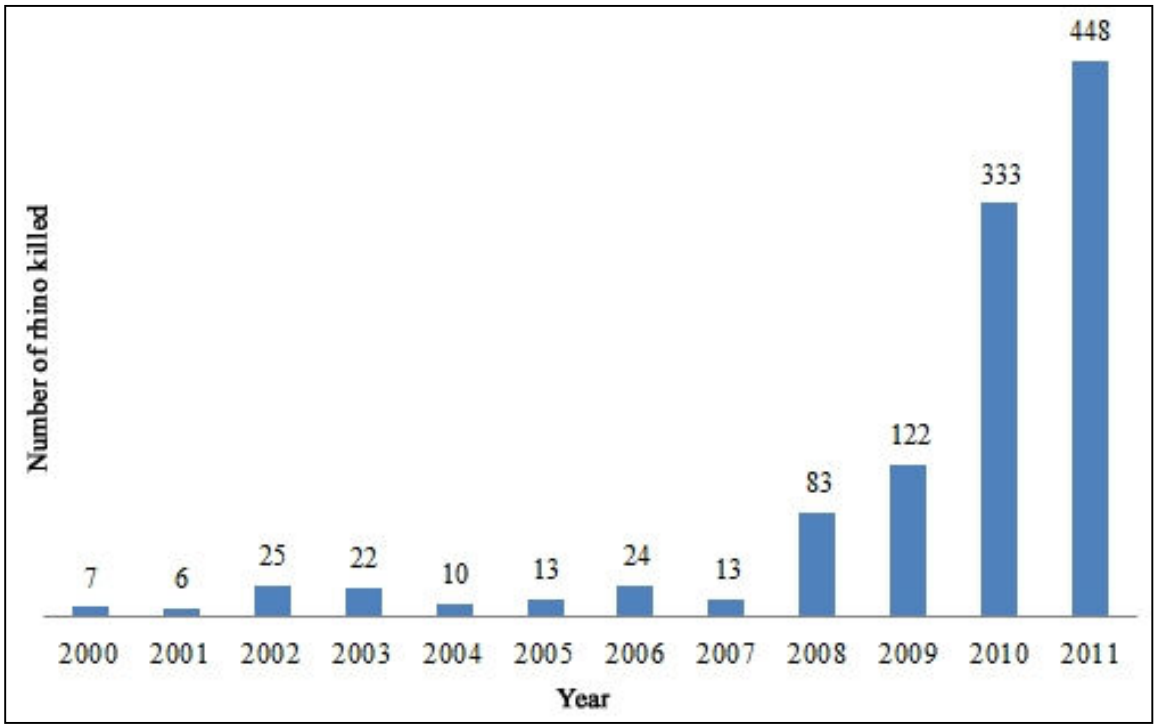

Fig. 1. Incidents of rhino poaching in South African National Parks based on data from South African National Parks (SANParks[5]).

Black market horn

Poachers are using a range of methods to acquire horn, from misappropriating game licenses using Thai prostitutes[6] to using helicopters, tranquiliser guns and chainsaws to take the horn from living rhinos (usually fatally wounding them in the process). Besides poaching, there has been a great deal of illicit activity surrounding rhino horn stockpiles, involving armed organised crime cartels and implicating South African[7] and Vietnamese[8,9] officials.

The first inklings that the black market in rhino horn was starting to have an impact on historic material came in 2008 when an unknown number of horns were stolen from Grahamstown Observatory Museum and Oudtshoorn Museum in South Africa (HSI, 2011). The following year Cape Town's National Iziko Museum had two 19th century White Rhinoceros horns stolen (HSI, 2011).

There were also indications that historic horn was finding its way onto the black market from legal sources, when auction prices of rhino horn suddenly increased dramatically. A report on an auction conducted in May 2010 makes the following statement: "*The biggest surprises came in a sale of rhinoceros horn carvings, in which 30 lots, estimated at $3.9 million, sold for $30 million. The record for a single piece now stands at $5 million, the price a Chinese collector paid for a 300-year-old rhinoceros horn vase.*" (Gleadell, 2010).

While carved libation cups and vases have commanded considerable sums for many years, the market for trophy horns also became unusually active. To illustrate, in November 2008 Tennants Auctioneers in Yorkshire listed a guide price of £5,000-7,000 for a Black Rhinoceros horn trophy shield (Lot 1235[10]), which sold for £19,000; the same auctioneers in July 2010 listed a very similar Black Rhinoceros horn trophy (Lot 1153[11]) at a guide price of £15,000-25,000 and it was sold for £42,000.

This escalation in price at auction and the increasing number of buyers based in Asia suggested that black marketeers were exploiting a loophole in CITES legislation regarding sale of worked rhino material. The European Commission responded by issuing guidance[12] which led to amendments to legislation in the UK by Animal Health (which become part of Animal Health and Veterinary Laboratories Agency, AHVLA, on April 1st 2011) and the Wildlife Licensing and Registration Service (WLRS) in February 2011[13]. These changes meant that mounted horns would no longer be recognised as having been 'worked' and would therefore no longer be covered by the Antiques Derogation that had previously allowed the sale of such material.

In light of the Europe Commission reassessment of the CITES guidelines cutting off a supply route for rhino horn, black market elements turned to thefts from European Natural Science Collections to supplement the supply. Between 31st December 2010 and 31st December 2011 there have been 26 reported incidents across Europe involving the theft or attempted theft of one or more rhino horns from museums, historic houses, auctioneers and displays in zoos (see figure 2).

In July 2011 Europol identified an Irish organised crime group as being involved in the illegal acquisition and trading of rhino horn from Europe. The group may be acquiring horn by offering cash to petty criminals who commit the robberies. This certainly appears to be the case for a specimen stolen from Liege, where the thieves were caught and informed police that they were to leave the horn at a drop point to be exchanged for €3,000.

Several thefts have been undertaken during museum opening hours and on occasion the thieves have used force (including tear-gas) or the threat of force to make an escape, which raises concerns over staff safety on top of concern for the collections. There have also been a number of incidents in museums where suspicious individuals or groups have been identified undertaking hostile reconnaissance, sometimes intimidating and explicitly asking staff where the rhino material is stored. On one occasion curatorial staff and a group of visitors bravely (and successfully) foiled a raid on a specimen[14], but in doing so they exposed themselves to potential harm. Adequate briefing and training of staff have proven important when dealing with such incidents and with foresight and appropriate action the risks to staff should be minimised.

Other thefts have taken place outside opening hours, with thieves gaining entry by breaking into premises. In several such incidents thieves have been disturbed during their initial attempt, but they have returned with days or even hours to achieve their goal. Clearly the criminals undertaking the thefts are highly motivated and willing to take considerable risks.

Fig. 2. Location of thefts or attempted thefts of rhino horn in Europe from 31st December 2010 to 31st December 2011. Derived using Google Maps, interactive map with data available at: http://g.co/maps/e29k8

It is worth noting that the Police force have been taking the situation seriously and there have been arrests and charges brought against some of those undertaking thefts, including Jamie Channon of Melba Gardens, Tilbury who was one of those responsible for the theft of horn from Haselmere Educational Museum in Surrey in May 2011[15] and Darren Bennet of Battenberg Road, Leicester for the theft of two replica horns from the Natural History Museum at Tring in August 2011[16].

NatSCA's involvement

After the initial spate of European thefts, NatSCA issued the following guidance[17] for rhino horn in museum collections:

1. This is an area that has implications for the safety of people and objects. We recommend that a security audit is carried out and if your material is not secure it should be taken off display and put in a secure location.

2. If you are worried about holding on to rhino horn then you should either put it in a more secure location at your site or dispose of it (either by loan or permanently) to another museum willing to take it on. This would probably be a museum that already looks after rhino horn.

3. Rhino material should not be destroyed. Apart from the obvious problems of destroying museum material, there are good scientific reasons for maintaining rhino horn for future research that can tie in to conservation efforts. A guide might be taken from national parks in South Africa where rangers lock up rhino horn rather than destroy it.

4. NatSCA does not advise on value, but for insurance valuation purposes auction houses can provide some guidance.

5. Do not publicise your rhino material. Thefts have targeted rhino horn that is on display or has been publicised in some way.

The above guidance has been circulated to the Museums Association (MA) and has received mention in articles on the MA website[18,19], on rhino conservation blogs[20] and in the wider press[21].

In addition to the published guidance, it is recommended that front-of-house and collections staff are made aware of the situation regarding the status and security of rhino horn and are adequately primed to safely deal with genuine enquiries from the public and reconnaissance from would be thieves.

It is also suggested that for horns which are difficult to take off display, for example horns on large trophy heads or full taxidermy mounts, it may be worth considering removal of the horn by a conservation professional and replacement with replicas. This reduces the likelihood of damage to specimens from the inexpert removal of the horn by thieves. It is important to make it clear that any replacement horns are indeed replicas, since some thieves have stolen replicas[22] and caused damage to specimens in the process. Contact details of well-established natural history conservators able to produce and install replica horns can be supplied by the author on request.

Beyond the level of collections, NatSCA has approached the AHVLA with concerns about the sale of rhino horn during the autumn of 2011 by UK auction houses. A particular point of concern has been a recent tendency of some auctioneers to list the weight of objects made of rhino horn, a detail not included for ivory or other materials. By listing weight items become more easily assessed as material products as opposed to primarily cultural objects – contravening the intent (if not the letter) of current legislation relating to sales of objects made from rhino horn.

The AHVLA looked into the issue, but were unable to act since the auction houses were acting in compliance with current requirements. However, NatSCA were informed that the whole issue regarding the sale of rhino horn, rhino horn products and trade with third countries in the specimens is currently under review by the AHVLA and DEFRA, and that our concerns have been highlighted. Rest assured that NatSCA will circulate any further information that arises in relation to this topic, particularly when new legislation is put in place.

Members can always approach NatSCA for advice or with any concerns or queries regarding this particular issue via the email provided on the website.

Acknowledgements
I would like to extend my warm thanks to the anonymous reviewer for their input, which has certainly helped to improve this article.

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Further information

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[5] http://celtis.sanparks.org

[6] http://www.news24.com/SouthAfrica/News/Sex-workers-used-to-hunt-rhino-20110722

[7] http://www.news24.com/SouthAfrica/News/Rhino-horn-theft-government-officials-fingered-20101027

[8] http://www.traffic.org/recent-coverage/health-fads-put-rhinos-on-death-row.html

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[11] http://www.tennants.co.uk/Catalogue/Lots/75769.aspx

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[18] http://www.museumsassociation.org/museums-journal/news/13062011-rhino-horn-warning

[19] http://www.museumsassociation.org/museums-journal/news/10082011-rhino-horn

[20] http://www.rhinoconservation.org/2011/07/06/rhino-head-stolen-from-brussels-museum/

[21] http://www.bbc.co.uk/news/uk-england-london-14278681

[22] http://www.nhm.ac.uk/about-us/news/2011/august/theft-of-replica-rhino-horns-at-natural-history-museum-tring102898.html

Mobile Macrophotography

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Abstract

Although it is relatively easy to purchase a good quality digital camera with the facility to take 'macro' photographs of very small objects, such a camera may not always be available when needed. However, most people now have access to a mobile phone with a camera facility. Here it is demonstrated that quite useful digital photos can be taken of very small objects such as insects with an average mobile phone camera utilising a small inexpensive hand lens. Examples of such photos are given, along with the pros and cons of each hand lens tested and some tips on their use with mobile phones.

Introduction

It seems fewer people carry 'proper' cameras around with them these days, even in circumstances where photographs might be expected to be taken. Many people now rely on mobile phones with in-built digital cameras. Unfortunately, although mobile phones can be useful for general photography and are improving in quality all the time, they can rarely take photos at a short focal range, and anything smaller than A5 size can be very difficult to photograph. Some modern digital cameras do not even have a 'macro' facility. However, the lenses on mobile phones are usually tiny (c. 5 mm diameter), and people interested in natural history often have a magnifying glass or hand lens which will fit comfortably over the lens on the back of a mobile. Depending on the phone and the magnifying glass used, this can provide effective results. While the images may not be of publishable quality, this can be a useful way to photograph very small things when a decent digital camera or microscope is not to hand – for instance when an insect is seen whilst out in the field but not captured, or to record a small specimen or label found whilst visiting another museum's natural history collection. Those with a camcorder facility on their mobile phone will find they can make short videos this way as well. Some test shots were taken of two subjects using three different hand lenses and a mobile phone, and for comparison purposes the same photos were taken with a *Nikon* digital camera on a macro setting. Example images are shown below, along with details of the three magnifiers used.

Materials

Mobile phone: *Motorola Defy*, with a 5 megapixel camera with autofocus and image stabilization (also a camcorder VGA@30fps), manufactured in 2010. Not the best mobile phone camera but adequate although it does not offer touch focus so the user does not have complete control over what part of the image is in focus. Nevertheless, good normal photographs and useable macro photographs have been captured with this phone. Other mobile phones may work even better with hand lenses and magnifiers and experimentation is encouraged.

Digital camera

Nikon Coolpix 4500. 4 megapixel, manufactured in 2002. Used on macro setting.

Magnifying glasses

- A x5 magnifier from the Natural History Museum, London (NHM) shop with a lens diameter of 28 mm (Fig. 1). This is a great little inexpensive hand lens. It is kept inside the plastic cover but pops out at the touch of the button on the side.
- *Triplet* magnifier from United Kingdom Geologists Equipment (UKGE) provides a choice of two lenses: x10 and x20, the lenses being 18 mm and 12 mm diameter respectively (Fig. 2).
- A standard domestic magnifying glass, of approximately x5 magnification, of unknown make and provenance and lens diameter 50 mm (Fig. 3).

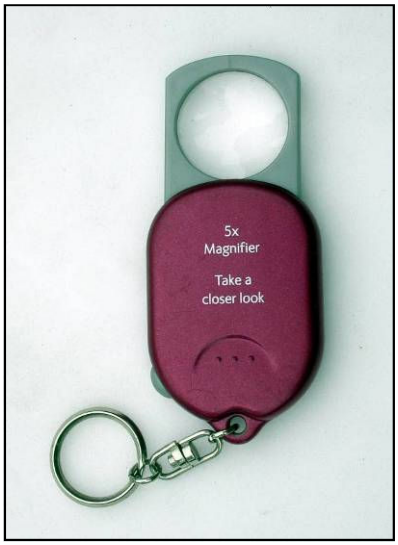

Fig 1. A x5 magnifier from the Natural History Museum, London (NHM) shop with a lens diameter of 28 mm.

Fig 2. *Triplet* magnifier from United Kingdom Geologists Equipment (UKGE) provides a choice of two lenses: x10 and x20, the lenses being 18 mm and 12 mm diameter respectively.

Fig 3. A standard domestic magnifying glass, of approximately x5 magnification, of unknown make and provenance and lens diameter 50 mm.

Specimens

- Greenbottle (*Lucilia* sp.) (Figs 4-7). This particular greenbottle is a very poor specimen, it is not the fault of the photography (this and the owl pellet are from the entomology collection of the author's daughter).
- Owl pellet with beetle remains (unknown species) (Figs 8-11).
- 22-spot ladybird (*Psyllobora vigintiduopunctata)* (Fig. 12).

Results

See Figs 4-12. All the photos have been cropped.

Fig 4. *Lucilia* sp. greenbottle, taken using a *Nikon Coolpix* 4500 digital camera on macro

Fig 5. *Lucilia* sp. greenbottle, taken using a Mobile phone and NHM x5 lens.

Fig 6. *Lucilia* sp. greenbottle, taken using a Mobile phone and *Triplet* x10 lens.

Fig 7. *Lucilia* sp. greenbottle, taken using a Mobile phone and domestic lens approx x5.

Fig 8. Owl pellet (c. 18 mm across) taken using a *Nikon Coolpix* 4500 digital camera on macro setting.

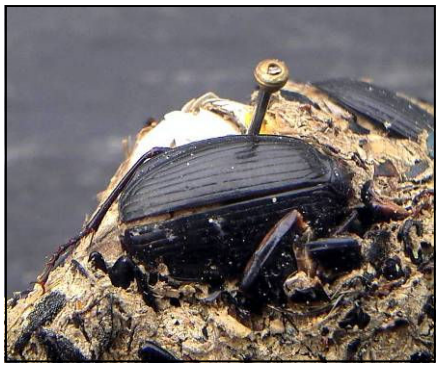

Fig 9. Owl pellet (c. 18 mm across) taken using a mobile phone and NHM x5 lens

Fig 10. Owl pellet (c. 18 mm across) taken using a mobile phone and *Triplet* x10 lens.

Fig 11. Owl pellet (c. 18 mm across) taken using a mobile phone and domestic lens approx

Discussion

In a way, it is unfair to compare the results from the *Nikon* digital camera to the images taken with the mobile phone and hand lenses for two reasons. Firstly, the *Nikon* camera – though made in 2002 – is a dedicated digital camera with a specific macro facility, rather than a mobile phone that happens to have a camera built into it. Secondly, the *Nikon* camera was on a tripod and the timed shutter release facility was used, minimising camera shake, whereas the mobile phone was used without a tripod and whilst trying to hold the magnifier steady underneath it. Nevertheless, it is very interesting to see that all the photos taken turned out to be useful, in that the specimens in the image could be identified relatively easily. As the depth of field is shallow it is difficult to compare the images exactly as slightly different parts of the subject are in focus each time. Despite not using a tripod for the mobile phone, it would be difficult at first glance to say which of these images were taken with the *Nikon* camera other than the background was white when the *Nikon* was used, whereas the mobile phone did not cope well with such contrast so the background was changed. Also, the depth of field appears to be shallower when using the mobile phone.

Fig 12. *Psyllobora vigintiduopunctata* (22-spot ladybird) (c. 4 mm in length). Mobile phone and NHM x5 lens.

The 'household' magnifier (Fig. 3) was very easy to use as it had the widest lens and therefore was easy to position under the lens of the mobile phone. When using the *Triplet* magnifier lenses (Fig. 2), care had to be taken that the whole hand lens was held steady and was positioned very accurately, or the edge of the small lens appeared in the photos. The shape of the hand lens as a whole, as well as the small size of the lenses, made this magnifier the most difficult to use. It did however provide the greatest amount of magnification. The x20 lens was so small that it was almost impossible to use without the edges appearing in the picture, and only the very centre of the image did not suffer from distortion. The x5 magnifier from the NHM is perfect for using with a mobile phone as both the lens and its cover are flat and wide and are easily held in position against the back of a mobile phone. Being very light, it can also be held in place easily with masking tape or an elastic band.

The 22-spot ladybird (Fig. 12) was seen at the house of a friend, and the mobile phone and (NHM) x5 hand lens were genuinely the only items close enough to hand to be used to photograph the insect before it was attacked by a house spider and dragged into a tiny gap in the skirting board (if only the camcorder facility was being tested rather than the camera!). There was no time to get a 'proper' camera to record the specimen, so this genuinely shows the usefulness of knowing that photographs of such a small specimen (4 mm across) can be taken in this way. It is less detailed than the other photos as the insect was moving. Also, getting down on the floor right by the skirting board to get close enough to take the photograph without blocking all the available light was a little difficult.

Admittedly, the depth of field can be very limited and if outdoors in bright sunshine it can be difficult to clearly see the screen of the mobile phone, but the autofocus tends to work well even though it is focusing through another piece of glass. With small hand lenses, care has to be taken that the magnifier is held steady and is positioned accurately, or the edge of the lens can appear in the photos. Also, the middle of the image is more in focus than the outer parts of the image. But useful photographs can still be taken of surprisingly small specimens, as a simple record of what has been seen.

Conclusions

The images presented here are not necessarily impressive but they are simply to demonstrate that recognisable photographs of some limited use can be taken this way, with a variety of hand lenses – which is quite useful to know. With practice, much better images would be obtained.

Acknowledgements

Tony Irwin for the identification of the greenbottle, an anonymous reviewer for their help with editing, and Evelyn Larkin for the use of her specimens and hand lens.

Thomas Algernon Chapman, "The Doctor": The Life and Times of a Forgotten Entomologist

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Abstract

Hereford Museum Resource & Learning Centre holds a small collection of coleoptera and a slightly larger collection of Lepidoptera donated by Thomas Algernon Chapman in 1894. Other than the collector name and knowing Chapman was a doctor, no other collector information was apparent so, in addition to the above, I aimed to find out something about the donor of the material. This paper outlines a project to assess the condition and quality of the coleoptera specimens and to determine the circumstances in which it was collected and donated, hopefully providing the collection with some hitherto unknown context.

Introduction

The Chapman coleoptera collection is made up of twelve drawers of beetles (Fig.1) from all over the world, most of them originating from South America (approximately 900 specimens). The collection was systematically examined noting condition of specimens and highlighting areas that needed attention. Occasional verdigris was noticed but otherwise the specimens were well preserved. The specimen labels are all handwritten, with many abbreviations of localities, and outdated location names. The information written on the labels was fragmentary and quite general (e.g. Bavaria or Brazil as the location). In order to get a better grip on the collection it was essential that I investigate the collector. Using the internet, the library and Herefordshire Archive Service, over several months a fairly comprehensive account of his life, as well as his associations with various institutions in the UK, was gathered.

Fig. 1. Some of Chapman's beetles with their associated handwritten labels (© Herefordshire Heritage Services).

His Life & Work

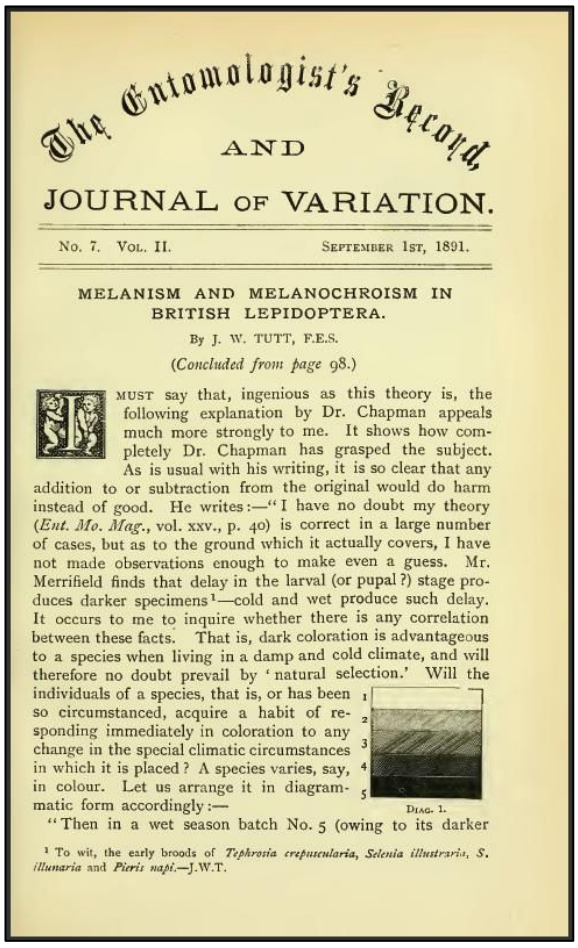
Dr. T. A. Chapman was born in Glasgow on the 2nd of June 1842. He studied medicine at the Universities of Glasgow and Edinburgh, eventually becoming the resident physician of the Glasgow Royal Infirmary. His father (also Thomas Chapman) was a member of the Glasgow Natural History Society and began his son's life-long fascination for entomology. Chapman moved to Abergavenny and worked in the Joint Counties Asylum in 1866 before relocating to Hereford in 1871 as the Medical Superintendent of Burghill Asylum.

While he was here he was a member of the Woolhope Club, becoming its president in 1876. He retired in 1895 and moved to Reigate, Surrey until he died in 1921. Chapman chose to retire there so that he could be close to the natural history institutions in London he was a member of, such as The Royal Society and the Royal Entomology Society (of which he was vice-president and turned down the offer of presidency). He was also a committee member of the Holmesdale Natural History Club in Reigate.

Throughout his life he dedicated his spare time to scientific research in the field of entomology, concentrating mainly on lepidoptera, and was a regular contributor to The Entomologist's Record (TER). He is most remembered for his work on Lycaenidae and their development, discovering the relationship between larvae of the Large Blue (*Phengaris arion*) and the ant, *Myrmica sabuleti*, among others (TER, 1951); he was instrumental in investigating melanism in British lepidoptera (Fig. 2), as discussed by J. W. Tutt, a friend of Chapman and someone he worked closely with (TER, 1891); and he wrote a thorough article about the genus, *Acronicta* (TER, 1890). He died in 1921 and was survived by two sisters (he never married).

Chapman was a generous man and keen to help his peers; he supported Hereford Museum and, as the president of the Woolhope Club, instructed others to make collecting and donating to the museum a priority. He has even been referred to as rivalling Darwin himself in some ways, as pointed out in his obituary in The Entomologist (Sheldon, 1922):

"...a busy stream of ants we passed on the path attracted his attention; then it would be the burrow of a trap-door spider in a sandy bank; the cryptic attitude of a mantis; or some striking peculiarity in the structure of a flower: about all of these and others he would point something of absorbing interest; to him all nature was an open book. I remember wondering if even Darwin could have been more interesting and instructive!"



The Entomologist's Record AND JOURNAL OF VARIATION.

No. 7. Vol. II. September 1st, 1891.

MELANISM AND MELANOCHROISM IN BRITISH LEPIDOPTERA.

By J. W. TUTT, F.E.S.

(*Concluded from page* 98.)

I must say that, ingenious as this theory is, the following explanation by Dr. Chapman appeals much more strongly to me. It shows how completely Dr. Chapman has grasped the subject. As is usual with his writing, it is so clear that any addition to or subtraction from the original would do harm instead of good. He writes:—"I have no doubt my theory (*Ent. Mo. Mag.*, vol. xxv., p. 40) is correct in a large number of cases, but as to the ground which it actually covers, I have not made observations enough to make even a guess. Mr. Merrifield finds that delay in the larval (or pupal?) stage produces darker specimens[1]—cold and wet produce such delay. It occurs to me to inquire whether there is any correlation between these facts. That is, dark coloration is advantageous to a species when living in a damp and cold climate, and will therefore no doubt prevail by 'natural selection.' Will the individuals of a species, that is, or has been so circumstanced, acquire a habit of responding immediately in coloration to any change in the special climatic circumstances in which it is placed? A species varies, say, in colour. Let us arrange it in diagrammatic form accordingly:—

1 2 3 4 5

Diag. 1.

"Then in a wet season batch No. 5 (owing to its darker

[1] To wit, the early broods of *Tephrosia crepuscularia*, *Selenia illustraria*, *S. illunaria* and *Pieris napi*.—J.W.T.

Fig. 2. The first page of the "Melanism and Melanochroism in British Lepidoptera" article written by J. W. Tutt featuring Chapman's work (image reproduced with permission from The Entomologist's Record).

Other Institutions

Most of the information discovered about the life and collections of Chapman came from visiting other institutions. Since Chapman was born, studied and worked in Glasgow, Maggie Riley and Geoff Hancock at the Hunterian Museum (part of the university Chapman attended) were contacted, who confirmed that they have specimens collected by him. Geoff warned me that their specimens lacked comprehensive labels: this seemed to be a characteristic of Chapman's collections. Chapman's obituary mentions that he used anything he collected for research (Sheldon, 1922). As a result most of what he collected was destroyed in the process, or given away to other researchers; this may explain the lack of good quality information. Approximately 20 entomological store-boxes are held at the Hunterian Museum (Glasgow) (Fig. 3). It provided an ideal opportunity to compare that collection to Hereford's: I looked at the labels (even less informative than ours), methods of storage and the paper records. The main problem was that we were unable to say for certain whether the specimens were connected to Thomas Algernon Chapman or his father, Thomas Chapman. Geoff then discovered that the Hope Entomological Collections at the Oxford University Museum of Natural History (OUMNH) have some specimens and correspondence relating to Chapman; the visit to the Hunterian had provided some new information, and a new lead.

The library at the Natural History Museum, (NHM), London holds seven boxes of macro photographs and illustrations of lepidoptera that Chapman had commissioned and made notes on (Fig. 4). The material from the library was beautiful and very interesting, giving further insight into Chapman, his work and his habits. A visit is planned later in the year to visit and view Chapman's specimens.

Fig. 3. An insect store-box from the Hunterian in Glasgow holding some of Chapman's coleoptera specimens (© of The Hunterian Museum, Glasgow).

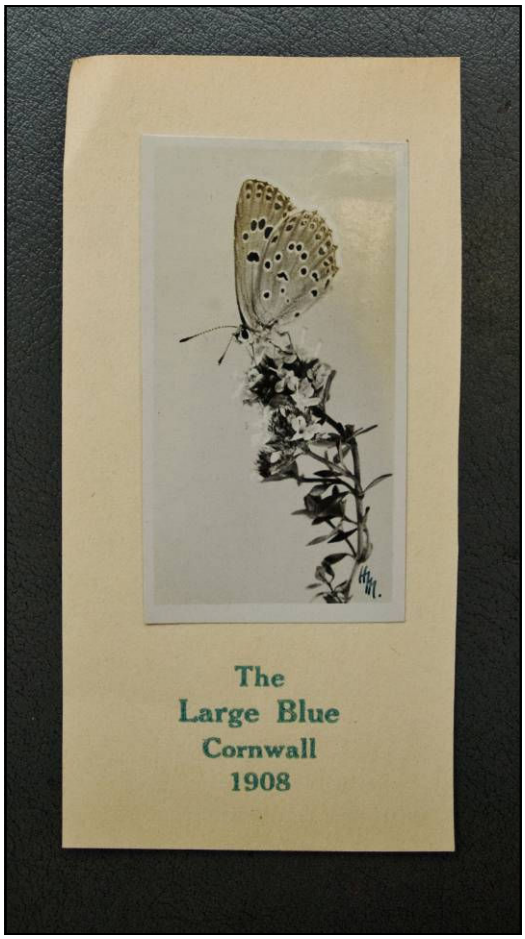


Fig. 4. One of the photographs in the Chapman collection. Chapman was famous for researching this species and discovering its relationship with a species of ant (© the Natural History Museum, London).

The Holmesdale Natural History Club (HNHC), in Reigate, Surrey also holds a small number of specimens that may be linked to Chapman. A selection of Lycaenidae, including a Large Blue (Fig. 5), were seen, but the labels were typed or written in a different hand as Hereford's. Two of the volunteers (Carol and Viviane) had very kindly gone through the minutes and bookmarked any mentions of Chapman, including some instances of his own handwriting. A few more details about his life came to light but nothing regarding his collections.

The Hope Entomological Collections at the OUMNH have a collection of correspondence between Chapman and John Obadiah Westwood and specimens listed as material Chapman collected and named. These were photographed and although nothing of note has come to light, they are yet to be investigated fully.

Summary
There is still work to be done in investigating some of the material (e.g. from OUMNH and Herefordshire Archive Service) which may suggest other institutions to ask or new routes of enquiry. The absolute importance of Hereford's Chapman collection is unknown as yet but the information about Chapman reveals a pioneering and highly regarded entomologist with links all over the UK and this alone elevates the collection significantly. Once the material has been looked through and institutions like the NHM visited further, new insights into the specimens may come to light. At the very least, Dr. Thomas Algernon Chapman was an eminent gentleman in the field of entomology, well respected and knowledgeable; Herefordshire Heritage Services is privileged to count his material as one of its earliest donations. The above findings have been added to an online report: http://prezi.com/yjerl4vnqu7i/thomas-algernon-chapman/

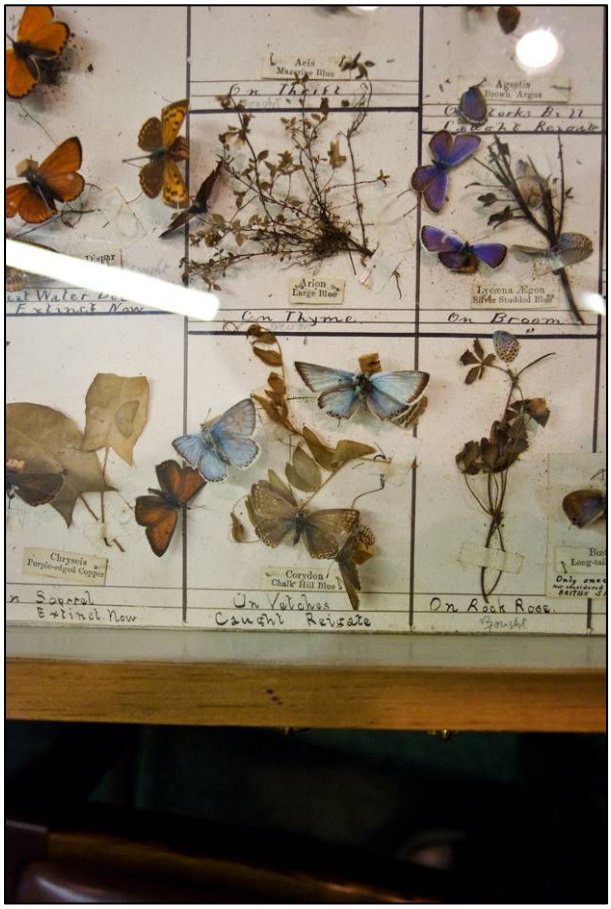


Fig. 5. Lepidoptera specimens at HNHC, including the Large Blue (© Holmesdale Natural History Club).

Acknowledgements
The twelve-month traineeship has taken me through the natural history collections of Ludlow and Hereford museums as I have been learning the skills required to be a natural history curator. The year so far has involved a variety of tasks and training courses from all areas of natural history curation, as well as visits to other museums. Without the HLF *Skills for the Future* traineeship, I would have been unable to undertake this project. I would like to thank Geoff and Maggie at the Hunterian in Glasgow, the library at the NHM, Carol and Viviane at the Holmesdale Natural History Club and Amoret Spooner and Katherine Santry at the OUMNH for giving me their time and access to their collections. I am grateful to the traineeship and Hereford and Ludlow Museums for giving me the opportunity to undertake this project, especially seeing as it has taken me around the country and to see some amazing collections.

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TER, 1890. The Entomologist's Record, 1891. The Genus Acronycta and its Allies. *The Entomologist's Record and Journal of Variation* 2, No. 1: 1.

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Living Specimens in England's Natural History Museums: Frequency, Use and Legislation

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Abstract

Living displays feature prominently in many of England's natural history museums, but what do they add to exhibits? We first take a closer look at the current living displays of three prominent museums: the Oxford University Museum of Natural History, Liverpool World Museum and Horniman Museum, then report the results of a questionnaire taking a more systematic look at the frequency and nature of current live animal displays in our natural history museums as well as curators' perceptions of the benefits (or disadvantages) of their inclusion. Results suggest a variety of attitudes towards living displays and learning outcomes a focus of justifications. Curators also note a number of practical challenges to maintaining living collections and interesting issues are raised with regards to legislation governing living animal collections within museums.

Introduction

To commemorate the 200th birthday of Charles Darwin and the 150th anniversary of Darwin's publication of *On the Origin of Species*, the Natural History Museum in London held a special exhibition titled 'Darwin: Big Idea, Big Exhibition'. The exhibit was filled with artefacts and mementos of Darwin's life and expeditions, including Darwin's own specimens and notebooks, as well as modern perspectives on the significance of evolutionary theory. Nestled among these specimens and anecdotes of Darwin's journeys were two living specimens, housed in large glass terrariums that were not unlike the glass cabinets containing other mementos and artefacts from the voyage.

The two animals were 'Charlie', a green iguana, *Iguana iguana* (Linnaeus, 1758) and an unnamed Argentine horned frog, *Ceratophrys ornata* (Bell, 1843). Both are species that are extremely common in the pet trade, and which hold rather tenuous links to Darwin himself. While the non-living specimens on display and journal pages were items that passed through the very hands of Darwin, neither living animal was descended from an animal that had interacted with the celebrated naturalist. Yet both of these living displays occupied central positions within the exhibit and featured prominently in the press release advertising the exhibit (NHM, 2008a), with 'Charlie' even appearing as the very first image in a slideshow on the official website of the exhibition (NHM, 2008b).

As I perused the exhibition, I wondered what incorporating these living displays added to the exhibition. But where I had my doubts, others celebrated the presence of real, live animals:

> "What an exhibition can do that is not done better in any other medium is to show *real things*. The closest this one come to giving an idea of what it was like to be Darwin the field naturalist is to be found in two glass cases: one is inhabited by a rarther sinister grey spotted pudding of a horned frog the other by a most green iguana. A small sample, but *seeing these live animals makes you realize that no image on screen or on paper can match them*." (Campbell, 2009, my emphasis)

Campbell's comments suggest that encountering these live animals heightened the visitor's experience, delivering a level of realism that cannot be accomplished by their non-living counterparts. For me, the presence of these living displays in the exhibit raised a number of interesting questions about their lives in glass cases. Did other visitors react to these living creatures in the same way Campbell had? How can and should live animal displays be used to enhance and compliment a museum's non-living exhibits? While natural history museums are typically collections of non-living plants and animals, we have another word for collections of live animals, zoos. This then begs the question, how does including living animals blur the distinction between zoo and museum? What might their inclusion achieve?

Living Animal Display Case Studies

A first step to understanding the use and role of living displays in natural history museums is to explore the frequency of live animal exhibits across our nation's museums and to find out more about the motivations and barriers (both practical and legislative) to housing living animals within the museum. To begin to understand the use of living displays by natural history museums, I contacted three prominent English natural museums that permanently house living specimens alongside non-living natural history collections (the Oxford University Museum of Natural History, Liverpool World Museum and Horniman Museum) to discuss their use of living animal displays. In this section, I will introduce these museums and describe their use of living specimen displays, offering a brief profile of their collections and sharing their curator's perspectives on the role and impact of these living displays.

Fig. 1: 'Charlie' the green iguana featured prominently in the Natural History Museum's exhibition 'Darwin: Big Idea, Big Exhibition'. This photo of Charlie was the first image on the museum's slideshow of the exhibition (NHM, 2008b).

Oxford University Museum of Natural History, Oxford

At the Oxford University Museum of Natural History, the first floor Hope Entomology gallery includes both non-living and living invertebrate displays. Live creatures such as the Madagascar hissing cockroaches, *Gromphadorhina portentosa* (Schaum, 1853), depicted in Fig. 2 are situated beside displays of non-living specimens, including preserved specimens and models, which are organized according to their taxonomy in the vertical display cases and by topics or themes in the flat display cases.

Live specimens are a relatively new introduction at the Oxford museum, where they have only been used in handling sessions for about 10 years. Sarah Lloyd, the museum's education officer, writes that the live arthropod displays are excellent for engaging visitors and extremely useful for illustrating aspects of behaviour that are not readily evident in the more static non-living displays (2009; Aw, 2012). By presenting living displays, the museum also opens a dialogue about their behind the scenes work, allowing museum staff to discuss the work of entomologists at the museum and university, who use a combination of living and preserved specimens in their research.

Lloyd (2009) adds that the living specimens are made more meaningful by the surrounding non-living displays. By presenting living specimens alongside preserved ones, Lloyd argues that the museum situates these specimens in a framework of taxonomy and systematics (2009). The living exhibits are illustrations of the principles and characters described in the taxonomically organized family descriptions. This framework contrasts with the context of similar displays in a zoo environment, where messages are primarily focused on conservation rather than classification.

Fig. 2: Cases housing living invertebrates are interspersed between non-living displays at the Oxford University Museum of Natural History's entomology gallery.

World Museum, Liverpool

At the World Museum in Liverpool, living animal displays make up a more substantial and integral part of the museum, accounting for a far greater proportion of the museum's exhibition space. The World Museum is home to an entire Natural World wing that includes two dedicated living animal galleries, a 'Bug House' and aquarium, in addition to a Natural History Centre, and separate Zoology and Botany galleries. Across the Natural History wing, nearly 10% of the World Museum's natural history displays include live animals.

These living displays are extremely popular with visitors. Mike Graham, curator of both the living displays and the natural history collection says, "Visitors are more attracted to live animals, especially when we use them in conjunction with the [non-living] collections" (2009). And this attraction is nothing new to the museum. Living animals were first introduced to the museum (then known as the Derby museum) in 1857 through the installation of the aquarium. Following the addition of which, the museum witnessed a vast increase in visitors.

> 'During the year, several Aquaria, both salt and fresh water, have been established in the Museum, and have proved of very great interest to the visi tors; indeed there is good reason to suppose that it is mainly to the new additions to the Museum that the number of visitors has been so much in advance of previous years' (Library and Museum Committee Minutes November 1855-September 1858, 5, cited by Graham, 2009).

Fig. 3: A demonstrator holds a crab. Photograph by Leila Romaya and Paul McCann via the National Museums Liverpool (2011).

Fig. 4: A close encounter with a meerkat at the World Museum during National Science Week. Photo by Gavin Trafford (Liverpool Echo, 2011).

Today, the Natural World wing attempts to bring all aspects of the Natural History wing together, to communicate the overarching message that individuals and species do not occur individually, but together in ecosystems. Likewise, the museum itself strives to integrate its displays into a broader learning environment, working closely with school groups, families and the national curriculum to incorporate demonstrations with live animals to explain the nature of their unique adaptations and environments.

The Horniman Museum, London

Fig. 5: The Horniman Museum's Natural History Gallery viewed from the first floor as reproduced from Horniman Museum (2011a).

The Horniman museum was founded by tea trader, Frederick Horniman, in the hope of creating a place for the people of London to use for recreation, instruction and enjoyment. Living displays feature prominently at the museum and help the museum achieve all of these aims. The Horniman Museum in London houses both a natural history collection and an aquarium. As at the World Museum in Liverpool, living specimens have played a prominent role in the museum throughout its history as well as today. At the Horniman, living specimens have been incorporated into the museum's displays for over 100 years, dating back at least to the opening of the museum at its current location (the Charles Harrison Townsend building) in 1901.

F

Fig. 6: The aquarium at the Horniman Museum. Photo courtesy of the Horniman Museum (2011b).

The Horniman's few hundred aquarium specimens and 'Nature Base' animals are dwarfed by the nearly 4,000 natural history specimens on display, but nonetheless feature prominently in the museum. In fact, according to the head of development and marketing at the museum, Marcus Pugh, the aquarium is the most popular wing of the museum, with 82% of all visitors frequenting this section. The Natural History gallery, which includes the Nature Base attracts 64% of all visitors (Pugh, 2009).

Fig. 7: A child explores a fox specimen at the Horniman Museum's Nature Base. Photo as reproduced from News Shopper (2009).

According to the Keeper of Natural History, Joanne Hatton, the living displays provide both "education and enjoyment, both [of which] contribute to achieving our mission of inspiring and engaging wonder and stimulating interest in nature and the environment both from a local but also a global perspective" (2009). Hatton adds that housing both living and non-living displays in the museums allows the two display types to complement and enhance each other. For while live displays can introduce aspects of behaviour that cannot easily be replicated in non living displays, they do not always foster the same opportunities for up close and personal encounters as taxidermy. Indeed, at the Nature Base corner, the famous Horniman beetles were

nowhere to be found and I was told by an apologetic member of staff that the beetles unfortunately "took Sundays off" by hiding; and only the very luckiest of visitors manage to catch a glimpse of the cryptic and secretive harvest mice. In contrast, the natural history museum's collection of exquisitely dissected preserved collections offer cross sections and images of anatomy and development one could never glimpse in life and are always prominently visible to visitors.

Conclusions

All of the curators working with live animal displays in these three museums conveyed extremely positive sentiments towards their living displays, describing their inclusion as enhancing the museum experience and providing meaningful encounters for museum visitors. Likewise, the living displays are also extremely popular at all three locations. Despite varying histories of life across the museums, all three institutions pointed to similar benefits of housing both living and non-living exhibits together and all three institutions cite education as the primary reason for holding live animal collections (Graham, 2009; Hatton, 2009; Lloyd, 2009).

Living Animal Display Questionnaire

Discussions with the curators at the above institutions begins to offer some insight into living animal displays, but to better understand the role of living displays across natural history museums, I wanted to take a more structured look at our museums and their displays by issuing a questionnaire about the use of live animals in the museum and get a better sense of the prevalence of living displays across the country. The following questionnaire attempts to get a glimpse of the frequency of live animal displays across natural history museums and to discover more about both the positive and negative aspects of museums housing living animals as well as investigate the practicalities and legislation concerning life within the museum.

Methods

Participants

To better understand how widespread living animal displays are in English Natural History Museums, I designed a questionnaire (see Appendix 2 or http://216.75.9.33/questionnaire) to find out more about both the displays museums currently house as well as their attitudes toward living displays and their motivations for and against housing live animals in the museum. I identified 25 museums with Natural History collections (see Appendix 1).

Distribution

Questionnaires were distributed to curators through an email sent directly to the curator (where a direct email addresses were provided) or addressed to the natural history curator via the general enquiries desk. My message introduced myself and the project and contained a hyperlink to an online questionnaire, which could be supplemented by a paper copy and self-addressed stamped envelope by request.

Results

Of the 25 museums contacted, only 10 responded. Nine of these institutions responded electronically and one museum responded by post. The responding institutions are marked with an asterisk in Appendix 1.

Frequency of Living Displays

Of the 10 responding museums, 5 held live animal displays at the time of responding and all of these living displays were maintained alongside non-living exhibits (i.e. in the same gallery). Of those institutions which did not house living displays at the time of responding, all 5 reported having done so in the past.

This raises a serious concern when considering this data. It is quite surprising that all of the responding museums currently or had previously held living displays. The introductory email to the questionnaire clearly requested responses from all museums whether or not they had ever housed living displays. It is unclear whether the present result of all museums having experience with housing live animals is an artefact of response bias, or actually representative of natural history museums across the country.

Types of Living Displays

Of the living animals on display, terrestrial invertebrates were the most frequently housed. These were present in 4 of the 5 museums (Table 1).

Aquatic Invertebrates	1
Terrestrial Invertebrates	4
Aquatic Vertebrates	1
Reptiles & Amphibians	1
Birds	0
Mammals	1

Table 1: Museums reporting housing these taxa among their current living displays. A total of 5 responding museums housed live animals, thus all but one had terrestrial invertebrates among their living displays.

Interestingly, none of the museums housed any living birds. Among museums which housed live animals at the time of responding, the mean number of live animal displays was 8.5 (range: 1 to 19) with a mean number of 30.3 species (range: 1-151). The number of individual animals ranged widely from 40 to the thousands for many institutions. The count of individuals was highly skewed by the inclusion of large colonies of social insect, with many institutions housing bee and ant colonies.

Justification and Motives

Education was seen as a primary reason for including living displays and was cited as the most important reason for including live animals by three of the five institutions. However, two institutions instead regarded entertainment as the most important feature of living displays. Interactivity was seen as the second most important benefit of these displays by three curators. Other reasons cited included engagement, conservation and use in the museum's outreach programmes.

Five of the museums had previously housed live animals, but no longer did so. Their reasons for not continuing to house live animals were primarily related to the maintenance of the animals, with many unable to afford the time and money associated with maintaining the displays and providing care for the animals. The curator of the Booth Museum reported many challenges in maintaining a freshwater aquarium and went so far as to say that their living fish display was therefore deemed 'inappropriate for a museum'.

Interestingly, one institution, the Potteries Museum in Stoke-on-Trent, described an alternative way of providing encounters with live animals. As the museum was unable to afford the high maintenance costs of living specimens, they outsourced activities involving living specimens to external companies for events during school holidays. These companies provide hands-on interaction with a wide array of species and cater to school groups, museums, care homes, and a wide range of events. For more details about these animal handling companies, see Animals in Hands (2011) and ZooLab (2011). Although these companies emphasize the educational aspect of their encounters, including themed lesson plans and ties to the national curriculum, these handling sessions were seen by the museum staff to be more entertaining than educational experiences.

Animal Care

Primary care of living specimens was attributed mainly to curators with no specialist animal care training. In museums where bees were housed, these colonies were maintained with assistance from local bee keepers; only the Horniman Aquarium described use of specialist animal care staff. Although the Nottingham Natural History Museum's Museum Assistants created a rota system by forming an 'Insect Team' to care for the animals, animal care was not a primary duty for any of these assistants.

Acquisition and Exchange

In response to questions about the origin of their animals, the majority cited sourcing specimens from captive breeders. The three institutions which housed bee colonies had acquired their colonies from local bee keepers. Petting zoos and safari parks were also cited as sources of live animals. Only the Horniman aquarium referenced programmes to exchange animals with other institutions and only 2 of the 5 museums reported that their living animals were part of captive breeding programs.

Funding Care

Specimens were financially supported from a wide range of sources. Most museums did not have funding specifically for the living displays and relied on funds taken from the museum's maintenance budget, specific museum departments, or the council's revenue budgets. However, some museums reported that provisioning for the displays was provided by the Higher Education Funding Council for England (HEFCE), a

Heritage Lottery Fund (HLF) grant and funding from the Department for Culture, Media and Sport (DCMS).

Regulation and Legislation
Two of the museums reported being regulated by the Department for Environment, Food and Rural Affairs (DEFRA) under the Zoo Licensing Act (1981). The other three museums reported that their collections were unregulated.

Discussion
Although only 10 of the 25 contacted institutions completed the questionnaire, their responses capture some of the important benefits and drawbacks to keeping living animals in the museum. Some curators expressed strong positive views about living displays, while others expressed disapproval, dismissing living displays as minimally educational entertainment. Interestingly, several curators of institutions which both did and did not house living specimens pointed to their educational value, which raises interesting questions about the difference between living and nonliving specimens in achieving learning outcomes.

General Discussion
Taking together the case studies and feedback from the questionnaire, we can begin to understand some of the perceived benefits and barriers to housing living animal displays within natural history museums. The importance of living displays as tools in learning and education are repeatedly cited as motivations for including these displays and may reflect the renewed focus on learning and inspiration in museums (as demonstrated by a number of new initiatives by museum governing bodies including, Inspiring Learning for All by the Museum, Libraries and Archives Council in 2004 and outlining of Generic Learning Outcomes by the Research Council of Museums and Galleries). But what evidence do we have for the role of living animal displays in learning and education?

Live Animals in Education
Although little research has been published on learning outcomes of live animal encounters, the few studies that have been conducted do suggest that interacting with living creatures may facilitate learning. The mere presence of living displays in the classroom has been shown to stimulate a greater degree of interest and curiosity in students; and this curiosity in turn influences attitudes towards learning and achievement (Saunders and Young, 1985); and students who had interacted with live animals show statistically greater changes in their attitudes toward these creatures than students who interacted with preserved specimens of the same species (Sherwood, Rallis and Stone, 1989).

Within a zoo or museum context, living and preserved specimens do stimulate broadly similar conversations among visitors, but as one might expect, comments about the behaviour of animals occurred with greater frequency in the zoo than museum (Tunnicliffe, 1995, 1996a, 1996b; Tunnicliffe, Lucas and Osborne, 1997). Although living specimens were not present in the museum, Tunnicliffe's research suggests that bringing live animals together with static specimens of the same or contrasting species with salient nonliving displays might enhance learning by both attracting visitors and directing their attention to some of the less-evident, but interesting animal characteristics, they might otherwise overlook and providing an opportunity for visitors to observe the behaviour of the animals as well (Tunnicliffe, Lucas and Osborne, 1997). Our natural history museums would be in an ideal position to showcase living and non-living specimens together and this type of facilitation of learning by situating living and nonliving displays together does appear to occur in many of the responding institutions.

Legislation Governing Live Animal Displays
Although many practical issues regarding the care of living animal displays were raised, few curators expressed awareness of the legislation governing such exhibits. Responses to the final questionnaire item regarding legislation were very interesting. The fact that only three of the 5 museums which reported holding live animal collections are regulated is quite a surprise, as the living specimens housed by museums seem quite clearly to fall under the category of 'zoo' according to the Zoo Licensing Act (1981). The act requires institutions not only to provision all of their animals with suitable environments with highest standards of animal husbandry, but also to participate in conservation measures and actively promote public education. In addition to these requirements, more specific guidelines can be found in DEFRA's Standards of Modern Zoo Practice (DEFRA, 2004).

The act, though issued by DEFRA leaves implementation and regulation in the hands of local authorities and regulation consists of inspections which include, but are not limited to visits from inspectors and veterinarians. However, the efficacy and consistency of such enforcement has fallen under question and DEFRA has recently commissioned ADAS to conduct a thorough review of the implementation of the Act by local authorities (DEFRA, 2011).

The fact that three of the museums described their living collections as unregulated is surprising when one explores the text of the act, as the living displays of the museum seem to fall unambiguously into the document's definition of a zoo. DEFRA's Zoo Licensing Act 1981 defines a 'zoo' as:

> "an establishment where wild animals (as defined by section 21) are kept for exhibition to the public otherwise than for the purpose of a circus (as so defined) and otherwise than in a pet shop (as so defined)". (1.2)

This definition is further clarified in Section 21:

> "'animals' means animals of the classes Mammalia, Aves, Reptilia, Amphibia, Pisces and Insecta and any other multi cellular organism that is not a plant or a fungus and
> 'wild animals' means animals not normally domesticated in Great Britain;
> 'circus' means a place where animals are kept or introduced wholly or mainly for the purpose of performing tricks or manoeuvres at that place;
> 'pet shop' means premises for whose keeping as a pet shop a licence is in force, or is required, under the Pet Animals Act 1951." (21.1)

By these definitions, any living displays housed in museums would be classed as a 'zoo'. The legislation applies to any zoo "to which members of the public have access, with or without charge for admission, on seven days or more in any period of twelve consecutive months" (1.2A). This again is a category into which almost all museums would fall. More detailed interpretation of section 1.2 of the Zoo Licensing Act have also been outlined by the Zoo Forum (2006), but these too, clearly point to any living specimens in the museum as to be classified under the heading 'zoo'. Thus it seems rather surprising that not all of the museum's living collections were reported as DEFRA regulated. However, ultimately, according to DEFRA Zoos Policy member Margaret Finn, the classification of an institution as a 'zoo' falls upon the local authorities (Finn, 2011).

Discussions with curators of natural history museums housing living animal displays and a questionnaire issued to natural history collections across England have generated a number of interesting questions regarding the use of living animal displays in the museum context. Unfortunately, given the small number of responding museums, and the fact that all of the responding museums currently or had previously housed live animals, it seems likely that the questionnaire has suffered from a considerable response bias, making it difficult to make generalizations beyond the responding institutions. However, it is also possible that these responses do reflect the situation of the non-responding museums. Nonetheless, the results presented here, taken together with curators' comments begin to show us the role of living displays from a curator's perspective and begin to paint a picture of the frequency and use of living displays across the country. It would be fascinating to accomplish a more comprehensive review of current practices and see how these figures and attitudes compare to those in other countries and explore the visitor's perspective on these displays, as the present discussions explore only the curatorial perspective. The relationship between living animal displays and their nonliving surrounds is also an area ripe for further research as the ways in which such displays are integrated and interpreted will certainly influence their effectiveness in achieving learning outcomes and attractive audiences.

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Appendix 1: List of English Natural History Museums contacted and responding to the questionnaire. Institutions marked with an asterisk are those which responded to the questionnaire.

Bagshaw Museum, Batley

Booth Museum of Natural History, Brighton*

Bristol City Museum and Art Gallery, Bristol

Buxton Museum & Art Gallery, Buxton

Charnwood Museum, Loughborough, Leicestershire*

Chelmsford Museum, Chelmsford*

Cole Museum of Zoology, Reading

Dorman Museum, Linthorpe

Hancock Museum, Newcastle upon Tyne

Horniman Museum, London*

Ipswich Museum, Ipswich

Kendal Museum, Kendal

Lapworth Museum of Geology, University of Birmingham, Edgbaston

Manchester Museum, Manchester*

Museum of Lancashire, Lancashire

Natural History Museum, London

Natural History Museum at Tring, Tring

Oxford University Museum of Natural History, Oxford*

Potteries Museum & Art Gallery, Stoke-on-Trent*

Royal Cornwall Museum, Truro

Tolson Museum, Huddersfield*

University Museum of Zoology Cambridge, University of Cambridge, Cambridge

Wollaton Hall Natural History Museum, Nottingham*

World Museum Liverpool, Liverpool

Yorkshire Museum, York*

*denote museums that responded to the curator questionnaire found in Appendix 2

Appendix 2: Living Animal Display Questionnaire in paper form. The online version can be viewed at http://216.75.9.93/questionnaire.

Live Displays in UK Zoos and Museums

Name:

Institution:

Position:

Does your institutions house live animals as parts of its displays?

☐ Yes
☐ No (if no, please skip to question 11)

Are these housed alongside non-living exhibits (i.e. in the same room/gallery space)?

☐ Yes
☐ No

What types of live animals do your living displays include? (Check all that apply)

☐ Aquatic Invertebrates (e.g. crustaceans)
☐ Terrestrial Invertebrates (e.g. insects, arachnids)
☐ Aquatic Vertebrates (e.g. fish)
☐ Reptiles/Amphibians
☐ Birds
☐ Mammals

How many living displays does your exhibit include?

☐ Exhibits
☐ Species
☐ Individuals

Who take primary responsibility for the care and husbandry of these animals?

Are these animals part of captive breeding programmes?

☐ Yes
☐ No

How/from where were specimens acquired?

How are your living specimens financially supported? (e.g. adoption scheme/sponsorship, admission fees, etc)

Who regulates the living conditions and care of these specimens? (e.g. UK Home Office, AZA)

What do you consider to be the primary role of living specimen exhibits? (Please rank all that apply)

- [ ] Education
- [ ] Conservation
- [ ] Entertainment
- [ ] Interactivity
- [ ] Outreach
- [ ] Other

If your institution does not house live specimens, has it does so in the past? Describe any reasons you/your institution would or would not include living displays in your exhibits.

Visitor's Responses to Living Invertebrate Displays in a Natural History Museum and Zoological Park: A Case Study

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Abstract

This observational study represents a preliminary look into visitor responses to living and nonliving invertebrate displays in a natural history museum (the Oxford University Museum of Natural History) and zoological park (the London Zoo). Basic patterns in visitor behaviour are captured, taking into account the type of display, institution and demographic variables. There was a significant effect of display type, with living exhibits attracting more visitors and holding their attention for a longer period of time than one would expect by chance. This result is consistent with the curators' anecdotal reports regarding the attractiveness of living displays and speaks powerfully to their potential as tools in attracting audiences and stimulating interest in zoology. Individuals also spent significantly longer per exhibit at the London Zoo B.U.G.S. House than the O.U.M.N.H. entomology gallery. Interestingly, demographic variables did not appear to be significant nor were their interactions with main effects.

Introduction

Our fascination with wild animals is an ancient one and collections of live animals date back as far as 3000 BC, when the first zoological gardens were created in the earliest of urbanized civilizations (although one could argue the even these were preceded by animal collections if one includes early attempts at domestication, Kisling 2001). In his history of zoological gardens, Kisling (2001) writes:

> 'Exotic animals have long been the ultimate collectibles. Exotic animals, alive, and active, have been more fascinating and exciting than natural history (museum) specimens, plants, or cultural artifacts – in part because animals are less common, more difficult to acquire, and more expensive to maintain. And then, there is the fascination, both emotional and scientific…'

This passage by Kisling captures the multifaceted attraction that the live animal has for us and it is this feature that has inspired their collection throughout history. But these live animal collections have largely occurred outside of the museum; and the history of the zoological garden runs more or less parallel to that of the natural history museum, where nonliving specimens predominate (as detailed in works by Kisling, 2001; Hardouin-Fugier and Baratay, 2003).

Despite the fact that zoos and natural history museums share a common subject and are both composed of collections of animals, the two types of institutions have traditionally differed in their cultural status. While private zoological gardens and collections have always been associated with society's most elite, the publicly accessible zoological collections have largely been regarded as a popular amusement. This comes in stark contrast to the ascendance of museums and art galleries to the realm of high culture:

> 'For the general public [zoos] were (and we would argue still are) merely places for recreation, places where one could walk and amuse oneself looking at strange and interesting animals. In an important sense they were not serious places, as for example a science museum or art gallery was' (Mullan and Marvin, 1987)

The contrast is a curious one, particularly when one compares the zoological garden to the zoological collections of a natural history museum. It is as if the preservation and encasing of the specimen in a glass cabinet awards it greater prestige or scientific merit not afforded to the same individual in life, while it is arguably more authentic in life before preservation and taxidermists have imposed their interpretation (Mullan and Marvin, 1987).

Whilst institutions such as museums and art galleries command a reverential consideration as places of culture and collections of objects requiring careful interpretation, collections of living animals are perceived as not requiring interpretation and therefore not intimidating (Mullan and Marvin, 1987):

> 'For the [zoo] visitor to have an enjoyable experience, he does not need a high level of knowledge. The important thing for him is that the simply sees the animals. Whereas museums and art galleries become involved with connoisseurship, zoos did not'

While this is seen as a source of frustration to the likes of Mullan and Marvin, the perceptions of zoos as both accessible and enjoyable, may put them in an ideal position to access audiences who might otherwise be intimidated by the more scholarly, interpretation-rich setting of the traditional natural history museum.

Indeed, when it comes to attracting visitors, zoos appear to be more successful than museums. Museums typically attract audiences that are wealthier and more educated than would be representative of their regions, while zoos attract visitors from across the socioeconomic spectrum (in the USA: Bitgood and Benefield, 1986; Hanna and West, 1989; Merriman, 1991; Falk and Dierking, 1992; in the UK: Ament, 1994; MORI, 2001; Travers, 2006; Nabola, 2008). This is quite surprising, given the high entry costs to most UK zoos and free entry to most UK museums. But with the popularity of zoos across demographics, could museums learn from zoos? Could including living displays help make museums seem more accessible? Could the inclusion of living displays within the natural history museum create help achieve the desired interactive museum experience (see discussions in Alberch, 1994; Aw, 2012)?

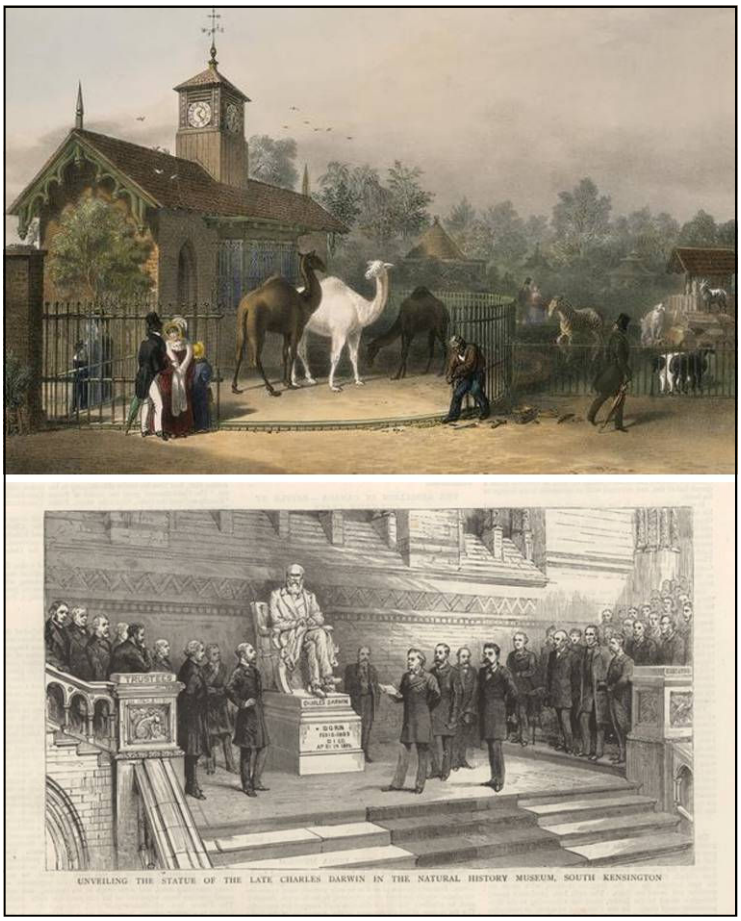


Fig. 1. Views of the London Zoo (above) and Natural History Museum at South Kensington (below) depicting the differences in cultural status of zoos and museums. The above painting shows the Zoological Gardens in Regent's Park, London, 1835. From the collection of the Museum of London, as reproduced from Wikimedia Commons (2011). The second image shows the unveiling of Darwin's statue at the Natural History Museum in 1885. The artist is anonymous. Image as reproduced from Darwin Online (2011).

The reasons why visitors come to zoos and museums may also differ. In keeping with perceptions and cultural status of zoos and museums, the goals of museum and zoo visitors also point to differences in the perceived aims of the two institutions. While museum visitors typically express learning goals as their primary motivation for visiting, zoo visitors express greater social orientation, with learning as a secondary motive (Hood, 1983; Bitgood and Thompson, 1987; Linton and Young, 1992; and review in Tunnicliffe, 1995). While zoos are also seen as places where learning occurs, they are perceived as environments which are as 'information-poor, experience-rich' in contrast to the formal classroom setting which is 'information-rich, experience-poor' (Packer and Ballantyne, 2002; Rosenfeld, 1980). Venues such as natural history museums may be situated ideally between these two experiences, as museums strive to combine the closely related activities of learning, education and entertainment (Kelly, 2007). Given these different perceptions and motivations, we might expect visitors to respond differently to similar displays in these two different contexts.

An observational study of visitor behaviour is presented in the face of both living and non-living invertebrate displays in a zoo and museum environment. Understanding how visitors respond to living and non-living displays is a first step to learning how best to use these powerful, sometimes controversial display types to maximum effect. This study represents an initial exploration into the use of life in the UK museum, that only skims the surface of a complex and controversial topic, raising as many questions as it answers. It is my hope these questions inspire further research into the presence and effects of life in the museum.

The present paper explores the behaviour of visitors in the face of living and non-living displays. This provides the first comparison of living and non-living display types in both a zoo and museum setting, exploring the amount of time visitors spend looking at exhibits according to the type of display they are viewing (living or non-living) when both display types are situated side by side in the same exhibition space. I explore visitation to different exhibition types in these two contexts and attempt to uncover the factors which influence the time individuals spend at each exhibit. This study focuses on invertebrates, as these are the taxa most frequently housed within museums (see Aw, 2012) and because focusing on invertebrates allows for a more direct comparison between the Natural History Museum and zoo settings.

Procedure

Study Sites

The Hope Entomological Collections of the Oxford University Museum of Natural History (hereafter O.U.M.N.H.) and the B.U.G.S. House (which stands for Biodiversity Underpinning Global Survival) at the London Zoo were selected as study sites. These two exhibition spaces are home to living invertebrate displays as well as non-living displays and interpretive panels. In the B.U.G.S. House, one vertebrate living display was present in the observation areas, the Naked Mole Rat, *Heterocephalus glaber* (Rüppell, 1842).However, since these mammals were housed together with crickets, the display was not coded as different from other living displays. Both living and non-living display types are housed side by side in the same exhibition spaces, facilitating comparison between the two display types. Images of some of the living displays at each site can be found in Appendices 4 and 5.

Both of the study sites represent gallery spaces which are clearly separated from other exhibits: a distinct corridor at the O.U.M.N.H. and a dedicated building at the London Zoo. At the O.U.M.N.H. this corridor has an entry and exit point at each end (see Appendix 1), while at the London Zoo, the B.U.G.S. house has a single entry and exit (see Appendix 2). This layout lends the space to observational studies, allowing us to easily alert visitors to the study taking place and monitor activity.

These galleries were divided into observation areas which were roughly equal in their physical area and number of exhibits both within and across study sites (see Appendices 1 and 2).

Participants

Participants were made aware that an observational study was in progress before entering the exhibition and had the right to exclude themselves from the study or seek more information about the project if desired. Exclusion from observations was signalled by placing a sticker or peg on their left arm.

If they did not exclude themselves, participants were observed upon entry to the gallery. The observer remained seated discreetly in the gallery with a silent stopwatch, monitoring behaviour. If more than one person entered the gallery at a same time, a focal individual was selected at random by numbering individuals and using a random number generator. To reduce pseudoreplication and confounds of interactions between members of the same group, only one individual was observed from each group of visitors. No personally identifying information was stored and no video or photographic recording of participants was conducted. As a result, this observational study is in compliance with the University of Leicester's *Research Ethics Code of Practice* (2011). The project was further approved by the ethical committees of both the London Zoo and O.U.M.N.H.

Duration of Observations

Individuals were observed in a single visible section of the gallery at a time (i.e. were not followed through the space). The observer was positioned to provide between-subjects coverage of the gallery space (see floor plans in Appendices 1 and 2). Each individual was observed up to a maximum of 20 minutes or until he or she exited the observation area. Notes were taken of the date and time during observation sessions. The following variables were recorded and a sample observation sheet can be found in Appendix 3.

Demographic variables recorded:

- Age: Under 10, 10-20, 20-30, 30-40, 40-50, 50-60, 60+
- Gender: Male/Female
- Group Size: 0, 1, 2-4, 5+
- If the individual was accompanied by a group:
    - group type: school, family (multigenerational group), adult tour, other

Observational Coding

- Exhibit Type: Living or Non-living (both locations). Non-living exhibits were further divided into Flat and Vertical at the O.U.M.N.H.
- Case Title: title of case for reference (see Appendices 1 and 2 for coding)
- Time spent at exhibit in seconds
- Revisit: Yes/No
- Notes: any additional observations, e.g. was the focal individual called to the exhibit by another group member? Was he or she called away? If facing a living exhibit, was the animal located? Did the visitor take notes? Did he or she take a photo?

Results

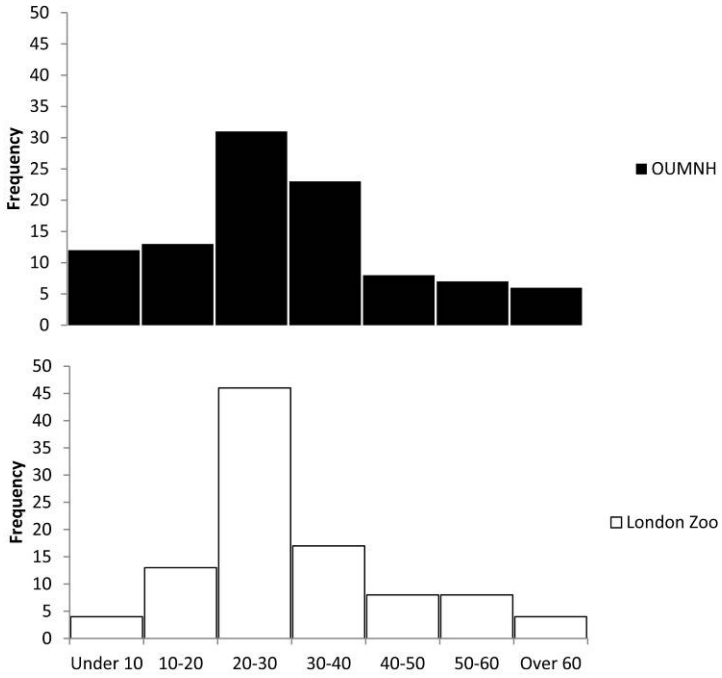
A total of 100 individuals were observed at each study site over the course of 2-3 observation days.
Data were collected at the O.U.M.N.H. on Sunday, 7 November, 2010 (58 observations), Saturday, 18 December, 2010 (8 observations) and Thursday, 6 January, 2011 (34 observations). The third day of observations was required due to inclement weather on the second day, which made it extremely difficult for visitors to access the museum. Data was collected simultaneously by two observers trained to follow the same data recording protocol. Observers were seated in the locations described in Figure 8.

Data were collected at the London Zoo on Saturday, 11 December, 2010 (100). Data were simultaneously collected by the same two observers from the O.U.M.N.H. site trained to follow the same data recording protocol. Observers were seated in the locations described in Figures 9 and 10.
No potential participants opted out of the study on any study day at either site.

Descriptive Statistics

Breakdown by age

Age was approximated by the observers in bins of 10 years. Frequency distributions of participant age can be found in Figure 2. Note that these are approximate ages of focal individuals rather than the entire population that passed through the gallery during the observation period.



	Under 10	10-20	20-30	30-40	40-50	50-60	Over 60
OUMNH	12	13	31	23	8	7	6
ZSL	4	13	46	17	8	8	4

Fig. 2. Distribution of estimated ages of focal individuals at the O.U.M.N.H. (above) and London Zoo (below). The table represents age estimated in bins of 10 years, as approximated by observers and only characterizes focal individuals (those who were observed).

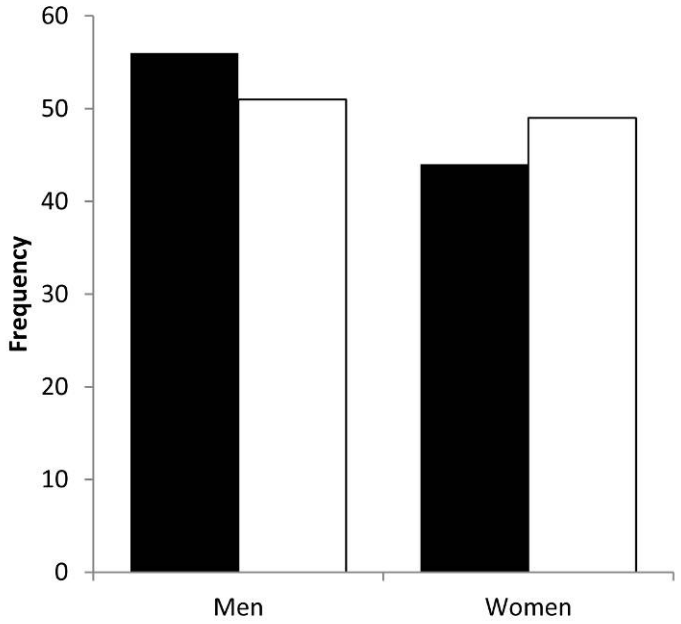


Fig. 3. Counts of focal individuals by gender at the O.U.M.N.H. (black bars) and London Zoo (white bars).

Breakdown by gender

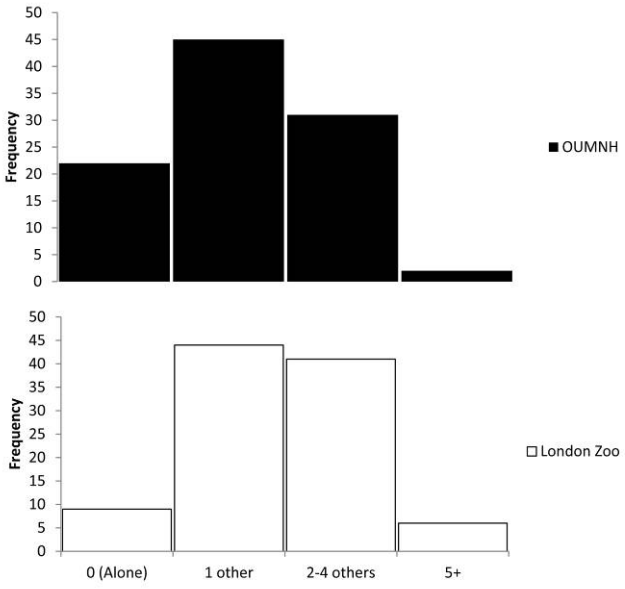
Approximately equal numbers of men and women were observed at each site (O.U.M.N.H.: 56 Men and 44 Women; London Zoo: 51 Men and 49 Women, Figure 3). Of course, these numbers are not counts of the number of individuals who visited the galleries, but counts of the focal individuals that were randomly selected to be observed.

Breakdown by Group Size and Type

Individuals were observed alone and in groups at both sites. At both O.U.M.N.H. and the London Zoo, participants were most frequently observed in pairs (Figure 4). Although not all groups were counted, this appeared to be the most common group size during the observational sessions. Groups over of 5 or more individuals were rarely observed at either location. More lone individuals were observed at the O.U.M.N.H. than the London Zoo.

Group Types

The majority of the observed groups were families (multigenerational groups). This was true of both study sites, see Figure 5. This data may have been biased by the dates of the observations, which were primarily weekends and included school holidays. Couples were the second most common group observed, but the distinction between couples and one other friend are primarily conjecture.



	Alone	1 other	2-4	5+
OUMNH	22	45	31	2
ZSL	9	44	41	6

Fig. 4. Frequency distribution of the group sizes of focal individuals at the O.U.M.N.H. (above) and London Zoo (below). Focal individuals were most commonly observed with one other group member at both locations. Solitary individuals were observed more frequently in the museum than zoo setting.

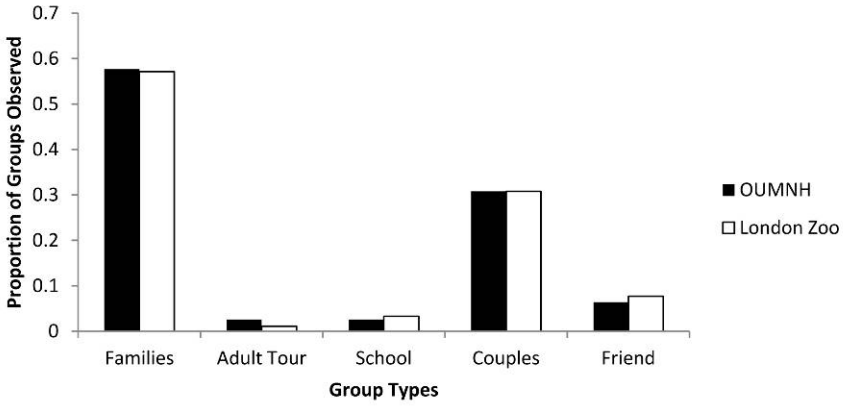


Fig. 5. Proportion of group types observed at the O.U.M.N.H. (black bars) and London Zoo (white bars). Families (defined as intergenerational groups) were the most common group type observed at both locations, accounting for over half of all groups.

	OUMNH	London Zoo
Families	45	52
Adult Tour	2	1
School	2	3
Couples	24	28
Friend	5	7
TOTAL	78	91

Time Spent in Observation Areas

All visitors spent less than 20 minutes in the observation area, and therefore no visits were artificially truncated. The longest visit occurred at the O.U.M.N.H. (15 min 24s). As durations are prone to highly skewed distributions due to the bound at 0, I will present subsequent duration data as medians rather than means. Visitors spent approximately the same amount of time under observation at the two institutions. The median time spent within an observation area at the O.U.M.N.H. was 2 min 17.5s (range 10s – 15 min 24s, n=100). The median gallery time at the London Zoo was 2 min 16s (range 5s – 9 min 34s, n=100). A histogram of visit times can be found below in Figure 6. Although this data is pooled across observation areas within each institution, areas were approximately equal in size and number of displays and these areas were taken into consideration in the analyses to follow.

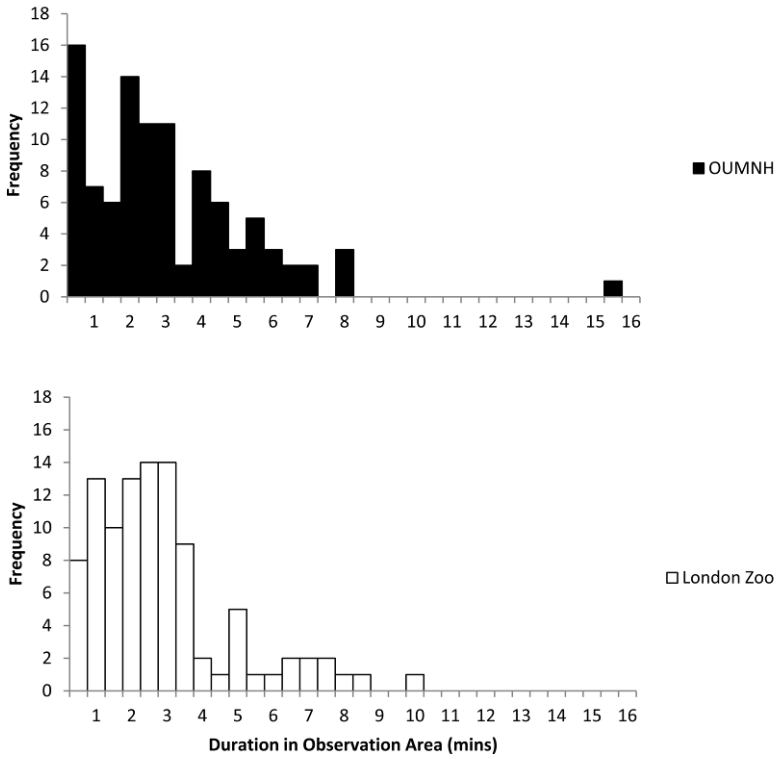


Fig. 6. Frequency distribution of duration focal individuals spent in an observation area at the O.U.M.N.H. (above) and London Zoo (below). Data are organized in bins of 30 seconds. Note the large outlier in the figure above of 15 minutes. This exceptional value was an observation in which a family were drawing the contents of several display cases.

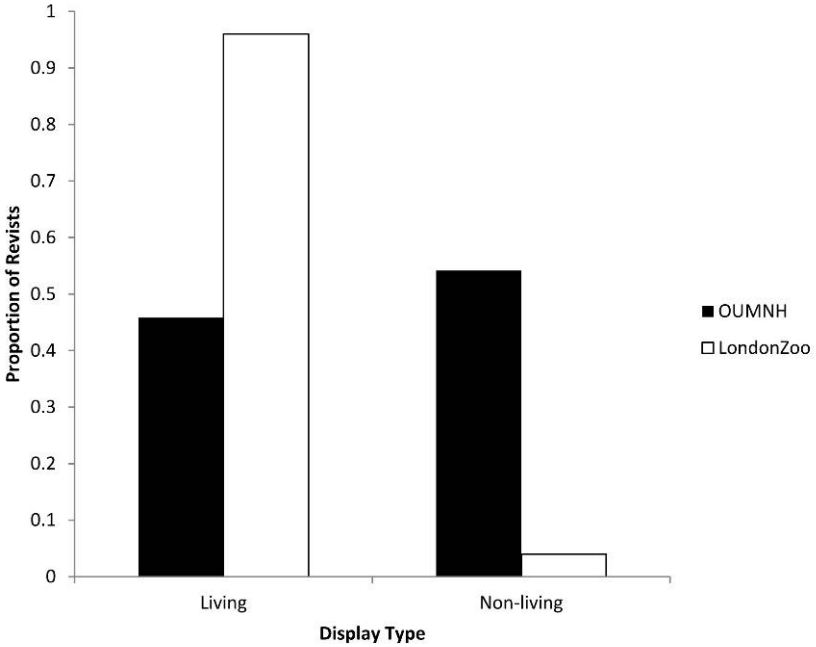


Fig. 7. Revisits made to living and non-living displays at the O.U.M.N.H. (black bars) and London Zoo (white bars). Note that these results are not scaled to the frequency of display types within the two galleries. When one takes into account the proportion of displays which include living and non-living displays, it is clear that living displays are extremely over-represented in the number of revisits they attract.

Frequency of Exhibition Types

Both the O.U.M.N.H. and London Zoo B.U.G.S. House contained both living and non-living displays. The O.U.M.N.H. observation areas contained a total of 45 actively used display cases: 41 non-living exhibits (24 flat display cases and 17 vertical display cases) and 4 living display cases. At the London Zoo's B.U.G.S. House, the observation areas contained many more living displays. Across observation areas, this came to a total of 49 active displays: 29 living and 20 non-living. The organization of these exhibitions can be seen in Figures 8-10 and Appendices 3 and 4.

Revisitation and Non-visitation

One of the greatest challenges in analyzing this data is making sense of non-visitation. Times recorded were those where individuals stopped to look at exhibits and therefore we have many instances for which we have individuals stopping to examine some, but not all of the displays in a given area.

In contrast, individuals also occasionally visit the same exhibit more than once during observation. A total of 50 revisits were observed (25 at the London Zoo and 25 at the O.U.M.N.H.). Revisits occurred to both living and non-living exhibits.

The most commonly revisited displays at the O.U.M.N.H. were the live cockroaches (6 revisits), followed by the live beetle exhibit (4 revisits) and the vertical non-living beetle display (3 revisits). At the London Zoo, revisits were made primarily to the live locust display (5 revisits), live stick insects (4 revisits) and live mantids (3 revisits).

The proportion of revisits made to living and non-living displays is certainly influenced by the number of different exhibit types present in the two museums. However, the null expectation for patterns of revisitation is less clear. Revisits mark returning to a previously viewed exhibit and to model a prediction, we would need to take into account the rate of initial visitation of each exhibit.

The small number of revisits observed, make these observations more anecdotal than representative and we lack the power required for a full analysis. However, consider the following: living displays accounted for just 9% of the displays at the O.U.M.N.H. and 41% at the London Zoo. This means that if all displays attracted visitors equally, we would predict the rate of revisitation to be the joint probability of visitation to these exhibits, meaning we would expect living exhibits at the O.U.M.N.H. to attract approximately 8.1% of revisits and those at the London Zoo to make up just 17%. The observed revisitation rates differ drastically from these predictions, with revisitation to living exhibits of 44% at the O.U.M.N.H. and 96% at the London Zoo. Thus revisits were disproportionately occurring to living over non-living displays.

Visitation by Exhibit
Understanding which particular exhibits our focal individuals visited and how long they spent at these exhibits is also an interesting opportunity provided by the dataset. The goal here is to provide a visualisation of the behaviour of observed individuals rather than analysis.

There are two elements of visitation of interest here. Firstly, the drawing power of the display (i.e. how many visitors looked at this particular display) and the holding power of that display (i.e. how long did visitors stay once attracted). To do so, I calculated the ratio of focal individuals who visited each exhibit and the number of focal individuals in the relevant zone. To capture the holding power of the exhibit, I took the median duration of the visits to that particular display. Many metrics of visit duration could have been used here. I chose median visit duration because this would minimize the effect of outliers.

I also considered looking at the ratio of the visit to the exhibit time to the individual's total time in the observation area. However, to illustrate visitation patterns, we need to generate single time-related value per exhibit. While this could be accomplished by averaging these proportions across individuals, such averaging can be misleading.

Consider the following scenario: Subject A observes 4 exhibits in a given gallery, spending a total of 100 seconds. Of this time, s/he devotes 20 seconds to Exhibit X. According to the scoring above, this would give a score of 0.2. Imagine another individual, Subject B, who spends 200 seconds in the gallery, but looks at 20 exhibits. This individual looks at the exhibit for 20 seconds. This individual would also have a score of just 0.1. Thus, if we were to average the proportions of subjects A and B, we would end with a lower score, despite the two individuals showing the same interest.

I conceived another scoring possibility, whereby the score was influenced by the number of exhibits an individual visited. The null hypothesis being that if all exhibits were equally interesting, individuals would spend the same amount of time at each. Scores would be comparisons of observed values to this assumption. If we consider subject A, we would expect him/her to spend 25 seconds at each exhibit (total time/ number of exhibits visited), but s/he only spend 20 seconds observing Exhibit A. This would result in a negative score of -5s, as the exhibit was deemed less interesting than chance.

However, there is a major flaw in this design: subjects did not visit every display. Therefore, how were non-visitations to be considered? Should all visit times be divided by the total number of exhibits? Would these all receive negative scores? Furthermore, this scoring system moves away from presenting the data and well towards analysis, comparing observed values to a possibly flawed set of expectations. For these reasons, I have chosen to represent time spent at the exhibit as median times, with the caveat that these times are not taken from equal samples, due to variation in the interests and visitation patterns of the focal individuals.

Figures 8 -10 show each observation zone and the visits and duration spent at each exhibit. The size of the mark represents the proportion of visitors who were observed in that zone who visited a given exhibit (large dots/square denoting high proportions of visitation). The fill of the dots indicate the time spent at these exhibits and is taken to be the median visit durations of those individuals who visited that exhibit, with white showing a short amount of time and black, a longer one. Scales are consistent within, but not between figures.

Non-Coded Time
Only durations spent looking at exhibits were coded. Therefore time spent travelling between exhibits or in the gallery spaces, but not attending the displays, occurred between bouts of exhibit attendance. This 'non-exhibit' time accounted for a median of 28.5 seconds at the O.U.M.N.H. (range 0 – 372 seconds) and a median of 68.5 seconds at the London Zoo (range 0 – 556 seconds). On average non-attendance time accounted for approximately 0.44 ± 0.04 proportion of all gallery time at the O.U.M.N.H. and 0.69 ± 0.03 at the London Zoo.

Time Spent Observing Living versus Non-living Exhibits
Taking the most conservative approach, I did not include non-visits in the data set for this and the following analyses. That is to say, all data points were durations of 1 or more seconds. This means that for a given individual, we do not have an observation for every exhibit within an observation area. However, the previous section does capture some of the patterns of visitor behaviour and proportion of visitors that viewed each exhibit within each observation area.

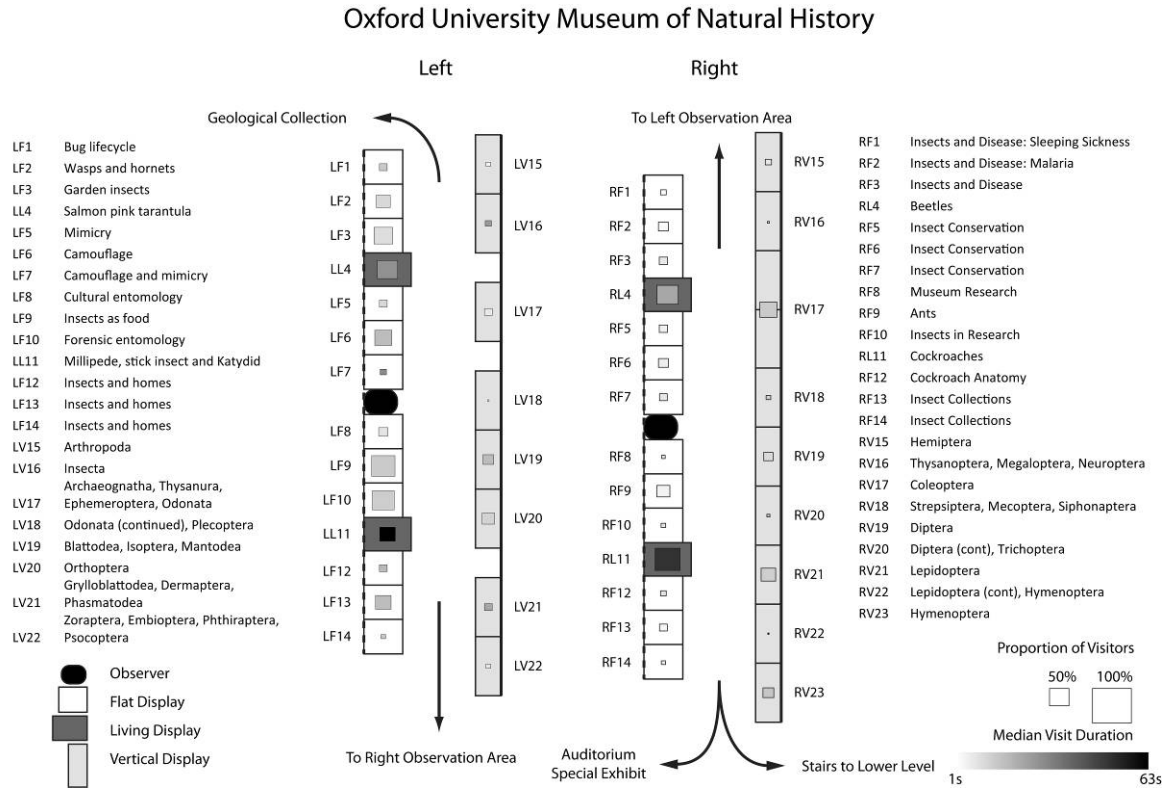


Fig. 8. A schematic of visitor behaviour within the O.U.M.N.H. in the left and right observation areas. The behaviour of focal individuals is superimposed onto the schematic of the gallery. The size of the rectangles represents the proportion of visitors attending to the display (with larger rectangles denoting higher proportions of visitors) and the darkness of the filling of these rectangles represents the median duration of this attendance (with pure white being 1s and pure black being 63s).

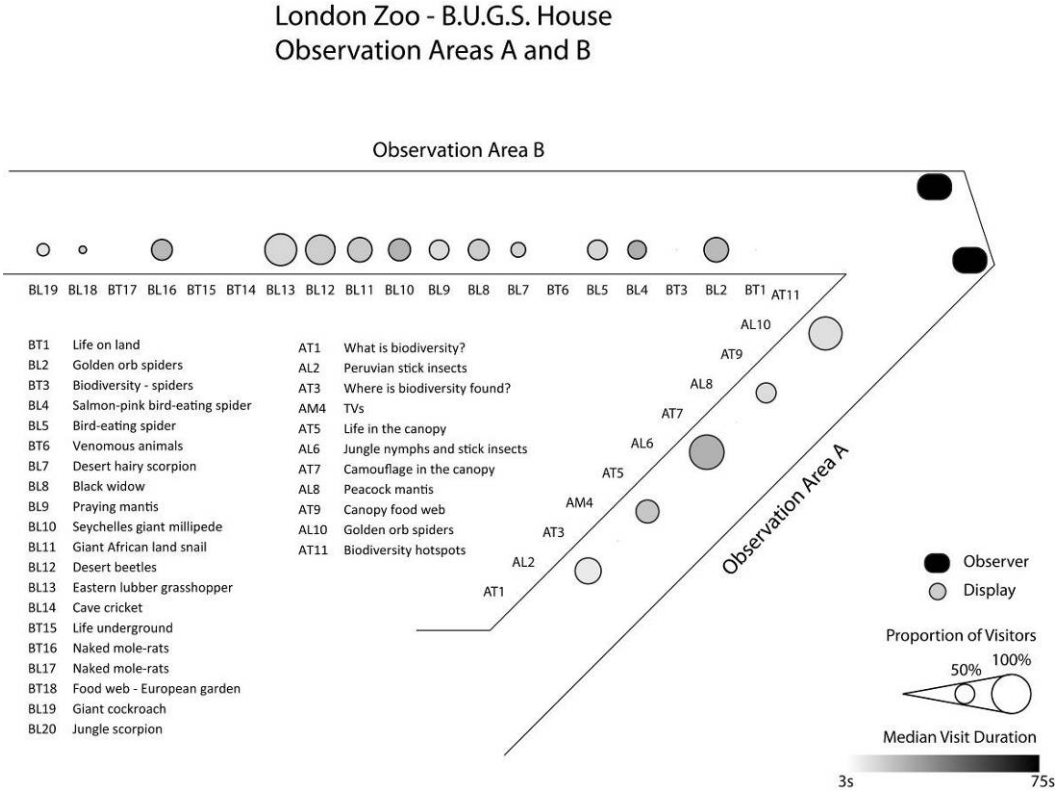


Fig. 9. A schematic of visitor behaviour within the London Zoo in Observation Areas A and B. The behaviour of focal individuals is superimposed onto the schematic of the gallery. The size of the circles represents the proportion of visitors attending to the display (with larger circles denoting higher proportions of visitors) and the darkness of the filling of these circles represents the median duration of this attendance (with pure white being 3s and pure black being 75s).

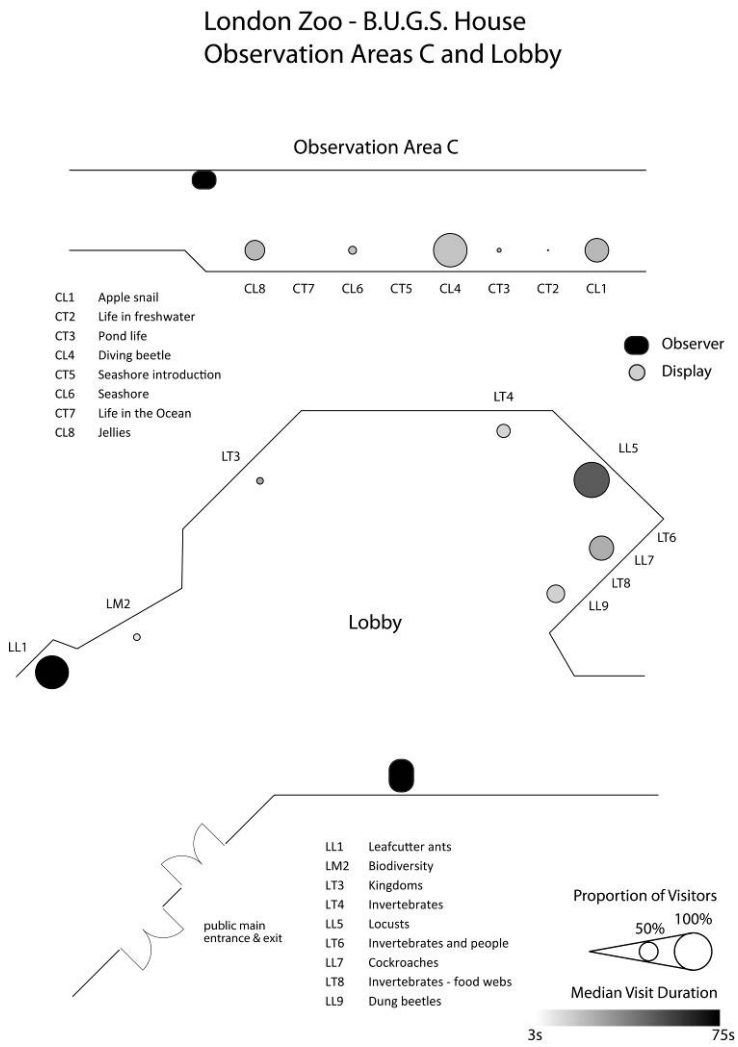


Fig. 10. A schematic of visitor behaviour within the London Zoo in the Lobby and Observation Area C. The behaviour of focal individuals is superimposed onto the schematic of the gallery. The size of the circles represents the proportion of visitors attending to the display (with larger circles denoting higher proportions of visitors) and the darkness of the filling of these circles represents the median duration of this attendance (with pure white being 3s and pure black being 75s).

Taking into consideration all observed visits, I found that visitors spent slightly longer looking at living exhibits at the London Zoo than the O.U.M.N.H. (Figure 11). Visitors spent longer looking at living displays than their non-living counterparts. At the London Zoo, visitors spent a median of 23.31 seconds observing live animal displays (range: 4 – 207.5s, n = 98) as opposed to just 13.67 seconds observing non-living exhibits (range: 2 − 162s, n = 41). At the O.U.M.N.H., visitors spent an average of 36 seconds observing living exhibits (range: 3 – 182s, n = 75) as opposed to an average of 14.84 seconds per non-living exhibit (range: 1 − 155.6s, n = 96).

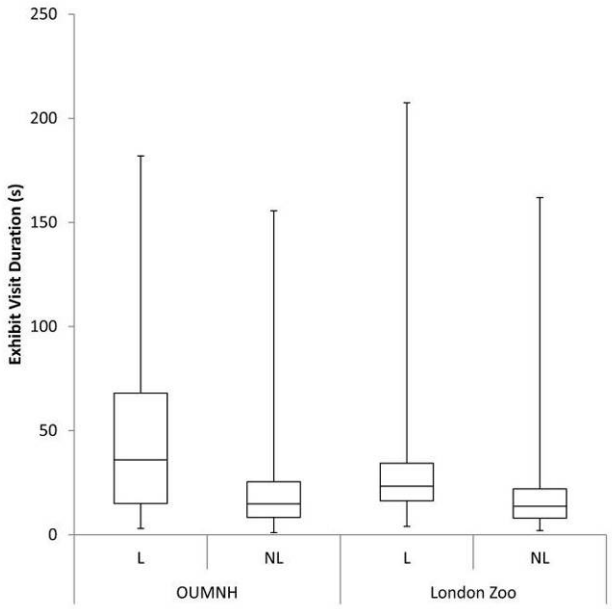


Fig. 11. Boxplot of the visit duration to living (L) and non-living (NL) exhibits at the OUMH (left) and London Zoo (right). Lines denote medians, boxes denote the interquartile range and error bars denote the ob-

Modelling Visit Durations

I wanted to understand what impact our various measures had on the duration individuals spent looking at the exhibits. The primary question is whether the content of a display (living or non-living) influences this time, but we also want to understand whether the institution, group size and characteristics of the individual (e.g. age and gender) might influence these differences. Moreover, as we have several observations from the same individual, to test these hypotheses, a model that took individual into account as well as the unbalanced design was required.

For the purposes of the models, the duration spent at a given exhibit was considered to be the total time spent by an individual in that exhibit (i.e. repeat visits to the same exhibit had their durations summed). As the duration data were highly skewed (being bound by 0), these times were transformed using a natural logarithm prior to analysis. To analyse the data, a Poisson family mixed model was fitted to the data with duration spent at the exhibit as the dependent variable. Participant identification number was entered as a random factor and fixed factors included Institution (London Zoo or O.U.M.N.H.), Display type (Living or Non-living), Age Range (Under 10, 10-20, 20-30, 30-40, 40-50, 50-60, Over 60), Group Size (0, 1, 2-4, 5 or more) and Gender (Male or Female).

The models were fitted using the glmmPQL function in MASS package of the statistical package R. This function fits a General Linear Mixed Model with Penalized Quasi-Likelihood (see R documentation, 2011). In the resulting model, the institution was a significant factor ($t = 4.96$, $p < 0.00$), as was whether the display was living or non-living ($t = -10.10$, $p < 0.00$). This implies that individuals spent longer looking at living exhibits and spent longer looking at exhibits in the London Zoo than the O.U.M.N.H. All other factors were nonsignificant, including interaction terms.

Discussion

Despite using an extremely simple methodology, the observational data forms a rich database and one which helps us start to understand the way visitors respond in galleries that contain both living and non-living displays and in both a zoo and museum context. The data collected capture the behaviour of focal individuals of both genders, from a wide range of ages and in groups of different sizes and compositions. Although the analyses presented here only begin to skim the surface of such an extremely complex and varied data set, this study represents the first direct comparison of visitor behaviour in response to living and non-living display types in more than one institution.

The dependent variable was simply the time visitors spent looking at each exhibit. However, even with this measure, we were able to observe clear effects of the content of the exhibit. The predominant result is the strong effect of display type, with living exhibits attracting more visitors and holding their attention for a longer period of time than one would expect by chance. This result is consistent with the curators' anecdotal reports regarding the attractiveness of living displays and speaks powerfully to their potential as tools in attracting new audiences and stimulating interest. The other significant effect observed, was an effect of institution, with individuals spending longer per exhibit at the London Zoo B.U.G.S. House than the O.U.M.N.H. entomology gallery. However, generalizing these findings to other zoos and museums may not be valid, as we only studied one institution of each type and further investigation of the relationship between the living and nonliving displays within each gallery and into the nature of the language and content of the surrounding interpretation and displays.

The main effects of Institution and Display Type are not entirely surprising, but the lack of significant effects among demographic variables was unexpected. I would have expected both group size and the age of the focal individual to play a more significant role in influencing duration per exhibit. However, both lone visitors and visitors in groups spent longer looking at the living displays than their non-living counterparts. As many of the groups observed were families, it is possible (and certainly anecdotally the case) that group members strongly influenced one another's behaviour. We have numerous observations in which group members were called to or away from exhibits by other members of their party; as this means behaviour was influenced by other group members of different ages, such interactions could certainly have contributed to the lack of observable effects of the age of focal individuals. It is also possible that we did not observe an effect of visitor age due to the way this was recorded. Age was approximated by the observers and may not have been accurately assigned to the bins. The choice of 10 year bins may also have contributed to the lack of an age effect.

It is important to note that the exclusion of non-visitations may also influence the results reported here. However handling nonexistent data is always problematic and conservatism is preferable over potentially falsely supporting a hypothesis with the inclusion of these points.

I have begun to explore the behaviour of individuals on an exhibit by exhibit basis, but as always with field-work, we do not have equal numbers of observations for each exhibit and collecting only equal numbers would have biased our data, forcing a structure upon observations which does not match with the actual distribution of visitors. Nonetheless, the figures showing the proportion of visitors different exhibits attracted begin to tell a story and show that there is much more to be learned about the behaviour of visitors in the gallery where living and non-living displays are included.

There are several interesting and surprising outliers in the present data that also merit further study. For example, although the stick insects in the left side gallery of the O.U.M.N.H. did not attract the most visitors in its observation zone (O.U.M.N.H. left), it did have the longest median visits. Why was this so? Did those who stopped spend longer locating the well camouflaged insects within the display?

Another interesting aspect that could be explored with this data set is the order in which exhibits were visited. For example, did visitors go straight for the living displays first, or skip ahead to get to them? Were visitors more likely to read about a taxonomic family after viewing the living specimens of that family? Did individuals move through the gallery methodically or double back on themselves? It is clear that there is much more to be explored within this data set.

A critical aspect of future research will require careful consideration of the treatment of non-visitation, which occurred in most observations within the observation areas. Any treatment of these non-visits involves imposing assumptions about the visitor's behaviour, but the patterns of non-visitation are almost certainly revealing. My hope is that the visual representations of the proportion of visitors attracted goes some way towards addressing this issue, but it remains a challenge to be carefully considered.

Despite these shortcomings, this first step into examining visitor behaviour in response to living and non-living displays captures some degree of the attraction of living displays. While further work is certainly required to uncover the nuances and reasoning behind this attraction and further exploration into the minds of visitors would contribute to our understanding of visitor behaviour, the present study suggests that living exhibits attract more visitors in both zoos and museums and hold the attention of these visitors for longer than their non-living counterparts.

Acknowledgements
This work was conducted as a part of an MA in Museum Studies at the University of Leicester titled 'Life in the Museum: Living Displays in UK Museums' (2011). This work would not have been possible without the help of all of the visitors who agreed to be observed at both study sites. I also appreciate the support and assistance of my husband, Charles Osborne, who did a wonderful job as a second observer. This research was made possible by some extraordinary individuals who helped support this work at both the O.U.M.N.H. and London Zoo. I am particularly grateful for the help and support of Zoe Simmons, Darren Mann and all the porters at the O.U.M.N.H. as well as Becky Coe, Paul Pierce-Kelly, Tom Hart, Seirian Sumner, Guy Conlishaw, Craig Walker, Nick Lindsay of the London Zoo and ZSL. I am also grateful to all those at the University of Leicester for their kind words and encouragement to publish this work and Paolo Viscardi for re-motivating me to submit this work.

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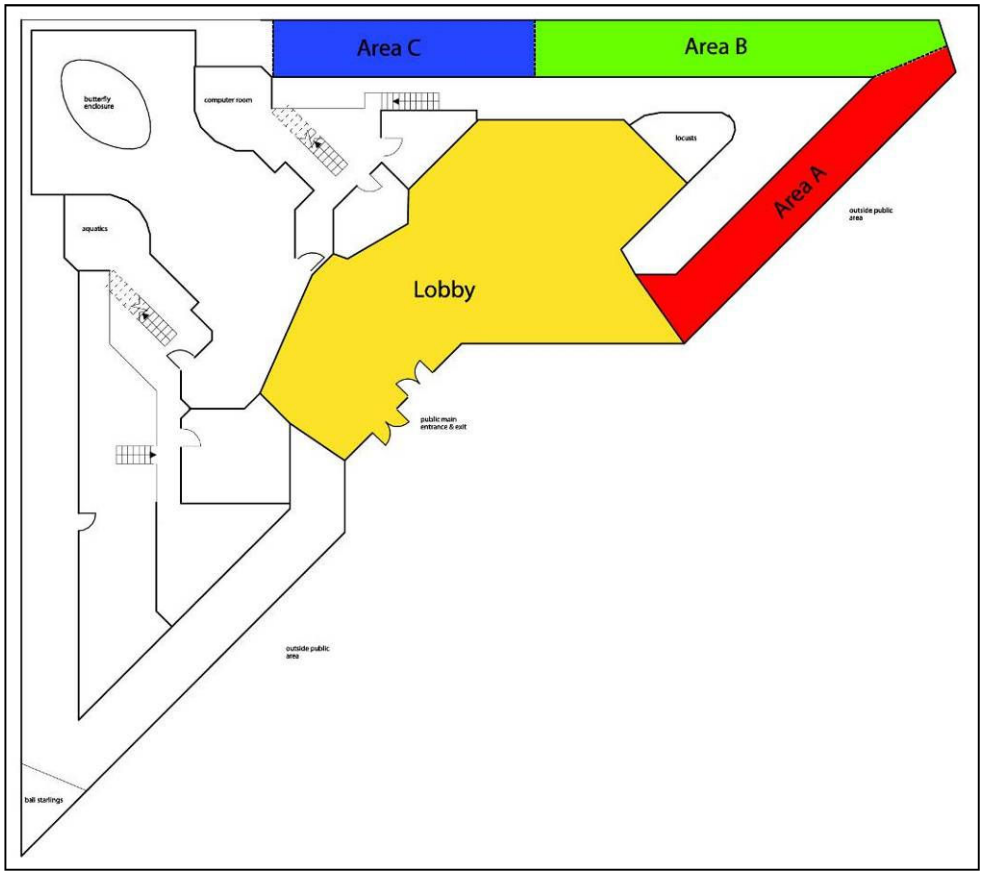
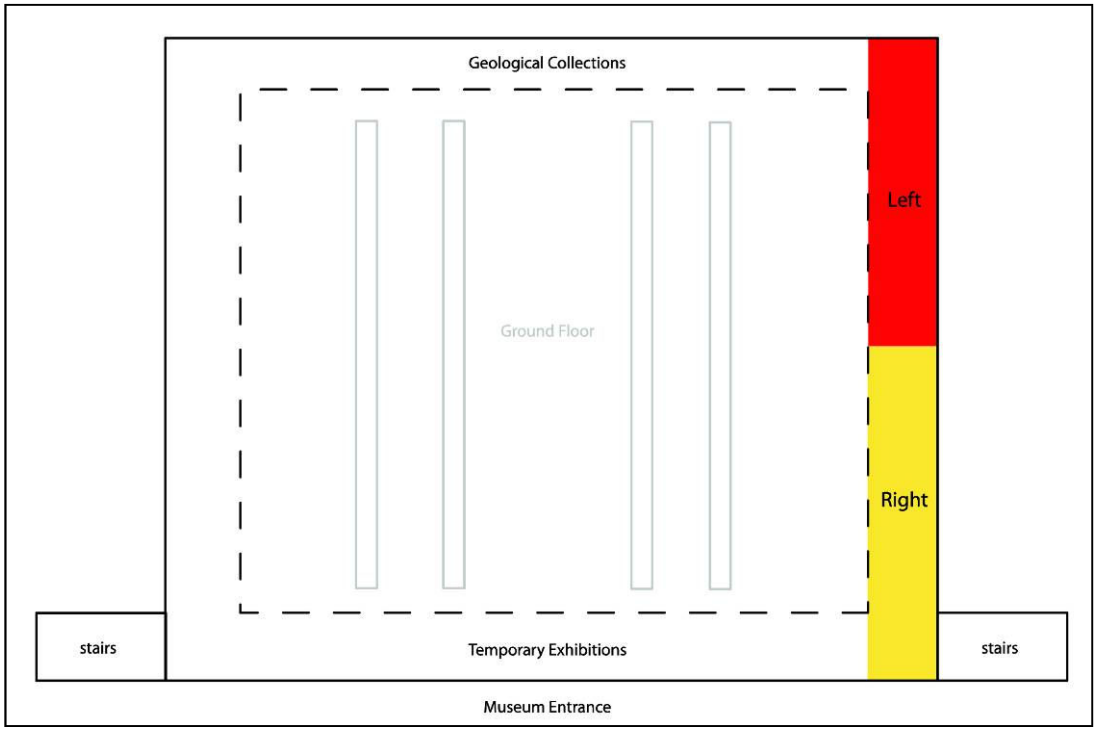
[Unveiling the statue of the late Charles Darwin at the Natural History Museum, South Kensington. The Graphic (20 June): 621-2] 1885. [image] Available at: <http://darwin-online.org.uk/content/frameset?viewtype=side&itemID=A542&pageseq=1> [Accessed 20 February 2011].

[A View of the Zoological Gardens in Regent's Park, London] 1835. [image] Available at: <http://en.wikipedia.org/wiki/File:View_of_the_Zoological_Gardens1835.jpg> [Accessed 15 February 2011].

Appendix 1: Schematic of the London Zoo B.U.G.S House showing the four observational areas.



Appendix 2: Schematic of Hope Entomological Collections at the O.U.M.N.H showing the two observation areas.



Appendix 3: Sample observation recording sheet used at both study sites.

Subject ID		Age	Under 10	10-20	20-30	30-40	40-50	50-60	60+
Date	06/11/2010	Gender	Male	Female					
Time		Group Size	0	1	2-4	5			
Gallery	O.U.M.N.H.	Group Type	School	Family	Adult Tour	Other			

Arrive	Leave	Exhibit Type	Case Title	Revisit?	Notes

Appendix 4: Images of selected living displays at the B.U.G.S House at the London Zoo.

Appendix 5: Images of selected living specimens at the Hope Entomological Gallery at the O.U.M.N.H.

Safe Handling and Storage of Potentially Hazardous Minerals in Natural History Collections.

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Abstract

Minerals in museum collections may pose potential hazards to curators and visitors. This paper discusses the background and use of radioactive minerals and asbestiform minerals, providing examples of safe handling and storage techniques. Toxic elements are also discussed using examples of the more common elements and associated minerals to be found in museum collections including arsenic, mercury, lead and antimony. Historical and current uses of these elements are discussed, along with adverse health affects. Developing a clearer understanding of specimens held in collections allows them to be handled safely, and reduces the common fear of potentially hazardous specimens.

Introduction

Natural history collections contain numerous hazardous components, of which the curator must be wary of, which include man-made compounds and naturally occurring minerals. Minerals formed through geological processes in the Earth's crust can be both beautiful and potentially hazardous. Geological collections present some obvious hazards, which can be identified almost immediately. For example, some minerals may be sharp and rocks, by their very nature, are heavy, resulting in potential problems with unlabeled boxes in geological store rooms (Knell & Taylor, 1989). These two examples are mitigated against relatively easily, as they are simple hazards to identify. However, the hazard of any mineral depends on the specimen itself (Lambert, 1994a); it may depend upon the chemical composition, the solubility and/or form of a specimen.

Generally, minerals with a large crystal structure are more stable and safe, because they are less likely to be ingested. Friable specimens may present more of a risk leading to airborne particles which may be ingested or inhaled (Knell & Taylor, 1989). For example, quartz is generally considered a safe and stable mineral, but it is classified as harmful as prolonged exposure to airborne dust produced through grinding can lead to the lung disease silicosis (HSE, 2002a). However, the risk to the average curator is minimal, unless they are grinding and polishing specimens, where the risk can be reduced considerably using water to suppress the dust. As many of the regional and smaller museums do not have the facilities to undertake geological laboratory work, this paper will focus on the day to day curation of geological specimens. (Further information regarding safe working practices with laboratory preparation work can be found on www.hse.gov.uk)

The curator has a responsibility to safeguard themselves, visitors to the collections, members of the public and future museum staff against the possibility of any risk from the collections. Safely handling them, updating documentation, and safe storage will reduce this risk against potentially hazardous specimens. Understanding the background to the specimens and how they can be safely handled and stored is important to minimise any possible risk. Present health and safety precautions should always be treated with respect, but a knowledge of the collections will allow research to be undertaken, which is vital to ongoing scientific knowledge.

Potential pathways to problems

Care is needed when handling specimens as there are three main routes of exposure; inhalation, ingestion and absorption. Each can be simply mitigated against to reduce any risk;

- **Inhalation** is the breathing in of particulates or vapour produced from the specimen. This can include airborne dust created from handling or transporting specimens. The risk of inhalation is increased when working directly with friable specimens in enclosed areas. Personal Protective Equipment (PPE), such as a dust mask can reduce the risk and if working directly with a specimen working within a fume cupboard would minimise the risk further and reduce the likelihood of airborne particulates in the work space.

- **Ingestion** can occur if particulates from the specimens enter the mouth, which is more likely from handling mineral specimens that are extremely friable. The majority of minerals are inert to stomach acid, and will pass straight through the body with no adverse effects (Cotterell, *pers comm.* 2011), but it is important to know those which are not. Some minerals are water soluble and can be identified by taste, such as the mineral halite, but the curator should always be cautious and never lick unidentified specimens (Brunton, *et al*. 1985; Knell and Taylor, 1989), particularly as there are some poisonous minerals which are water soluble. Particularly harmful soluble minerals should be highlighted with precautions and with medical advice in case of ingestion. Identification of minerals through taste is an old method, still taught in A-Level and University Geology courses; however, it is highly recommended that curators do not lick their specimens. The risk of ingestion can automatically be reduced, or eliminated, by using disposable gloves if handling the specimens and washing hands directly after use.

- **Absorption** is when a mineral is absorbed directly through the skin, or through a lesion (cut or abrasion) in the skin. Although less of a potential risk to the curator, some specimens, such as mercury, may be absorbed directly through the skin (although the main hazard from mercury is from heating the native element producing the vapour methyl mercury). The soluble, and very toxic form of arsenic, arsenolite, can be absorbed through the skin. Absorption can be minimised by wearing disposable gloves and washing hands immediately after use.

A hazard can be defined as something that has the potential to cause adverse affects to the human body (HSE, 2011). In terms of geological collections, potentially hazardous minerals can be broken down into the following groups (after Lambert, 1994a);

- Radioactive minerals
- Asbestiform minerals
- Toxic minerals

Radioactive minerals

Museums holding mineral collections are likely to contain some radioactive specimens. Lambert (1994b) suggests that as much as 10% of a mineral collection will be radioactive; however, the number of radioactive specimens will depend upon historical collecting policies and on the geological history of the local area.

The force binding the protons and neutrons together in the nuclei of stable atoms (such as lead) is strong enough to hold together each nucleus as a whole. In uranium and thorium, however, this energy is not strong enough and the nuclei are unstable, resulting in energy and particles being emitted (Ellis, *pers comm.*, 2011). Radioactivity can be defined as the break down of atoms, resulting in lighter atoms being released emitting alpha, beta and gamma rays (Brunton, *et al*. 1985).

There are a variety of names for different radioactive minerals which the curator should be aware of, the more common being, autunite, torbernite, meta-torbernite, saleeite, meta-saleeite, uranophane and uraninite [synonym of pitchblende]. 'Meta' before a mineral name means the specimen is 'meta stable'; so meta-torbernite has lost a small proportion of its water of crystalisation compared with torbernite. There may be other mineral specimens in collections, which have radioactive elements in; for example bismuth can be associated with uranium ores, but is not itself radioactive. The original specimen labels need to be examined and the information updated with the specimens and the museum database. Historical labels may not state whether there is any radioactive material associated with the 'main' mineral, and it is recommended to test the entire mineral collection with a Geiger Counter.

Radioactive specimens do present possible risks to staff and visitors, because specimens can emit invisible alpha, beta and gamma radiation, as well as emitting radon gas that can build up in store rooms; prolonged exposure to these types of radiation can cause severe health problems. (Radon gas has a short half-life, so will only build up in the store if there is poor ventilation.) There may be additional risks if specimens are friable, leading to an increased risk of the fine particles being inhaled or ingested (Henderson, 1982).Sec-

ondary uranium minerals are particularly friable, as they have a tendency to form platy or acicular crystals in crusts. Uranium can be transported through groundwater leaching of primary uranium oxide minerals with redeposition in a different location (Dixon, 1983). Secondary uranium minerals generally have less uranium content, than primary uranium phases as they occur as complex hydrated phosphates, sulphates, carbonates and silicates while some of the uranium will be carried off in the groundwater.

The inhalation and/or ingestion of radioactive particles is significantly more dangerous than handling the specimens directly; human skin is made up of cells which are replaced daily, but if the material is ingested or inhaled, the alpha radiation can bombard the live cells inside the body (Cotterell, *pers comm.*, 2011). This obviously depends on the dosage received; the Russian military who cleaned up after the Chernobyl incident received enormous doses of radiation in a short space of time and died shortly afterwards (Marples, 1996).

The Radioactive Substances (Geological Specimens) Exemption Order (1962) allows the storage of up to 100kg of uranium and thorium, and most, if not all, museum mineral collections will be below this limit, so will not need to register under the Environmental Permitting Regulations, 2010. However, there are guidelines for safely working with radioactive materials which are outlined in the Ionising Radiations Regulations, 1999 (IRR99). The guidelines cover different work settings, from working with X-Ray machines to the nuclear industry, but the key recommendation for all work settings is the same; to keep radiation doses 'As Low As Reasonably Practicable' (ALARP).

Measurements of radiation levels are usually expressed in microsieverts per hour (μSv h) or millisieverts per hour (mSv h) and this can be measured with a standard Geiger Counter. The maximum level of 2.5 μSv h is recommended outside a radioactive store where there is general employee access (IRR99). This is the recommended dose limit, and it must be remembered that there is natural background radiation; the background radiation measured at Plymouth City Museum and Art Gallery on 7th April 2011 was 0.5 μSv h. Natural radiation from the sun is higher at higher altitudes, and can result in natural dose rates of 5 μSv h when flying in an aeroplane (Ellis, 2011, *pers comm.*).

It must be remembered that these are recommended hourly dose rate, and measure in *microsieverts* (1000 mSv = 1 μSv). The dose rates can be put in perspective with the following example; a curator inspects a radioactive specimen (which measures 30 μSv h) for one hour. For 10 minutes of this hour the curator is directly handling the specimen and the remaining 50 minutes is a visual inspection of the specimen. During the 50 minute visual inspection, the dose rate will be reduced (to about a third), as the curator is further away from the specimen. The radiation uptake would be 5 μSv for directly handling the specimen and 8 μSv when inspecting the specimen. So the total radiation uptake for one week would be 13 μSv, and so the total uptake for a year, if carried out for one hour of each week in a year, would be 700 μSv. The yearly example is under the recommended maximum dose levels for employees in one year, which is 20 mSv (or 20,000 μSv) (IRR99).

Different museums will store their radioactive specimens depending on their funds available, space available and advice given (Freedman, 2011). For example, Dundee's Art Gallery and Museum, The McManus, have stored their radioactive material with advice from the Scottish Radiation Protection Advisor. Their collections, including mineral specimens and luminous watch dials, are stored in Perspex boxes, in a labelled drawer within the main museum collection (Lampard, 2010, *pers comm.*). This solution at The McManus kept the risk ALARP for their collections and their staff. The National Museum Wales, Cardiff, had to undertake a different solution. After separating the radioactive minerals into a 'radioactive bay' in the main store, and monitoring radon levels in the store room, it was decided that a Designated Store would be more suitable for the collection (Lambert, 1994b). The new store, which holds all the radioactive specimens, has restricted access and has built in extraction to remove any radon gas to the outside of the building (Lambert, 1994b). Freedman (2011) notes several other examples of storage solutions to large and small radioactive collections.

Plymouth City Museum and Art Gallery (PCMAG) holds over 10,000 mineral specimens of local and historical importance, including 139 radioactive specimens. All the mineral specimens were stored in the Hey (1962) cataloguing system in the main mineral store, which also holds other natural history, archaeology and social history collections. PCMAG contacted a Radiation Protection Advisor (RPA) to assess the radioactive collections and to make recommendations for the storage of the radioactive specimens, to reduce any risk in line with ALARP. If measured levels outside storage cabinets exceed 7.5 μSv h, it is recommended

to use a Designated Area/Store, which is a restricted area holding the radioactive specimens (IRR99). The radon levels were measured just above this limit at PCMAG, (8 µSv h), so it was recommended to store all the radioactive specimens in a Designated Area away from the general public and from other members of staff (Freedman, 2011).

All the minerals are stored in acid free card trays in wooden drawers, and the radioactive minerals were stored in clear zip-lock bags limiting the alpha radiation being released (Henderson, 1982), but the particulates in the bags could potentially be released into the work space if opened. Before being transferred to the new Designated Area, all the radioactive specimens were repacked in clear polystyrene boxes, so the specimen was clearly visible, and lined with *Plastazote*, to reduce any abrasion of the specimen (Fig. 1). All repacking was carried out in a fume cupboard, with appropriate PPE, including respiratory mask, disposable gloves and disposable aprons (Henderson, 1982; Brunton, *et al.* 1985; Mast, 1996; Wilson, 1996). The specimens have been transferred to new yellow metal cabinets (Fig. 2). The outside of the drawers of the metal cabinets have been labelled with magnetic tape, which will allow for specimens to be moved with ease in the future, and it is clear what drawer holds what specimen.

Fig. 1. Torbernite specimen re-packed in clear polystyrene plastic container, with *Plastazote* lining. The associated labels are facing outwards to minimise any disturbance of the specimen.

Fig. 2. One of two new metal storage cabinets. The drawers are labelled on the outside with the specimen name, number and collector. The labels are magnetic tape, which will allow easy move in the future if necessary.

Transferring the specimens into new clear polystyrene boxes allowed an opportunity to limit double handling of the specimens and safely digitally image them. Each specimen was imaged with its associated labels on a shallow tray, which was subsequently cleaned with a damp cloth to remove any particulates (Henderson, 1982; Mast, 1996). The images have not only been attached to the specimen record on the museum database, they have also been used to create a 'hand-guide' of the specimens in the new store. Highlighting the specimen number, name, locality, collector, and which cabinet and drawer it is stored in, the hand-guide has further reduced the need of obtaining information directly from the specimens, and dramatically reduces the time in the store if direct examination is required.

Asbestiform minerals

Asbestos is the name used for a group of naturally occurring fibrous minerals formerly widely used in industrial application. Asbestos itself, means 'unquenchable', referring to it's resistance to fire. There are two groups of asbestiform minerals; those with a serpentine structure and those with an amphibole structure. Chrysotile (white asbestos) is a serpentine group mineral, with twisty and curly fibres, and was the most widely used form of asbestos. Crocidolite (blue asbestos) is a variety of riebeckite, and amosite (brown asbestos), is a variety of the mineral grunerite, and are both amphibole forms. The amphibole forms of asbestos generally produce sharp, brittle fibres and are significantly more hazardous than the serpentine group (Skinner, 2003; National Cancer Institute, 2009). Actinolite, tremolite and anthophyllite are other amphibole group minerals that can occasionally form fibres suitable for industrial application as asbestos (Cotterell, *pers comm.*, 2011). Asbestos fibres can be long (up to 30cm) and very thin (0.01-0.40μm in diameter) (Wachowski & Domka, 2000).

The popular mineral Tiger's Eye is formed by successive growth layers of quartz and crocidolite, but because of its compressed and solid form, it does not pose any risk to the curator so there is no need to treat these as hazardous specimens. However, a technician carrying out cutting of specimens should be aware of the potential risk from crocidolite and the appropriate laboratory health and safety guidelines should be followed.

Each asbestiform mineral has different properties and as such is used for different purposes. The mining of chrysotile, amosite and crocidolite for large scale industrial use began in the 1880s (Gee & Greenberg, 2002). Asbestos has been used for building insulation and to insulate steam engines, and has been used in over 3000 products, including cardboard, plastics, felt, paper, protective suits, roofing, blankets, electrical insulation, and floor tiles (Wachowski & Domka, 2000; National Cancer Institute, 2009.). The use of asbestiform minerals for heat resistant products is not new; 4000 years ago, asbestos was used to make ceramic dishes more heat resistant (Wachowski & Domka, 2000). Mattenklott (2007) has analysed commercial soap stones and talcum powders demonstrating that asbestos can be found in very small quantities in about one in four of the samples investigated. The list of products is important, because social history collections in museums may hold objects which could contained processed asbestos. Examples of refined or partly refined asbestiform samples may be found in mineral collections; these may be more hazardous than the natural specimens, as they have been processed, so will contain smaller and finer particles (Mattenklott, 2007).

Fibres of asbestos are present in the air due to natural erosion and from industrial processes and sewage and water pipes; interestingly, the natural processes producing airborne fibres is greater than that of man made production (Wachowski & Domka, 2000). After mechanical processing, it has been noticed, that asbestos fibres are even smaller and finer (Mattenklott, 2007). New asbestosiform carbon-type fibres are produced by industry for industrial and even telecommunications use (Skinner, 2003), which may add new types of particulates to the air.

Health risks of asbestos inhalation depends upon the type of mineral, the size of the inhaled fibres and the time of exposure and usually takes about 30 years for symptoms to show (Wachowski & Domka, 2000; National Cancer Institute, 2009). Health risks will increase with larger exposures of asbestos and longer exposure times. Fibres between 1μm and 10μm long, and less than 3μm diameter, will be deposited in the air sacks in the lungs; fibres less than 1μm are easily inhaled, but they are so small that they cause little effect inside the body; fibres longer than 10μm are inhaled, but are stuck on the mucus membrane and do not reach the air sacks (Hume & Rimstidt, 1992; Wachowski & Domka, 2000). Prolonged inhalation of asbestos fibres can cause some cancers, including colon cancer, stomach cancer and the lung disease, mesothelioma (Wachowski & Domka, 2000; Gee & Greenberg, 2002).

Handling and storage of asbestos specimens in collections must be dealt with extreme caution. In 2001, PCMAG undertook a project to safely store the asbestos of over 70 specimens. They were stored in clear zip-lock bags in acid free card trays. The museum contacted the asbestos removal team for Plymouth City Council to assess the collections and make recommendations. Due to the historical importance of the collectors, and the localities associated with the specimens, all specimens were retained. The asbestos removal team offered their assistance in safely storing the mineral specimens.

A sealed tent with air extraction was set up on site, and specimens were brought up from the store room. Fully clothed in PPE, including protective suit, masks, goggles and gloves, the team transferred the minerals into clear boxes, placed the labels on the outside, and then the labels and the box in clear zip-lock bags (Fig. 3). All the drawers holding the specimens, and the labels associated with the specimens, were vacuumed to remove any trace of asbestos particulates. This current storage is not ideal, as the specimens in the clear boxes may move freely in the box causing abrasion of the specimens, and producing more particulates, which could potentially become airborne when the specimen is directly handled. The storage of this collection will be reviewed in the future.

Fig. 3. Chrysotile specimen stored in clear box in zip lock bag. This method was suitable for the funds available at the time, and the storage will be reviewed in the future.

The Royal Cornwall Museum, Truro, recently stored all asbestos minerals in translucent *Escal* sealed bags, with the associated labels sealed separately from the specimen (Fig. 4). The work was carried out in asbestos grade fume cupboards at Cornwall Council's Engineering Services laboratories so they could be sealed safely. All specimens were digitally imaged at the same time to minimise double handling of the specimens (Ratcliffe, 2011, *pers comm.*). The sealed specimens are now stored in card trays in labelled drawers to minimise movement of the specimens (Ratcliffe, 2011, *pers comm.*). This barrier film, sealed shut with a heat sealer, allows the asbestos to be viewed safely without the need of opening the bags and the labels are kept away from contamination of asbestos fibres (Freedman & Lawrence, 2008). Sealed in *Escal*, the specimens are stored tightly in the drawers to prevent movement and physical damage. However, this method of storage does appear to create static resulting in broken fibres being stuck to the inside of the *Escal* packing; this would be hazardous if opened resulting in more airborne fibres being released.

These above two examples work for the institution and the funds available keeping the risk as low as possible. The *Escal* method works very well, as it stops the specimen from knocking other specimens, and it provides a completely sealed environment. However, *Escal* is expensive, and a heat sealer is required to ensure the packing is carried out effectively. Static inside the *Escal* sealed bags can dislodge fibres on the specimen, so extra care is needed if sampling is required directly from the specimen.

Fig. 4. - Sheaves of long very slender pale green prismatic actinolite sealed in clear *Escal* packing, it allows the specimen to be viewed from all sides and the label is sealed separately. Note the small fibres attached to the inside of the packing due to static. (Asbestos 002 (RCM Asbestos 4): Image reproduced with permission from the Royal Cornwall Museum, Truro).

All asbestos specimens should be stored in sealed containers (Knell & Taylor, 1989; Lambert, 1994a) and if possible, specimens should be packed well using *Plastazote* to avoid any breakages of the fine fibres creating more dust (Lambert, 1994a). However, even packing specimens in *Plastazote* can dislodge the fibres, so care must always be taken when storing specimens. All storage containers and drawers holding the specimens should be labelled clearly with a warning label (Knell & Taylor, 1989), so other museum staff, visitors, and future museum staff are aware. If undertaking new storage projects of asbestos collections, the curator should contact their local council asbestos removal team, who are specifically trained to safely handle asbestos. Alternatively the curator can contact another museum who has carried out a similar project for advice.

Toxic Minerals

There may be up to 200 mineral species which may be classed as toxic, but in museum collections many of these are not considered to pose any direct danger to staff (Lambert, 1994a). A toxic element can be defined as one which adversely reacts with enzymes in the cell causing damage to the heath of an organism, and is in effect a poison (Waites & Harrison, 1999). The chemical composition of minerals may make them more toxic, as they can contain toxic elements (Brunton, *et al.* 1985), so understanding the mineral will lead to a clearer knowledge of safe handling and storage. Elements which are toxic and may be associated with some minerals are antimony, arsenic, bismuth, boron, copper, fluorine, lead, mercury, oxalates, selenium, thallium, uranium and zinc (Brunton, *et al.* 1985). Often, the specific compound itself is more toxic than the element. These toxic elements are extremely rare in their native form and are unlikely to be encountered in natural history collections. It should be remembered that some of these elements may be toxic, but are also important to human health (for example fluoride in toothpaste and added to tap water). The element zinc is required for fertility and calamine lotion is a zinc based treatment for skin problems (Cotterell, *pers comm*., 2012).

The solubility of a mineral will determine it toxicity (i.e. it's ability to dissolve in water). Most minerals are insoluble in stomach acid, so there is no risk of many minerals being absorbed by ingestion, for example barite and galena (Lambert, 1994a); although these two examples contain toxic elements, their actual toxicity through absorption is absent. Some minerals however are highly soluble in water, including rock salt (the mineral halite) which is only harmful in large concentrations, but others, such as potassium dichromate (lopezite) minerals are highly toxic. Chromite, a chromium oxide, and barium are considered harmful elements but are not because they are inert (Cotterell, *pers comm.*, 2011). Baryte (barium sulphate) if ingested does not react with stomach acid and will pass straight through the body; witherite (barium carbonate) specimens however will react with the stomach acid releasing barium into the body (Cotterell, *pers comm.*, 2011).

Below provides some background to the more common toxic elements including arsenic, mercury, lead and antimony, with associated minerals containing these elements, which may be encountered in museum collections. (The general handling and storage of these four examples is the same for the above list of toxic elements, and advice should be sought if unsure about the safety of any specimen in a collection.)

Toxic elements: Arsenic

Geological collections frequently hold mineral specimens containing arsenic, such as the iron arsenic sulphide, arsenopyrite, and the arsenic sulphides realgar (red arsenic) and orpiment (yellow arsenic). Native arsenic is rare in nature, but is often present in older museum collections, particularly those with a strong European influence (Cotterell, *pers comm.*, 2011). Native arsenic may also be present in collections with examples of refined metals and semi-metals, along with the significantly more hazardous, water soluble white arsenic oxide, arsenolite. Many collections will also contain specimens of attractively coloured secondary arsenates of copper, lead and iron, most of which are relatively insoluble. A few examples include liroconite and olivinite (copper arsenates), mimetite (lead chloroarsenate) and scorodie and pharmacosiderte (iron arsenates).

The industrial use of arsenic has concentrated on the arsenic sulphides, arsenopyrite, realgar and orpiment. Arsenic compounds can also be found in minerals, which pose less of a hazard, such as copper, lead, iron and cobalt bearing species (Gorby, 1988; CAREX Canada, 2010). Biological and ethnography collections may contain arsenic powder, which has historically been used as a preservative for bird and mammal skins (Wagstaffe & Fidler, 1968; Knapp, 2000) and can be seen on specimens as a fine white powder (Knapp, 2000). Two arsenic mixtures have historically been used to 'brush' over taxidermy specimens to protect them from insect damage; arsenic-borax powder (50:50 powdered arsenic [arsenic trioxide] and powdered borax [sodium tetraborate]), and arsenic-alum powder (50:50 powdered arsenic [arsenic trioxide] and powdered alum [potassium aluminium sulphate]) (Wagstaffe & Fidler, 1968). Arsenic paste and soap have even been used in the past for fixing and preserving spirit specimens (Carter & Walker, 1999; Knapp, 2000).

Arsenic has a long history of human use; peculiarly for Westerners, as a medicine. Hippocrates advised on using a realgar paste to help cure ulcers (Bentley & Chasteen, 2002). As well as being used as an aphrodisiac in the 19th century, eating arsenic compounds was believed to give 'plumpness to the figure, cleanness and softness to the skin, and beauty and freshness to the complexion' (Bentley & Chasteen, 2002). Prostitutes favoured rubbing arsenic in their cheeks to give a rosy tint, but unfortunately, this lovely alluring appearance is produced by the arsenic damaging blood vessels in the skin (Bentley & Chasteen, 2002). Arsenic derived from soluble sources have been used to produce a solution (known as Fowler's solution) that was used to treat a huge array of medical ailments, including syphilis, and drinking it regularly was recommended to give women a much fairer complexion (Bentley & Chasteen, 2002).

Arsenic compounds have also been used in cosmetics, foods, glass, and insecticides (Bentley & Chasteen, 2002). Currently arsenic use is limited and can be found in wood preservation and used with lead alloys in batteries (Bentley & Chasteen, 2002). Arsenic compounds have been, and are still, used in Chinese and Indian medicines; orpiment is used as a louse killer, a cure for scabies, insect bites and skin diseases; realgar is used for colds, toothaches, asthma, ulcers and, mixed with plants to treat cancer; arsenolite is successfully used to treat cervical cancers and solid tumour cells (Lui, *et al.*, 2008). Arsenolite has successfully been used in Western medicine recently, to treat leukemia (Lui, *et al.* 2008; CAREX Canada, 2010).

Arsenic is present in all living organisms (Gorby, 1988). The recommended levels of arsenic in drinking water are 0.01mgl (WHO, 2003), but it has been noted that the daily intake in humans is an average of 0.5 - 1mg (Gorby, 1988). Urine samples have demonstrated higher levels of arsenic present after consuming seafood (Gorby, 1988), resulting in higher averages than the recommended levels outlined by WHO (2003). As with any substance, too much can prove fatal, particularly if there is a cumulative intake of arsenic.

Experiments with rodents have shown that the fatal dose is very much dependent on the composition of the ingested arsenic compound (Lui, *et al.* 2008). Orpiment and realgar are poorly absorbed into the body, but arsenolite is more readily absorbed, making it more toxic with a lethal dose of between 32-39mg/kg (Lui, *et al.*2008). In humans the lethal dose of arsenic oxide is considered to be 100mg (Gorby, 1988). Potential effects of arsenic poisoning include, vomiting, stomach pains, convulsions (Wagstaffe & Fidler, 1968), and long term effects may include liver cancer, lung cancer and cancers of the reproductive organs (Knapp, 2000; CAREX Canada, 2010) and long term effects through ingestion can lead to skin cancer (CAREX Canada, 2010).

Specimens in collections labelled as arsenic, realgar, orpiment, arsenolite and arsenopyrite should always be handled with disposable gloves to minimise any risk of ingestion, or in the case of arsenolite, absorption. Arsenic is quite dense but the flaky nature of realgar and orpiment, and the fibrous and powdery habit of arsenolite, does have the potential to become airborne. If working directly with specimens, a dust mask and gloves should be worn, and work should be carried out in a fume cupboard. The work surface can be wiped down with a damp cloth to pick up any small fragments, which can be disposed of (Henderson, 1982; Mast, 1996).

Ideally, specimens should be stored in lidded containers, with *Plastazote* cut outs to hold the mineral to reduce the amount of movement and possible damage to the specimen. Clear polystyrene boxes will allow the associated labels to be visible inside the box (Fig. 1). However exposure to light can cause realgar to degrade to pararealgar; these specimens can be stored in *Plastazote* lined card boxes, with an image of the specimen on top and some brief information about the specimen on the lid, including identification number, specimen name, locality and collector. This reduces the need to open the box, and in the case of light sensitive specimens, an image of the specimen on the lid reduces the exposure to light. All containers holding toxic specimens should have a 'Toxic' label visible on the outside.

Toxic elements: Mercury

Described as liquid silver by Aristotle (Christie & Brathwaite, 1995), mercury is one of the more interesting elements that may be stored in collections; it is a liquid metal at room temperature, and its freezing point is very low, at -39^{o}C (Waites & Harrison, 1999). Native mercury may be found in geological collections stored in glass vials in its liquid form, but it may also occur as silvery metallic globules on the mineral ore, cinnabar (mercury sulphide). Other mineral specimens which may be associated with mercury are native gold and native silver, and lead-bearing and zinc-bearing minerals (Christie & Brathwaite, 1995).

Ancient Egyptians were using mercury from around 3500 years ago and later the Greeks, Chinese and Romans also used this metal (Christie & Brathwaite, 1995). Perhaps most well known for its' historical use in thermometers (which is now banned), it still has many uses today, including used in fluorescent lamps, switches, relays, batteries, paint, blood pressure machines and, alloyed with silver, tin and copper as amalgam, in fillings for teeth (Christie & Brathwaite, 1995). There is no evidence, however, that mercury in fillings has any adverse effect on human health, because the level of mercury used in the filling is small (Mackert, 1987; Olsson & Bergman, 1992; Mackert & Berglund, 1997).

Mercury is used with other metals as alloys, and has been used to extract gold from its ore, before the introduction of the cheaper method of cyanide (Christie & Brathwaite, 1995). Incredibly, in the 19th century, mercury was used to treat an array of illnesses; patients would receive massages rubbing in a mercury mixture in-between injections of arsenic mixtures into the body (Bently & Chasteen, 2002). At the beginning of the 20th century, injections of the mercury 'tonic' were used to treat tuberculosis, even though it was known to have serious cumulative effects (Moseley & Redlands, 1909.).

Once inside the body if ingested or inhaled mercury prohibits the function of enzymes leading to stomach ulcerations, bloody diarrhoea and kidney disease (Wagstaffe & Fidler, 1968; HSE, 2002a), and if received in continuous cumulative doses can lead to acute poisoning, including brain, liver and kidney damage (Christie & Brathwaite, 1995; HSE, 2002a). The most infamous example is the methyl mercury poisoning at Minamata Bay, Japan. Methyl mercury, which is produced as a gas through the heating of mercury, is a particularly dangerous form of mercury as it is rapidly absorbed in the gut. As a result of small mercury waste products discharged from a plastics factory, the organisms at the bottom of the food chain received a small dose of mercury. However, further up the food chain, the levels of mercury increased, which resulted in over 2000 local people developing severe mercury poisoning resulting in physical deformities, muscles weakness, and problems with the central nervous system (Skinner, Porter, & Botkin, 1999). It is highly unlikely that the museum curator will receive such a large continuous does of ingested mercury, but this extreme biological example is useful to demonstrate the severe effects of mercury poisoning.

Poisoning can occur through all three pathways; inhalation of vapour, ingestion of small particulates, and absorption through the skin (Christie & Brathwaite, 1995). Vapour is the most hazardous; liquid mercury is partially absorbed through skin contact, as the physical properties of mercury do not aid absorption; ingestion in animals has been shown to absorb only 0.01% (Cotterell, *pers comm.*, 2011). A small dose will have extremely little effect on health, as the dose should be out of the body within 24 hours, but cumulative doses will result in severe health problems (Moseley & Redlands, 1909).

Mercury vapours are found naturally in the air, due to degassing from the Earth's crust, volcanic eruptions, and erosion from rocks, and mercury is present at small amounts of 0.5μg L^{-1} in groundwater (Bull, 2007). The 'recommended' long term exposure limit (8 hour average) is 0.025 milligrams per cubic metre of air (mg m^{-3}) (HSE, 2002a). This is the amount of mercury in the air, so for poorly ventilated store rooms, this measurement may be significant; but it obviously depends on how the specimens are stored and how frequently they are handled.

Concentrations of mercury vapour can increase as the temperature increases; 20°C equals approximately 13.2mg m^{-3}, and at 30°C the amount of vapour has more than doubled to approximately 29.5mg m^{-3} (HSE, 2002a). This example of increased mercury vapour is important to remember, but is only significant in small, poorly ventilated stores with large collections of mercury bearing minerals. The temperatures in the store rooms should be monitored and kept low and constant to reduce the amount of mercury vapour which could potentially evaporate. It is very unlikely that museums will hold large enough collections of mercury ores to pose any real risk, but again, it is useful for the curator to be aware.

Mercury and mercury ores need to be stored appropriately to minimise any potential risk. If in sealed boxes, the vapour from the cinnabar specimens can seep and once the lid is removed, a concentrated gust of vapour is produced (Buttler, 2008, *pers comm.*). Liquid mercury samples in collections are usually held in sealed glass vials to avoid evaporation. If there is a strong reason to open the glass vials, gloves and a face mask should always be worn, and the vials should be opened in a fume cupboard.

Interestingly, mercury has a very low freezing point (-39°C), so in theory, specimens could be stored in deep freeze. However, the author is unaware of any institution that stores specimens in this way, and this storage method seems impractical and expensive with new hazards created, such as frostbite. The most practical method for storing mercury and mercury ores is in clear polystyrene boxes, with no lid; lipped boxes will hold any liquid mercury that has seeped from the ore, and the lidless container allows mercury vapour to dissipate and not build up. 'Toxic' labels should be clearly displayed on the outside of the boxes and storage drawers holding any mercury related specimen.

Toxic elements: Lead

Lead bearing ores and minerals, such as galena, anglesite, mimetite, and pyromorphite are not considered as potentially hazardous as the other examples such as lead oxides (litharge and minium) and lead chromate (crocoite), because they are not easily absorbed in the body. Some lead minerals, such as cerussite and pyromorphite sometimes have naturally fine crystal growth, and are very friable, but due to their high density are unlikely to become airborne. However, cerussite (lead carbonate) has the potential to be absorbed by stomach acid so particulates from this mineral could have the potential to cause harm. The sulphide galena, although a lead mineral, is not considered toxic because it is insoluble (Lambert, 1994a).

Along with mercury and arsenic, lead minerals have been used in China as medicines for over 2000 years (Weidong Yu, *et al*, 1995). Lead oxides have been used for treating skin diseases, epilepsy and depression (Weidong Yu, *et al*, 1995), and because the patients are recommended to take the drug for prolonged periods of time, the effects are cumulative and can result in lead poisoning. An astonishing mineral drug in China, called the 'longevity gold pellet' was thought to increase lifespan and slow the ageing process; ironically it was made with mercury and lead, and people taking this immortality pill soon discovered their own mortality (Weidong Yu, *et al*, 1995). Lead ores are smelted today and used in paint, as alloys with other metals, batteries, ceramics and glass (HSE, 2009).

Lead can enter the body through ingestion or inhalation (HSE, 2009). The more toxic compounds are the synthetic ones; historically lead acetate (known as sugar of lead) was produced by treating lead oxide with acetic acid, and was added to wine to sweeten the taste. The body naturally removes lead, just as it removes other toxins that enter, which is why continuous doses will cause problems; our body is unable to remove more toxin than is being put in. Lead poisoning can result in headaches, tiredness, stomach pains, constipation and anaemia, kidney damage, and seriously affect male fertility (HSE, 1998).

Industrial workplaces where lead is mined and smelted have their employees regularly tested to assess lead levels in their blood. The exposure limit for general employees which will cause the company to take action and prevent lead levels increasing is 50 micrograms of lead per decilitre of blood (μg/dL), and for women capable of having children is 25 μg/dL (HSE, 2009). The exposure limit of lead in the air is 0.15mg m^{-3} (HSE, 2002b). Employees working in industry, for example the scrap industry, batteries and alloys and re-

fining, are at much greater risk from increased levels of lead in their blood stream (HSE, 2010). This is because the processes they are working with daily produce large amounts of extremely fine airborne dust in their work environment. In comparison, curators are unlikely to work with a mineral specimen containing lead for each minute of an eight hour day for 5 days. Museum curators are not working with lead or processed lead at the same level of workers in industry, so already the risk is drastically reduced. The density of lead means that inhalation in the museum workplace is very unlikely.

Potential exposure should be prevented as much as is reasonably practical (HSE, 1998). Disposable gloves should be worn when handling specimens (HSE, 2002b), and disposed off to prevent ingestion of lead particulates. Directly after handling specimens, hands should be washed (HSE, 2009). It is important that other members of staff, researchers, and volunteers are aware of the safe handling methods carried out.

Cerussite and other potentially friable, soluble specimens which pose a direct hazard should be stored securely in clear lidded boxes, as described with the arsenic mineral specimens above. Clear boxes allow the specimen to be viewed without directly handling the specimen and the associated labels can be placed in the box facing outwards so they can be read without disturbing the specimen. The box should be lined with *Plastazote* to minimise any potential abrasion of the specimen against the box. A 'toxic' sticker can be attached to the outside of the box to warn other members of staff and future members of staff. The same storage can be used for galena, which will prevent abrasion of the specimen, but this mineral does not need a 'toxic' sticker on the box.

Toxic elements: Antimony

Antimony is rarely found in its elemental form; it is more commonly found in the ore stibnite (antimony sulphide) (Butteman & Carlin, 2004). Antimony occurs within other minerals, such as jamesonite, tetrahedrite, stibiconite, kermesite and senarmonite (Christie & Brathwaite, 1992), and is frequently associated with the elements iron, copper, lead, and silver (Butteman & Carlin, 2004).

Antimony is a soft, yet brittle, semi-metal. It has been used extensively in the past for everyday uses, including for mirrors and bells, and, fascinatingly, it was ground down and the powder was used as eyeliner and eyebrow painting by the Ancient Egyptians 2000 years ago (Wang, 1919; Christie & Brathwaite, 1992; Butteman & Carlin, 2004). It is currently used for flame retardants, batteries, glass, pigments, plastics, ceramics, and has been used as an alloy to add strength to other metals (Christie & Brathwaite, 1992; Butteman & Carlin, 2004). Some paints have been developed using antimony to make the paint water resistance (Wang, 1919).

Due to its commonly brittle form, antimony and stibnite may enter the body through inhalation and ingestion. However, with their large fragments, and high density antimony will not easily become airborne in the museum workplace. This is more likely for secondary antimony oxides which are more powdery resulting in potential airborne dust. Antimony can cause irritation to the eyes and lungs, and if inhaled in cumulative doses over prolonged periods of time, it may lead to acute health problems, in particular on the lungs, heart and stomach (U.S. Department of Health & Human Services, 1988; Butteman & Carlin, 2004). It may also be absorbed through the skin and the eyes (U.S. Department of Health & Human Services, 1988). Antimony toxicity has been investigated in urine from fire fighters wearing antimony trioxide as a flame-retardant in their uniforms, and there were no significant increased amounts of antimony measured (de Perio, *et al.*, 2010).

The Health & Safety Executive (2005) have recommended the workplace long term (8hrs) exposure limit of antimony in the air is $0.5 mg.m^{-3}$, so working directly with specimens in a fume cupboard will reduce airborne particulates. It is unlikely that the handling of specimens will produce such large quantities of airborne dust, as these exposure limits have been generally set for industrial workplace environments, but the curator should be aware and the reduction of exposure to antimony is still advisable.

When handling specimens containing antimony-bearing minerals, gloves should be worn (U.S. Department of Health & Human Services, 1988). The gloves can be disposed of, and hands should be washed, as this will reduce the risk of any particulates on the hands entering the mouth after handling the specimens. Not all specimens will be friable, but when developing repacking projects, imaging projects, or research on specimens, all work should be carried out in a fume cupboard. Staff should wear dust masks and eye goggles (U.S. Department of Health & Human Services, 1988), to reduce the risk of inhalation and ingestion. Specimens should be packed in the same method as the arsenic and lead examples above.

Summary
The general handling and storage for toxic specimens is the same whether dealing with the discussed elements, or barium, bismuth, boron, copper, fluorine, oxalates, selenium, thallium, and zinc; disposable gloves should always be worn, and hands should be washed immediately after handling (Lambert, 1994a). Disposable gloves will reduce any absorption of toxins through the skin, and it will also reduce the risk of ingestion, as any loose particulates will be disposed of with the gloves. Disposable lab coats can reduce the risk of particulates being transported from one location to another. It is important not to eat in the store rooms or around the specimens (Lambert, 1994a), as this will reduce any risk of ingestion further. Any work carried out on specimens, including storing them in new boxes, should be carried out in a fume cupboard. Goggles, dust mask and disposable apron should be worn to reduce the risk to the member of staff carrying out the work. The lab space can be cleaned down with a damp cloth, which can be disposed of.

Specimens are best stored in clear polystyrene boxes (Knell & Taylor, 1989) which should be clearly labelled as 'toxic' (Buttler, 1994; Lambert, 1994a), and because they are clear, it is easy to see the specimen with out directly handling the specimen. Labels may be damaged with specimens in card trays; storing minerals in new boxes, labels can be placed in polyester sleeves and placed facing outwards in the box, so they are clearly visible without disturbing the specimen. There is a potential to have a 'toxic rating system'. A similar system was carried out with the radioactive minerals specimens held at PCMAG and green, orange and red stickers have been placed on the polystyrene boxes of the specimens; green for 'low radioactivity' specimens (0-10 µSv h), orange for 'medium radioactivity' specimens (10-99 µSv h) and red for 'high radioactivity' specimens (>99 µSv h) Education staff may take specimens from the collections for school talks or activities so labelling the drawers and boxes will limit the mis-use of specimens from more inexperienced members of staff.

Specimens may move against one another during movement or handling causes abrasion and fine particles (Buttler, 1994). Ideally all mineral specimens should be packed with *Plastazote* cut-outs to secure the specimen and minimise further breakage and dust production (Lambert, 1994a). *Plastazote* is an inert material and will have no reaction with the specimen (Child, 1994). However, *Plastazote* is expensive, so good practice would be to break the main collection into smaller manageable collections (for example, packing the toxic mineral specimens first). If *Plastazote* is not available, acid free tissue can be used to create a nest and secure the mineral specimen in the box (Buttler, 1994).

It is important that other members of staff, researchers, and volunteers are aware of the safe handling methods carried out. All the database records of any toxic specimen should be updated on the museum database, including; image of the specimen; updated storage information; a note with the record to say 'hazardous specimen'. Moving specimens into new and suitable storage containers, provides the perfect opportunity to image the specimens. This updated information is vital to inform other members of staff, and future members of staff, the potential hazard this specimen presents (Freedman, 2011).

Some minerals automatically have a worry attached to them, which can lead to staff being over cautious. Recently, an emergency room in Denver was closed as a man was carrying a radioactive rock (which was shown to have 'low, low radioactivity') (Denver News, 2010). Most minerals in collections are safe, and a misunderstanding of specimens will prohibit the potential research. To prevent harm working with any collection, the correct identification of specimens is vital and the best way is to understand the specimens we care for, or if unsure, to seek advice from colleagues.

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Further information:
Support and advice can be found at;
www.geocurator.org
www.natsca.info

General information about minerals can be found on;
www.mindat.org

Information about the health and safety of asbestos can be found on;
http://www.nsc.org/ehc/chemical/asbestos.htm
http://www.netregs.gov.uk/netregs/
http://www.hse.gov.uk/asbestos/index.htm

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The Trophy Head Project, National Museums Northern Ireland

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Abstract

In 2010 a collection of 77 trophy heads were moved from an off-site store to a new facility. Having survived unsatisfactory storage for many years they then had to undergo asbestos decontamination and be frozen as a precaution against (or to remove) active pests. Following this treatment they have now been fully supported on racks (Fig.1) and are undergoing a programme of conservation cleaning and repair. Some are even now back on display at the Ulster Museum. This upgrade in storage has been so successful that there are plans for the other trophy heads in the collection to be given the same treatment.

Introduction

In 2008 one of the Ulster Museum's off-site stores was no longer viable and plans were made to decant to a new facility. The store had been used to house specimens too large or awkward to be stored in the main Collection Store including a number of trophy heads. Just as the majority of the packing was completed we suffered a major setback. A section of the ceiling collapsed and was discovered to contain asbestos. To cut a very long story short, specialist asbestos contractors were employed to clean the loose dust off the specimens before they could be removed from the building. The contractors were given training in handling specimens and were continually supervised by conservators via C.C.T.V. Staff waiting in an adjoining room then bagged the specimens for freezing in mobile units hired for the duration of the move. Although there were no signs of an active infestation some dead adults of Webbing Clothes Moth *Tineola bisselliella* were found on the surface of the heads. By June 2010 the trophy heads were safely secured onto the new racking (suitable for their considerable weight) using picture hooks and bungees (Hendry 1999). There are a wide range of species including warthog, moose, deer, gazelle and buffalo (Fig. 1).

Fig. 1. Selection of trophy heads on new racking.

Aims and Objectives
The aim of this project (still on-going) is to give the trophy heads physical and chemical stability and if required, bring them up to display standard. Maintaining this new, more stable, pest-free environment is a priority.

Conservation Treatments
This is a record of the treatment of a Dorcas Gazelle (*Gazella dorcas* - Lh102074) and a Warthog (*Phacochoerus africanus* – Lh102038). These are examples of the variation in condition of this collection and how conservation methods found in the literature have been used and adapted.

Dorcas Gazelle

Technical Assessment
Most of the damage to the specimen was as a result of poor support and unsuitable environmental conditions (Fig. 2). Although the loose dust had been removed by the asbestos contractors there was a layer of dirt obscuring the markings and the remaining eye and horns were also coated. The seam along the throat was split (Fig. 3) although the fill appeared stable. As with most of the trophy heads, the ears of the Dorcas Gazelle were curled and distorted. Three small exit holes indicated old pest activity but there were no signs of major damage. The left eye was missing. It was useful to download images of the gazelle from the internet to see the original position of the ears and any unusual markings such as pre-orbital glands and original coloration.

Fig. 2. Dorcas Gazelle before treatment.

Fig. 3. Dorcas Gazelle - split seam.

Cleaning
Wearing a '3M 8810' dust mask, the trophy head was dry brushed in the direction of hair growth towards the vacuum cleaner nozzle (covered with gauze). The horns were also brushed using a short, flat brush more appropriate for this surface. Fortunately the hair was in good condition and allowed further cleaning. The surface was gently swabbed with a 5% solution of Dehypon LS45 (low foaming non-ionic surfactant) and immediately dried to prevent absorption into the skin. It was wonderful to see the original colours and markings revealed. The eye and horns were also swabbed.

Repair
It was decided to fill the split along the seam. Although the original filler (which looked like plaster) appeared sound, it was further consolidated with Paraloid B72 in acetone. Glass microballoons GB03 in Paraloid B72 were used and once hardened, metal files were used to add texture. Acrylic paints were used to blend the repaired area with the fur (Fig. 4).

Fortunately we have a small cabinet of taxidermy materials left over from the days when the museum employed taxidermists. This included a selection of eyes and I was able to find one that matched the gazelle. It was held in place using Polyfilla which was matched to the other eye socket using acrylic paints.

Re-shaping
Fortunately, the ears were not split and it was decided to humidify them in order to gently ease them into the correct position. This was achieved by soaking a small amount of cotton wool in de-ionised water and placing it in a polyethylene zipper bag. The bag was then loosely sealed by the zipper around the ear and the cotton wool supported using a clamp on retort stand to avoid putting any extra weight on the ear. It was important that the cotton wool didn't come into contact with the ear as this could cause expansion and initiate chemical reactions (Carter 1998). The bag was left on for several hours and the ears tested regularly to check if they could move easily without causing damage. It was crucial not to leave the bag on for too long to prevent mould growth. When the ears became flexible they were gently uncurled and held in position using clamps. After a few hours the ears appeared stable in their original orientation and the clamps removed (Fig. 5).

Fig. 4. Dorcas Gazelle - seam after fill and retouching.

Fig. 5. Dorcas Gazelle after treatment.

Warthog

Technical Assessment
Although most of the skin appeared stable, the plaster used to fill around the mouth was cracked and some pieces were missing (Fig. 6). Cotton wool had been used to bulk out the filler. The ears were badly damaged and distorted with pieces missing (Figs. 7 & 8). The head and tusks were very dirty.

Fig. 6. Warthog before treatment.

Fig. 7. Warthog - damaged left ear.

Fig. 8. Warthog - damaged right ear.

Cleaning
The head was dry brushed with a soft brush as before. The tusks and eyes were swabbed with de-ionised water.

Repair
The loose plaster and cotton wool fill was removed from around the mouth using tweezers and a museum vac and the exposed surface was consolidated with 10% Paraloid B72 in acetone (Carter 1998). As there was quite a large gap to fill, ethafoam was used and topped with a layer of glass micro balloons GB03 mixed with Paraloid B72 (mixed to a consistency that allowed easy application). Using the glass micro balloons produced a smooth surface which could be given texture using a stiff bristled brush and dental tools. Once set, acrylic paints were used to retouch and particles collected from the original fill helped create a matt appearance and helped blend the repair with the surrounding skin. As this specimen was to be used for display this treatment was deemed appropriate.

Re-shaping

The left ear (Fig. 7) was complete although a lot of the fill was missing and it was split in several places. The fill was replaced with ethafoam and the tears repaired using Japanese tissue paper adhered using ParaloidB72 (Carter1998). Acrylic paints were used on the Japanese tissue paper (Tosa Usushi) to match the skin. The right ear (Fig. 8) required more work and Japanese tissue paper was needed to replace the missing pieces of skin. The warthog is now displayed in the 'Discover Nature' education suite at The Ulster Museum (Fig. 9).

Fig. 9. Warthog after treatment, on display at Ulster Museum.

Summary

This has proved to be a very rewarding project. As the original markings are revealed and the damage re-paired, the trophy heads have once again become accessible to the many people that visit the museum and its stores. Having the heads visible, both on display in the museum and on open racking in the collection store has raised awareness and appreciation for this collection.

Acknowledgements

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A Preliminary Comparison of Trisodium Phosphate with Agepon and Decon90 as Wetting Agents to Hydrate Dried Arachnida and Myriapoda Specimens

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Abstract

An experiment was established using 98 dry Arachnida and Myriapod specimens to determine the most appropriate wetting agent solution out of Decon 90, and trisodium phosphate with Agepon. Decon 90 is an industrial cleaning agent, and Agepon is a chemical used in photographic film processing. The effects of both wetting agent solutions were varied depending on the taxa of the specimens. It was discovered that Decon 90 was most effective on the orders Scorpiones, Acari, Araneae (*Heteropoda* sp.), Amblypgygi, Solifugae and Diplopoda. Trisodium phosphate with Agepon was most effective on Opiliones and Araneae (Theraphosidae – tarantulas). Both wetting agent solutions were effective on Chilopoda.
Keywords: trisodium phosphate, Agepon, Decon 90, wetting agents, Arachnida, Myriapoda

Introduction

The Entomology Department at the Natural History Museum (NHM) has a large collection of Arachnida and Myriapoda specimens stored in 70-80% industrial methylated spirit (IMS). There is also dry, pinned material dating back to the early 19th century. Around a decade ago, there was a policy to remove type specimens from the dried collection, hydrate them using trisodium phosphate (TSP), and to store them in the main spirit collection, in order to make them more accessible and easier to study. Although this policy is no longer active, the requirement for a good hydration fluid for dried specimens still stands, as arachnologists much prefer to study hydrated dried specimens, because they are flexible, especially the genitalia.

TSP in distilled water has been used for many years for hydrating botanical, palaentological and zoological specimens (Benninghoff 1947; Van Cleave & Ross 1947). TSP and distilled water mixed with the wetting agent Agepon (used in photographic film processing) has also been used for decades, but this does not appear to have been in the public domain until recently (Jocque 2008). A wetting agent is a chemical which reduces the surface tension of a liquid, enabling the liquid to spread more easily across a solid surface, and allowing the penetration of the solid by the liquid. Indeed, this is exactly how Agepon works when mixed with TSP and distilled water – it dissolves any grease from a specimen's exoskeleton, and enables the TSP and water to be absorbed by the specimen. The TSP then swells the internal tissues and restores them to their original shape. Agepon has been renamed 'Wac wetting agent' and is manufactured by Agfa. In this digital age of photography, certain brands of wetting agent for photographic processing may become obsolete (including Wac wetting agent). But there will always be specialist film developers, albeit in much smaller numbers than before. Any photographic wetting agent, if used in the same solution as recommended by Jocque (2008) and Nellist (2009), would have the same effect on specimens (pers. comm. D. Nellist, retired chemist and ex-committee member of the British Arachnological Society).

A paper was published comparing TSP and Decon 90 as wetting agent solutions using a selection of dry, pinned arachnids and myriapods from the NHM collection (Beccaloni 2001). Decon 90 is a surface active cleaning agent, and a radioactive decontaminant used for laboratory, medical and industrial applications. It was discovered that a 2% solution of Decon 90 in distilled water was the better wetting agent solution for most orders (Beccaloni 2001). After recently receiving rave reviews for TSP with Agepon (pers. comm. R. Gabriel), it was decided to set up a similar experiment to compare TSP plus Agepon, with 2% Decon 90, to establish which wetting agent solution solution to use.

Aim

To determine the most appropriate chemical out of TSP with Agepon (A&TSP) and Decon 90, to use as a wetting agent solution on dried Arachnida and Myriapoda material.

Methods

Previously (Beccaloni 2001), only one specimen was tested per wetting agent solution and different solution strength, which was definitely not a large enough sample size. It was therefore decided to use as many specimens as possible per wetting agent solution. Ninety eight specimens without data from a selection of Arachnida and Myriapoda groups were selected - Scorpiones (scorpions), Acari (mites), Araneae (spiders), Amblypygi (whip spiders) (Fig. 1), Opiliones (harvestmen) (Fig. 2), Solifugae (camel spiders), Diplopoda (millipedes) and Chilopoda (centipedes). All of these are identified to genus or species, except the liochelid Scorpiones - see Table 1. With each group, 5 specimens from the same genus/species were used to test each wetting agent solution, except with Diplopoda, Scorpiones and Araneae. For Diplopoda, 10 specimens were used per wetting agent solution - 5 large (*Zoospherium* sp.) and 5 small (*Glomeris marginata* Villers, 1789) (Fig. 3). For Scorpiones, 7 specimens were used per wetting agent solution for Scorpiones – 2 large (*Heterometrus* sp.) and 5 medium (Liochelidae). For Araneae, 7 specimens were used per wetting agent solution - 5 medium (*Heteropoda* sp.) and 2 tarantulas (*Paraphysa scrofa* Molina) (Fig. 4).

A 2% solution of Decon 90 was used, as this was found to be the more effective strength by Beccaloni (2001). Five grams of TSP in 1L distilled water, with 5ml of Agepon was used, as this solution strength was recommended by Jocque (2008) and Nellist (2009). The specimens were fully immersed in the test chemicals in tubes or small jars (Fig. 5). Beccaloni (2001) recorded results after 17 hours immersion in the test chemicals. This approach was not ideal because several specimens did not successfully hydrate and Nellist (2009) found that successful hydration in A&TSP occurred after an immersion time of between 10 and 15 days. It was therefore decided to monitor the specimens, and remove them once they had sunk in the test chemical, which would indicate successful hydration. The deterioration of specimens is considered totally undesirable, so where specimens began to deteriorate, even when they were still floating in the wetting agent solution, they were removed. The specimens were then thoroughly washed in distilled water and transferred into 80% IMS. This resulted in various immersion times between 5.5 and 16 days.

Fig. 1. Amblypygi (whip spiders) – *Damon annulatipes* (Wood, 1869).

Fig. 2. Opiliones (harvestmen) – *Pachylus chilensis* (Guer.-Men.).

Fig. 3. Diplopoda (millipedes) – *Glomeris marginata* (Villers, 1789).

Fig. 4. Araneae (Theraphosidae) – *Paraphysa scrofa* (Molina, 1788).

Fig. 5. Centipede specimens immersed in the test wetting agent solutions.

Results

The results are presented in Tables 1 - 4, and Graphs 1 - 2. Table 1 provides details of unique specimen numbers, which were assigned for the experiment (1 to 98); specimen identification; body length; wetting agent solution used and immersion times; whether the specimens sank in IMS, and if the specimens deteriorated. Table 2 summarises the total number of specimens successfully hydrated, compared to those which partially floated (PF) or floated (F) and were still rigid, with total number of specimens which deteriorated as a result of hydration per wetting agent solution. Table 3 summarises the total number of specimens which deteriorated per order. Table 4 summarises the total number of specimens successfully hydrated, and the total number of specimens that deteriorated per order/class/subclass.

Specimen numbers	Class/ subclass/ order	Family/genus/ species ; body length	Wetting Agent	Immersion time (days)	Sunk in IMS?	Specimen deterioration
1	Diplopda	*Glomeris marginata* (Villers,1789) (10mm)	A&SP	5.5	S	Flocculation of lipids quite bad
2					F	
3					F	Flocculation of lipids quite bad
4					S	Flocculation of lipids quite bad
5					S	Flocculation of lipids quite bad
6	Diplopoda	*Glomeris marginata* (10mm)	Decon 90	5.5	S	
7					S	
8					F	
9					F	
10					F	
					S	
11	Acari	*Trombidium* sp. (10mm)	A&STP	5.5	S	
12					S	
13					S	
14					S	
15					S	Bad flocculation, white patches
16	Acari	*Trombidium* sp. (10mm)	Decon 90	5.5	S	
17					S	
18					S	
19					S	
20					S	
21	Diplopoda	*Zoospherium* sp. (40mm)	A&STP	5.5	S	Bad flocculation, started to rot and break up
22					F	Bad flocculation
23					S	Bad flocculation, covered in lipid, started to rot and break up
24					S	Started to rot and break up
25					S	Started to rot and break up
26	Diplopoda	*Zoospherium* sp. (40mm)	Decon 90	5.5	S	
27					S	Beginning to break up
28					S	Beginning to break up
29					S	Beginning to break up
30					S	
31	Scorpiones	Liochelidae (40mm)	A&STP	16	S	Starting to break up, gelatinous
32				9	S	
33				9	S	Gelatinous
34				9	S	Gelatinous
35				16	S	Starting to break up; gelatinous
36	Scorpiones	Liochelidae (40mm)	Decon 90	9	S	
37				9	S	
38				16	S	Deteriorating
39				9	S	
40				9	S	Deteriorating
41	Solifugae	*Galeodes* sp. (45mm)	A&STP	5.5	S	
42				14	S	Breaking up
43				14	S	Legs gelatinous
44				14	S	
45				5.5	PF, fl	Gelatinous
46	Solifugae	*Galeodes* sp. (45mm)	Decon 90	14	F, fl	
47				14	F, fl	
48				5.5	S	
49				5.5	S	
50				9	S	
51	Amblypygi	*Damon annulatipes* (Wood, 1869) (20mm)	A&STP	14	S	Deteriorating & breaking up
52				14	S	Breaking up
53				14	S	
54				14	S	Deteriorating
55				14	S	really beginning to deteriorate. Body contents coming out.
56	Amblypygi	*Damon annulatipes* (20mm)	Decon 90	14	PF	Body broke in half - half floated, half sank
57				14	S	
58				14	F, fl	Breaking up
59				14	PF, fl	
60				14	S	

Table 1. Results of rehydration experiment Key: F = floating; S = sunk; PF = partially floating; fl = flexible (continued overleaf)

Specimen numbers	Class/ subclass/ order	Family/genus/ species ; body length	Wetting Agent	Immersion time (days)	Sunk in IMS?	Specimen deterioration
61	Opiliones	*Gonyleptes curvipes* (Koch, 1839) (10mm)	A&STP	14	F	
62				16	F	
63				16	S	
64				16	S	
65				16	S	Breaking up
66	Opiliones	*Gonyleptes curvipes* (10mm)	Decon 90	16	F	
67				16	F	Broken up
68				16	F	Starting to deteriorate
69				16	F	
70				16	F	Breaking up
71	Araneae	*Heteropoda* sp. (Araneomorphae) (25mm)	A&STP	5.5	F, fl	
72				9	F, fl	Abdomen deteriorating
73				5.5	F, fl	Bad flocculation on specimen
74					F, fl	
75				9 9	F, fl	Abdomen very floppy
76	Araneae	*Heteropoda* sp. (Araneomorphae) (25mm)	Decon 90	14	S	Broken up
77				14	F, fl	
78				14	F, fl	Breaking up
79				5.5	S	Deteriorating
80				5.5	F, fl	Deteriorating
81	Scorpiones	*Heterometrus* sp. (110mm)	A&STP	8	PF	Deterioration; metasoma broken up; bad smell; flocculation on specimen
82				5	PF	
83	Scorpiones	*Heterometrus* sp. (110mm)	Decon 90	10	F	
84				5	PF	
85	Chilopoda	*Scolopendra subspinipes* (125mm)	A&STP	5.5	S	
86				5.5	S	
87				9	S	Flocculation on specimen
88				5.5	S	
89				5.5	S	Flocculation on specimen
90	Chilopoda	*Scolopendra subspinipes* (Leach, 1815) (125mm)	Decon 90	5.5	S	
91					S	
92					S	
93					S	
94					S	
95	Araneae	*Paraphysa scrofa* (Molina) (Theraphosidae) (55mm)	A&STP	6	PF	
96					F(fl)	floppy
97	Araneae	*Paraphysa scrofa* (Molina) (Theraphosidae) (55mm)	Decon 90	6	F	
98					F	

Table 1. (Continued) Results of rehydration experiment Key: F = floating; S = sunk; PF = partially floating; fl = flexible

wetting agent	hydrated	partially floated	floated	deteriorated
A&TSP	**42**	**1**	**6**	**27**
Decon 90	**34**	**2**	**13**	**10**

Table 2. Total number of specimens successfully hydrated, compared to those which partially floated or floated and were still rigid, with total number of specimens which deteriorated as a result of hydration.

Order/ class	Number of specimens
Scorpiones	**7 (14)**
Solifugae	**3 (10)**
Opiliones	**0 (10)**
Acari	**1 (10)**
Amblypygi	**4 (10)**
Araneae	**8 (14)**
Diplopoda	**12 (20)**
Chilopoda	**0 (10)**

Table 3. Total number of specimens showing signs of deterioration after hydration per order/class/subclass (total number of specimens tested in parenthesis).

Order/ class	A&TSP		Decon 90	
	hydrated	deteriorated	hydrated	deteriorated
Scorpiones	**5 (7)**	**5 (7)**	**5 (7)**	**2 (7)**
Solifugae	**5 (5)**	**3 (5)**	**5 (5)**	**1 (5)**
Opiliones	**3 (5)**	**0 (5)**	**0 (5)**	**0 (5)**
Acari	**5 (5)**	**1 (5)**	**5 (5)**	**0 (5)**
Amblypygi	**5 (5)**	**3 (5)**	**4 (5)**	**1 (5)**
Araneae	**7 (7)**	**5 (7)**	**5 (7)**	**3 (7)**
Diplopoda	**7 (10)**	**9(10)**	**5 (10)**	**3 (10)**
Chilopoda	**5 (5)**	**0 (5)**	**5 (5)**	**0 (5)**

Table 4. Total number of specimens successfully hydrated per order/class/subclass, with total number of specimens which deteriorated as a result of hydration (total number of specimens tested in parenthesis).

Discussion

Overall, A&TSP hydrated 42 specimens - 1 specimen partially floated after immersion in IMS, whilst 6 floated (see Table 2 and Graph 1). Decon 90 hydrated 34 specimens overall - 2 specimens partially floated after immersion in IMS, whilst 13 floated (see Table 2 and Graph 1). Initially, hydration was considered to be successful only if the specimen had sunk. However, several specimens which were partially floating or floating were actually flexible, so were considered to be successfully hydrated, given the reason for hydrating initially.

From the results, it might seem a straightforward decision as to which wetting agent solution to select, but once the deterioration of specimens is taken into account, the outcome is altered. A&TSP caused 27 specimens to deteriorate, compared to Decon 90, which affected only 10. Given that deterioration is more serious than insufficient hydration, the wetting agent solution which causes the least amount of deterioration in each case is the one recommended.

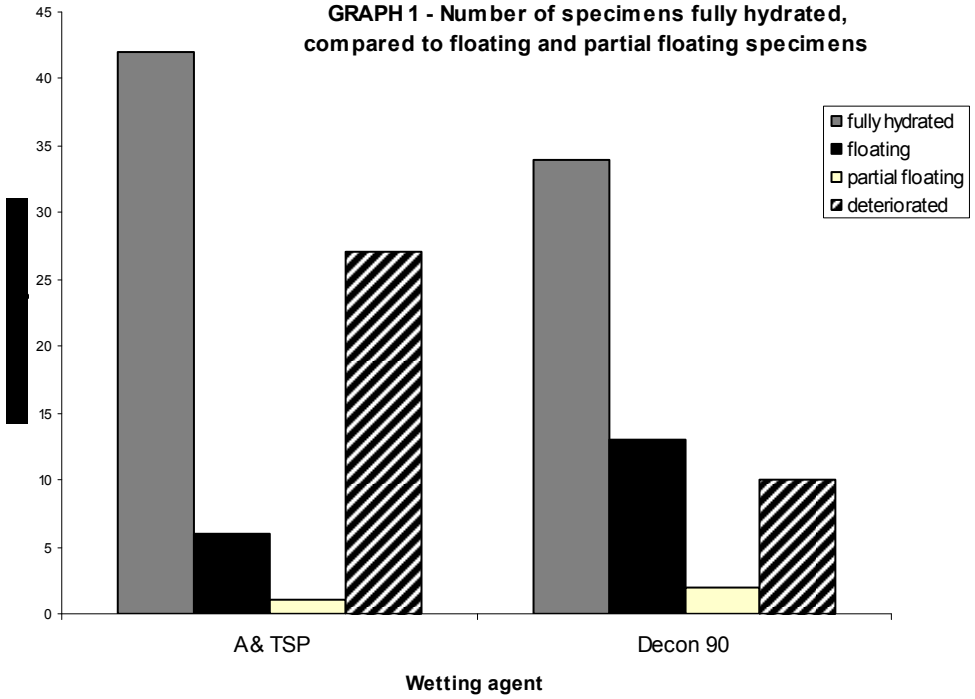
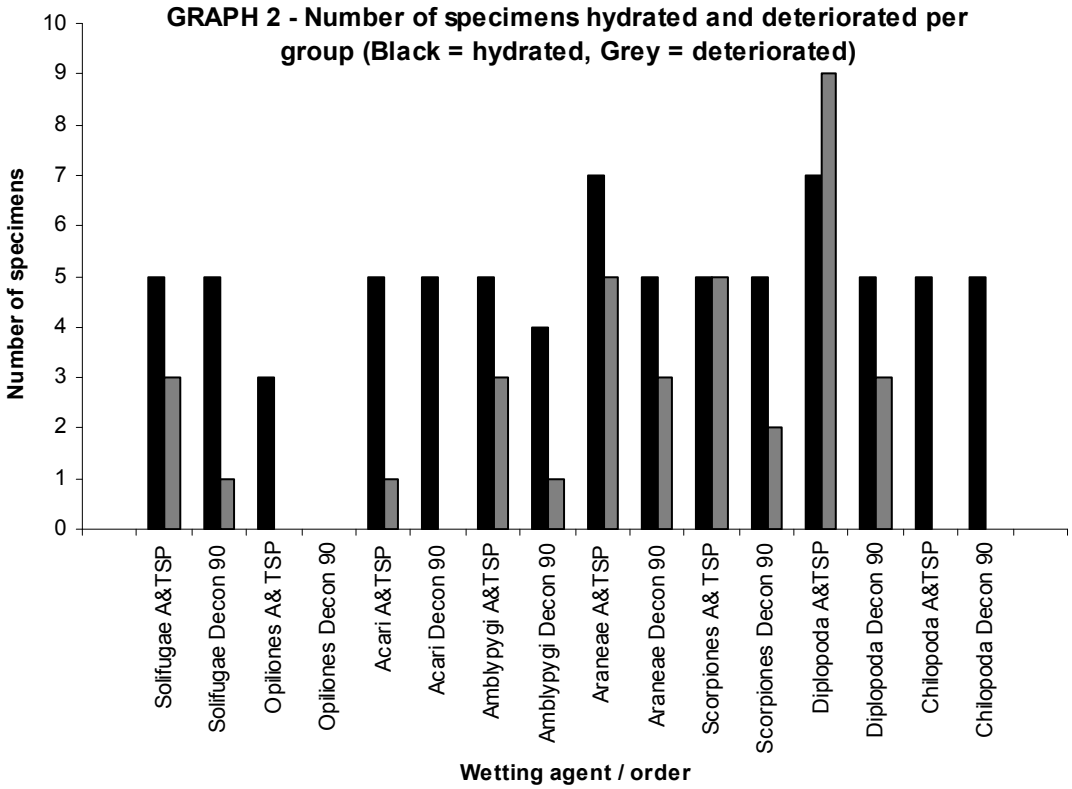


Table 3 summarises the total number of specimens showing signs of deterioration after hydration per order/ class/subclass. The three groups that showed greatest deterioration are: Scorpiones (7 out of 14 specimens), Diplopoda (12 out of 20 specimens) and Araneae (8 out of 14 specimens). It should come as no surprise that those orders with pronounced segmentation - Scorpiones and Diplopoda, should show greater deterioration. This is due to the much softer intersegmental membranes between the segments being affected more quickly than more highly sclerotized tissues. Once these tissues had split, the body contents were openly exposed, thus allowing more of the test chemical to enter the body cavity, which speeded up the hydration process and caused deterioration. Chilopods are of course, also segmented, but the specimens tested did not deteriorate. This observation has been noted in the dry collection at the NHM – no chilopod specimen has ever fallen apart, whereas dried diplopods are regularly prone to disintegration. This is because in diplopods, the soft tissue linking each sclerotised segment is thin and covers a smaller surface area compared to that in chilopods, There is no obvious explanation as to why the Araneae specimens were so affected, as they are similar in structure to solifugids, which were not so badly affected (3 out of 10 specimens).

At the group level (order/class/subclass), the performances varied greatly - see Table 4 & Graph 2. A&TSP performed fairly well with Opiliones, as it hydrated 3 out of 5 specimens, compared to no specimens hydrated by Decon 90. In addition, A&TSP caused no deterioration, so this is recommended as the wetting agent to use on Opiliones. However, it should be used with caution on other opilionid families which are much less highly sclerotized.

A&STP worked much better on tarantulas (Theraphosidae), as both specimens were flexible (even though one still floated and the other partially floated), compared to those in Decon 90, which floated and were still rigid. This concurs with information received (pers.comm. R.Gabriel). Both wetting agent solutions worked well on Chilopoda, with no deterioration, so both chemicals are recommended. This result was also noted in Beccaloni 2001.

With all the remaining orders below, Decon 90 is recommended as the preferred wetting agent, mainly due to the deterioration caused by A&TSP. With Araneae, both wetting agent solutions performed well as 12 out of 14 specimens were hydrated, although all 5 *Heteropoda* specimens floated in A&STP and 3 *Heteropoda* specimens floated in Decon 90. They were however, all flexible. It is somewhat ironic that more floated in A&STP than in Decon 90, because A&TSP is considered 'the' wetting agent solution to use (Jocque 2008; pers.comm. R.Gabriel). Although A&TSP was equally successful as Decon 90 as a wetting agent solution, it caused 5 out of 7 specimens to deteriorate, compared to 3 out of 7 with Decon 90.



With Solifugae, both wetting agent solutions hydrated all of the 5 specimens, but A&TSP caused 3 specimens to deteriorate, compared to 1 with Decon 90. With the Scorpiones, both wetting agent solutions hydrated 5 specimens each, but A&TSP caused 6 specimens to deteriorate, compared to only 2 with Decon 90. With Acari, both wetting agent solutions hydrated all of the 5 specimens, but A&TSP caused 1 specimen to deteriorate, compared to none with Decon 90. According to Beccaloni (2001), 2% Decon 90 was found to hydrate successfully 1 out of 2 acarine specimens, which is no doubt due to the shorter immersion time of 17 hours, compared to 5.5 days. With Diplopoda, A&TSP hydrated 7 out of 10 specimens, compared to 5 out of 10 with Decon 90. However, 9 specimens showed signs of bad deterioration, compared to 3 out of 10 specimens that had began to break up in Decon 90. Beccaloni (2001) found that only half of the diplopod specimens were successfully hydrated with 2% Decon 90 too, after an immersion time of 17 hours. Even by increasing the immersion time to 5.5 days, it was found to be difficult to hydrate the specimens in 2% Decon 90. For Amblypygi, A&TSP hydrated all 5 specimens, compared to 4 out of 5 with Decon 90, but 3 out of 5 specimens had begun to deteriorate, compared to 1 out of 5 specimens in Decon 90.

Due to the lack of availability of suitable material for experimentation, the sample size was too small to analyse statistically. However, it is still possible to draw useful conclusions from those data collected. It is evident that in general, *both* chemicals are a compromise, because they caused deterioration to a lesser or greater extent. This emphasises the need to only hydrate specimens where absolutely necessary.

Recommendations
Where there is an option for selectively using both wetting agents, the following is recommended:

Decon 90

- Scorpiones
- Acari
- Araneae: Araneomorphae

- Amblypygi
- Solifugae
- Diplopoda

Trisodium phosphate with Apegon

- Opiliones
- Araneae: Theraphosidae

Either

- Chilopoda

Further Work

The above data highlight the need for further, extensive tests on a much greater number of specimens, so that the data can be statistically analysed. However, in practise, it is very difficult in to obtain so many specimens for experimental purposes.

Since the work in this paper was undertaken, it has come to light that the problem of specimen deterioration can be prevented by warming the wetting agent solutions to around 50ºC. This catalyses the reaction and reduces the need to leave the specimens in the solutions for such long periods. The use of an air vaccum pump, which removes trapped air from the specimens and draws fluid in, can be used alongside the heating methodology (pers. comm. Simon Moore). It is therefore proposed that another experiment is run, with warmed wetting agent solutions and the use of a vacuum air pump, in order to perfect the wetting agent technique. In addition, a study would also be undertaken to establish whether the DNA of the specimens is adversely affected by such hydration of the tissues.

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Adulterating Polypropylene Containers: Not a Clear Open and Shut Case

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Abstract

Clear polyethylene and polypropylene containers with securely fitting lids provide not only usefully sturdy and stackable storage media for museum specimens but can also provide some buffering to changes in external environmental conditions. However, a range of containers used in museums analysed in the 1990s were found to be releasing volatile organic compounds, especially when new. Therefore to reduce the likelihood of adulteration, natural history specimens in particular should only be stored in containers that have had time to 'off-gas'. It is recommended that the lidded Gratnell containers now used widely in museums should also be investigated for volatile organic compounds and that when empty they should be stored with their lids removed.

Introduction

In the 1990s the author and colleagues undertook research into lidded polyethylene and polypropylene containers frequently used in museums for storing specimens, including the ubiquitous 'Stewart boxes'. This was to investigate how the containers compared in terms of providing a barrier or buffer to external changes in relative humidity (RH) (Larkin *et al*, 1998) and what volatile organic compounds (VOCs) they were emitting (Larkin *et al* 2000). The results were published in two papers summarised below. However, in the last decade a new type of lidded polypropylene container - the 'Gratnell' (Figures 1 and 2) - has become very widely used in museums, and certainly seems popular for the storage of natural history collections. For example Milly Farrell, in a recent edition of NatSCA News (Issue 19, 2010), describes the 'lock-lid transparent plastic boxes' used for re-housing the Primate Odontological Collection at the Royal College of Surgeons, with a photograph of the containers in use. They are also being used for the storage of some natural history specimens in, for example, Cambridge University Museum of Zoology, Plymouth City Museum and Art Gallery, Royal Cornwall Museum, Truro, and the Hunterian Museum at the Royal College of Surgeons. Whilst these Gratnell containers are undoubtedly useful and are available in a range of sizes it is unfortunate that, considering all polyethylene and polypropylene containers off-gas VOCs to varying extents and duration after manufacture, no research has yet been published about the chemical suitability of the Gratnell containers that are now used so widely in museums. Considering that many natural history specimens stored within these containers may be sampled for biomolecules in the future and in the meantime the specimens may be suffering from some adulteration, ideally the Gratnell containers should be tested for VOCs *etc* if funding could be found for the project.

Fig. 1. Lidded Gratnell containers with 'locking handles' in the collections area of Cambridge University Museum of Zoology. Note the three useful sizes.

Fig. 2. Lidded Gratnell containers (housing mineral specimens), in metal racks at Plymouth City Museum & Art Gallery. (Image reproduced with permission from Plymouth City Museum & Art Gallery).

Analyses of lidded polyethylene and polypropylene containers pre-2001

Many museums store their sensitive archaeological metalwork and some problematical palaeontological material in 'air-tight' plastic containers (such as 'Stewart boxes') along with a desiccant in an attempt to stabilise the relative humidity (RH) surrounding the specimen and provide a barrier to extreme changes in the RH of the storage area outside the container. However, several manufacturers had changed their container material from polyethylene to polypropylene by the mid-1990s and the seal between the new polypropylene containers and their lids did not seem as secure. If this was the case, it would reduce their effectiveness as a barrier to changes in RH. To ascertain any extra risk to museum specimens from the new polypropylene containers, a study was undertaken with dataloggers to test the performance of both the old polyethylene containers (some 'new' unused old-style polyethylene containers were sourced) and the new polypropylene containers. Whilst all the containers tested did provide a partial barrier to changing external RH, the differences between their apparent effectiveness was not great. The old style polyethylene Stewart containers were found consistently to out-perform the others tested albeit by a very small amount (Larkin *et al*, 1998).

In a follow-up investigation, the air inside a number of empty and unused polypropylene and polyethylene lidded containers was sampled for VOCs, and standard Oddy tests (Oddy, 1973) were undertaken on the container materials to ascertain any extra risk to museum specimens from the new polypropylene containers (polypropylene being inherently less stable than polyethylene). In the Oddy tests, lead coupons were consistently the most affected by the container materials, and polypropylene material appeared only slightly more problematic than polyethylene. The containers were sampled for VOCs using passive sampling diffusion tubes, and many VOCs were identified as being present such as short-chain aliphatic hydrocarbons, aromatic molecules, oxygenated species and aldehydes - the first time they had been recorded in this context (for a full list, see Larkin *et al,* 2000). Although at the time none of the compounds identified were considered as likely to be particularly reactive or harmful to most museum specimens, it was recognised that anything stored in these containers for a long time might potentially be adulterated by the compounds, possibly creating problems for the biomolecular study of the specimens in the future. Significantly, it was found that the greatest concentrations of these compounds occurred soon after manufacture, and that they can remain at high levels in sealed containers for several years. Therefore it was recommended that until more data are gathered on the identified species and their interactions with various museum specimens are analysed, such containers should be stored with the lids removed for at least several months between purchase and use with collections (Larkin *et al*, 2000).

Discussion and conclusions

The Gratnell lidded containers currently seem to be preferred for storing specimens in museum collections partly for their 'stackabilty', partly for their (apparently) secure 'sealing' handles that snap over the lid and partly because of their cost. Some museums may be using them to provide what it presumed to be a more controllable microclimate to prevent problems such as pyrite decay in mineral and fossil specimens (Larkin, 2011). These containers are apparently made from '20% talc-filled polypropylene - the talc is in there as a buffer to stabilise the container for chemical storage in school chemistry labs' (personal communication, Matt Williams). They also contain an unidentified antistatic additive. In the absence of knowing exactly what VOCs or additives the Gratnell containers might be off-gassing, it is at least reassuring to know that these containers do not seem to be sold with their lids attached. It would seem prudent to make sure that they are also stored with their lids removed until they are put to use.

As these containers seem to be increasingly used for the storage of natural history specimens that will become of greater use to science as further biomolecule retrieval techniques are developed and refined, further research is required, if funding can be found, into the potential for plastic containers generally and Gratnell boxes in particular to adulterate specimens over time.

Acknowledgements

Thank you to the reviewer for providing useful comments and to Jan Freedman for providing the photo for Figure 2. Thanks also to Helen Fothergill, Douglas Russell and Matt Williams for their contributions to this discussion.

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Book Review

The Afterlives of Animals: A Museum Menagerie
Edited by Samuel J.M.M. Alberti,
Published by University of Virginia Press, 2011

ISBN 978-0-8139-3167-8
£30.50 (at time of writing) @ www.amazon.co.uk

The Afterlives of Animals comprises a unique collection of object biographies, or 'afterlives' which serve to trace the cultural histories of a menagerie of biological specimens from around the UK and abroad. By tracing the life, death and afterlife of a variety of preserved animal objects, many of which have retained or achieved iconic status postmortem, this compilation of essays uncovers and explores the potential of the biography as a novel and diverse means of engaging with museum objects. The contributors come from a broad spectrum of professions and disciplines and include curators, historians, anthropologists, fine artists, geographers and journalists. The specimens discussed are equally varied, and include animal 'celebrities' such as 'Chi-Chi' the Panda (Natural History Museum), 'Maharajah' the Elephant (Manchester Museum) and 'Balto' the Dog (Cleveland Museum of Natural History) to name a few. As perhaps may be expected, there is a distinct bias to vertebrate mammals in the volume. However, the material forms of the specimens themselves is perhaps less predictable, with chapters dedicated not only to taxidermied animals but also to osteological specimens, and even to two study skins, which feature as the 'anti-celebrities' of the afterlives project.

With the majority of the essays following a similar theme, the reader would be forgiven for considering that the content has the potential to become a little repetitive. In reality however, the multidisciplinarity of *The Afterlives of Animals* ensures the topic remains interesting and insightful from cover to cover, with each contributor exploring their chosen subject from their own unique perspective. For this reviewer, Richard C. Sabin's account of *The Thames Whale: The Difficult Birth of a Celebrity Specimen* was most poignant and insightful. Recalling a quite recent and heavily publicised event, Sabin narrates his personal experience of the stranding of a northern bottlenose whale in the Thames, which having captured the imagination of the general public, almost brought London to a standstill in 2006. As a curator at NHM, Sabin reflects upon some of the challenges he was presented with in dealing with the death of an animal celebrity, along with the difficulty entailed in interpreting the whale's transition from nature to museum specimen to an anxious public and seemingly relentless press.

There are ten biographies in total, with two additional essays by Gary Marvin and Geoffrey N. Swinney which serve to engage the reader in a broader discussion of how different meanings may be constructed and attributed to preserved animal remains. In *Enlivened through Memory: Hunters and Hunting Trophies*, Marvin frames hunting trophies as memories of the hunt objectified. Marvin's account highlights how hunting trophies enable hunters to recall and relive their subjective and highly emotive encounters with other non-human species, and in doing so, underscores how animal remains are subject to different value systems according to their particular cultural contexts. In the concluding essay *An Afterword on Afterlife*, Geoffrey N. Swinney provides an insightful exploration of the theoretical and technical processes involved in the journey a deceased animal makes from nature to culture in order to become a museum 'specimen'. Swinney goes on to examine how object afterlives may operate collectively, and posits that the telling of afterlives need not be limited to singular specimens, or indeed, to front-of-house exhibitionary spaces.

The publication of a collection of natural history object biographies is timely in its reflection of recent trends in academia, especially in the fields of anthropology, material culture studies and museum studies. Moreover, much can be said of the increasing omnipresence of biological 'celebrity' objects in UK museums more generally, a phenomenon Hannah Paddon coins as 'mascotism' in her essay on 'Alfred' the gorilla (Bristol City Museum and Art Gallery). Indeed, as many curators are all too aware, such objects remain stubbornly popular with the museum going public, and as such hold considerable potential for audience engagement and museum publicity in an era marred by cuts to museum funding. The fact that many of these 'star' objects in museums across the UK are from natural history collections (over other disciplines) is indicative of the continued value of these collections and their enduring popularity with the public. Although taxidermy in particular has weathered a somewhat troubled existence in the last few decades, *The Afterlives of Animals* is demonstrative not only of a renewed interest in these collections, but also of the alternative interpretative possibilities inherent in biological specimens; of how their more conventional status as embodied sets of scientific data can be complimented by other ways of 'knowing' objects in the museum context.

Enhanced by illustrations and an extensive bibliography for further reading, *The Afterlives of Animals* presents a well-researched, sensitively compiled and accessible collection of essays which will appeal to a broad readership. The contributors include: Samuel J.M. M. Alberti, Christopher Plumb, Richard Sutcliffe, Mike Rutherford & Jeanne Robinson, Sophie Everest, Rachel Poliquin, Merle Patchett, Kate Foster & Hayden Lorimer, Hannah Paddon, Michelle Henning, Henry Nicholls, Richard C. Sabin, Gary Marvin and Geoffrey N. Swinney. The editor, Samuel J.M. M. Alberti, is Director of Museums and Archives at the Royal College of Surgeons, London.

Review by Ebony Andrews
Postgraduate Researcher in Museum Studies
University of Leeds
November 2011

Book Review

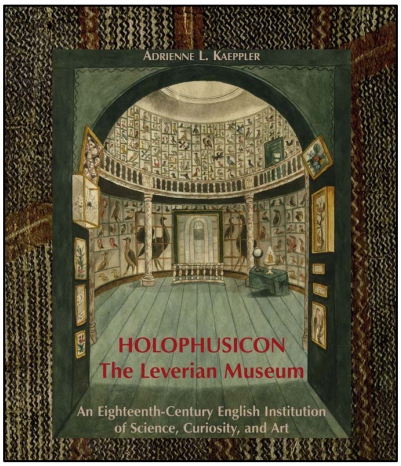
Holphusicon, the Leverian Museum, an eighteenth century English institution of science, curiosity and art.

Kaeppler, Adrienne

ZKF Publishers, Fasanenweg 4a,
D- 63674 Alstenstadt, Germany [xii + 308pp.],
2011.

ISBN 978-3-9811620-4-2
Cost: Euros 39.90

http://www.pacificarts.org/files/Holophusicon.pdf



The author has spent several decades researching the fate of the Leverian Museum. This famous collection, originating in eighteenth century England, was eventually dispersed in 1806 by auction. That event which scattered the contents exerted a long and continuous fascination on following generations of curators and other interested parties. This is because the 'Holophusicon' contained many iconic specimens both from earlier sources while based in Manchester and later when the museum moved to London. It then became even more famous, particularly with the addition of items from Captain Cook's voyages. It is within this latter category that initially prompted Kaeppler's own journey of investigation as her subject area specialism is the Oceanic cultures. This is reflected in her career path, from the Bishop Museum, Honolulu, during which work on Tongan artefacts first begged the question of the provenance of items that ended up in the Leverian, to becoming a curator in The Smithsonian Institution.

The culmination is this book, expanded to a comprehensive description of the dispersal of the whole collection a substantial percentage of which is natural history. After an account of the history of Leverian Museum there are chapters on paintings and other relevant contemporary illustrations, natural history specimens and human cultural artefacts. The two following sections detail particular specimens in these areas. Here there is a lot of information on collecting practices and historical commentary on the period. There is a comprehensive index.

The Leverian was rendered even more famous for being sold by a lottery in 1786 so any new owner obtained one of the biggest museum collections purely by chance. The winning ticket was that of James Parkinson who decided to manage the museum for twenty generally unprofitable years before giving in and finally selling it off by auction. This process took nearly three weeks. A number of original sale catalogues are annotated with buyers' names and notes which allow some of the lots to be relatively easily traced but others required persistent research and many remain as yet unfound. For research reasons relevant to the collections of the Hunterian Museum, Glasgow University, the reviewer has been to see one of these annotated catalogues, preserved in Rochdale, Lancashire, that of James Laskey. Laskey has several interesting connections with Glasgow as he bought some of the lots for himself and on behalf of others and presented some specimens to the Hunterian. I could not find any drawings in this particular copy that Kaeppler describes from her own examination. Perhaps her notes have confused this copy with one of the others that do have marginal drawings of some of the lots. Either that or a librarian has moved them if they were loose and not actually drawn on the printed pages.

An interesting situation during the period when the Leverian was open to the public under the direction of its original owner was the antipathy of Sir Joseph Banks towards Sir Ashton Lever. It seems he regarded Lever as socially and scientifically inferior. As Banks was in a position of power he was responsible for preventing the ambition of both Lever, and later Parkinson, to persuade the government to adopt the collection for the nation. Banks' friends such as the entomologist Johann Christian Fabricius adopted the same attitude. Fabricius in his 'Die Briefe aus London' (1784) while praising the birds in the Leverian said:

"The collection itself is more attractive than rich, and more dazzling than genuinely useful. Everything is on display and … has been cleaned, polished, perhaps even put together, supplemented and repaired. Sir Ashton is no expert, merely an enthusiast … one is not completely sure that different parts, heads, fins and so on have not been added. I have not dared to describe anything here, as the fact that everything is under glass makes it harder to identify the species."

Fabricius also says of anthropological items from Captain Cook's third voyage: "brought … back for the Admiralty, and the British Museum, as the collection of the people, could have laid claim to it. However, Lord Sandwich, who was First Lord of the Admiralty at the time, procured it for Sir Ashton Lever because he believed he needed his influence in a certain parliamentary election. This collection is fine, rich, extensive and the best in the entire cabinet." Kaeppler makes no reference to any political pay back that might have influenced the transfer to a private individual of publicly funded acquisitions. She refers to scientific friends of Lever and the ships' captains who were insisting that Cook's intentions in this direction were carried through. It still begs the question of who was the true owner of the collections, the tax payer or any other parties but the moral judgements of today cannot always be applied to the past. Indeed, Banks himself regarded the collections from various official sources as his own to work on or give away, especially with regard to herbarium material.

One wonders if Banks' opinions had coloured the Fabrician view of the situation. Notwithstanding Fabricius' reluctance to study the Leverian collection, there were numerous insects in the museum that were of importance although details are scanty and it is likely that more time on historical entomology research could discover more extant specimens. A most entertaining account of some specimens that have been located is that of two albatross feather lice from Cook's second voyage (see Ricardo Palma, 1991, Archives of Natural History, volume 18).

British collections that have a known connection with the Leverian Museum include Cambridge, Exeter, Glasgow (Hunterian Museum), Liverpool, London (British Museum, Natural History Museum), Oxford, Salisbury and Southwark (Cuming Museum). Due to the dispersal by auction things got widely scattered and so other museums around the world can also point to items that were once in the Leverian. Undoubtedly there will be other odd items might prove to be Leverian but proving it would be a challenge. One would have to emulate the author's application and diligence in following numerous clues over time and space. I have been looking forward to reading this book for a few years now, as have others. At last the definitive work on the justly famous Leverian Museum has been published.

E. Geoffrey Hancock,
The Hunterian (Zoology Museum), University of Glasgow, November 2011

Recent publications relevant to the natural history curator

There are numerous journals the natural history curators have submitted articles to in the past year. This new section of *NatSCA News* will list the publications produced by NatSCA members which may be relevant to natural history curators.

Ashby, J. & Wood, C. 2010: Lessons in Learning: Primary schools, universities and museums. UCL, London
This publication is the result of an evaluation study into the Primary schools outreach programme offered by UCL Museums & Collections. It will be of interest to universities, museums and other institutions that engage in outreach programmes with schools. We present a good practice guide for working with Primary school children, including the strategic background to such projects. The key to outreach that is effective and engaging is discovery-based learning, developed from an exploratory model. Concepts of Higher Education (HE) are poorly understood among Primary-aged children but it is both possible and appropriate for universities or museums to introduce such concepts at this level through hands-on interactive workshops in schools.
Available here: http://www.ucl.ac.uk/museums/learning/documents/Lessons_in_learning.pdf

Buckley, M., Larkin, N., and Collins, M. 2011. Mammoth and Mastodon collagen sequences; survival and utility. *Geochimica et Cosmochimica Acta.* Volume 75, Issue 7. Pages 2007-2016.
Near-complete collagen (I) sequences are proposed for elephantid and mammutid taxa, based upon available African elephant genomic data and supported with LC–MALDI-MS/MS and LC–ESI-MS/MS analyses of collagen digests from proboscidean bone. Collagen sequence coverage was investigated from several specimens of two extinct mammoths (Mammuthus trogontherii and Mammuthus primigenius), the extinct American mastodon (Mammut americanum), the extinct straight-tusked elephant (Elephas (Palaeoloxodon) antiquus) and extant Asian (Elephas maximus) and African (Loxodonta africana) elephants and compared between the two ionization techniques used. Two suspected mammoth fossils from the British Middle Pleistocene (Cromerian) deposits of the West Runton Forest Bed were analysed to investigate the potential use of peptide mass spectrometry for fossil identification. Despite the age of the fossils, sufficient peptides were obtained to identify these as elephantid, and sufficient sequence variation to discriminate elephantid and mammutid collagen (I). In-depth LC–MS analyses further failed to identify a peptide that could be used to reliably distinguish between the three genera of elephantids (Elephas, Loxodonta and Mammuthus), an observation consistent with predicted amino acid substitution rates between these species.

Buhl, P. N. & Notton, D. G. 2009. A revised catalogue of the Platygastridae of the British Isles (Hymenoptera: Platygastroidea). *Journal of Natural History* 43(27): 1651 — 1703.
About 260 species of Platygastridae are listed from the British Isles. Forty-seven species and one genus are recorded as new to the UK. Fourteen new synonymies are proposed. One replacement name and two new combinations are proposed. For some species taxonomic notes supplementing the published descriptions are given.

Eklund, J. A., and Thomas (2010), Assessing the effects of conservation treatments on short sequences of DNA *in vitro*, in *Journal of Archaeological Science*, 37, p. 2831-2841.
Little is known about what effects conservation treatments used to preserve human and animal hard and soft tissues have on DNA preservation. We have developed a method to assess quantitatively the extent of lesions or strand breakage caused by conservation treatments on short sequences of DNA in vitro. The method developed enables the determination of the percentage of DNA preserved following exposure to a conservation treatment solution relative to control samples, thereby allowing the direct comparison of treat-

ments based upon their preserving/damaging effects on a DNA sequence. Forty-three chemicals commonly used in the preparation and/or conservation of human and/or animal remains were examined. We found that the majority were damaging, in particular and as expected, acidic treatments and treatments carried out at elevated temperatures. A few, primarily organic solvents, were not damaging. The approach we have adopted can be applied to screen other treatments either used in the past or for future conservation applications as they are developed to assess their effects on DNA. How these results should be interpreted in terms of conservation and sampling is also discussed.

Freedman, J., Buckland, C., Fothergill, H., Longworth, R., Smithers, P., Fileman, E., and Fisher, J. 2010. Taxing Taxonomy, Scary Systematics and Confusing Classification; Developing interactive activities for school groups to make scientific jargon more accessible. *In Science Exhibitions: Communication and Evaluation.* Ed. Filippoupoliti, A. Museums Etc.

Scientific jargon can often be daunting to those unfamiliar with its meaning. This unconscious fear and association with a dead language has an effect on how the younger generation are taught and consequently what career choices they later make. This paper explores the work between Plymouth City Museum and Art Gallery (PCMAG) and several partners in the City of Plymouth to create a series of events as part of National Science and Engineering Week (NSEW). Taxonomy, Systematics and Classification were chosen as the theme under the non-threatening title '*Naming Nature*'. The aim was to produce a temporary interactive display in a large gallery at PCMAG for the duration of NSEW with information about the history of classifying plants and animals and how and why they are scientifically named. Discussions and planning with partner organisations allowed five sections of activities to be developed, with each theme supported by the key work areas for the organisation. The activities would facilitate topics on the schools curriculum which could be adapted for the different age ranges (4-16 year olds). Schools booked slots during the week, and spent around 15 minutes on each activity. The sessions finished with a group activity, asking the students to create their own animal or plant and to name it in Latin, with help from the scientists, examples of which are included in this report. The whole week was staffed by the organisations, with support from university volunteers. Front line scientists engaged both school groups and the general public with activities supplemented by real specimens from PCMAG's collections. A day open to the public encouraged museum visitors to explore and unravel the not so mysterious world of scientific nomenclature.

Freedman, J. 2011. Type specimens discovered in the Spirit Preserved Collections at Plymouth City Museum and Art Gallery. *MBA News.* Issue 46. pp.13.

This article outlines the review project undertaken on the 4000+ spirit preserved marine collections at Plymouth City Museum and Art Gallery. The review discovered the type specimen of *Amalosoma eddystonense* and two co-type specimens of *Polycitor searli* and *Lissolinum cupliferum*.

Freedman, J. 2011. Storage of the radioactive mineral collections held at Plymouth City Museum and Art Gallery, UK. *Collections: A Journal for Museum and Archives Professionals.* Vol. 7. No. 2. pp. 201-212.

Devon and Cornwall, in the South West of Britain, have a rich variety of rare and beautiful minerals formed through millions of years of geological change. Plymouth City Museum and Art Gallery (PCMAG), in Devon, holds over 10,000 mineral specimens from rare and unique sites across Devon and Cornwall. Held within the main mineral collection at PCMAG are 139 radioactive minerals. This paper explores the best practice for storing the radioactive mineral collection safely in the workplace, minimising any potential hazard and risk to staff and researchers. Included in this paper are examples of how other museums have stored their radioactive minerals safely and includes relevant legislation. The storage project also allowed the opportunity to digitally image the entire radioactive mineral collection permitting PCMAG's database to be updated with images, and new storage information. PCMAG worked closely with a Radiation Protection Advisor for advice and also appointed three Radiation Protection Supervisors to monitor access to the collections and reduce any potential risk further.

Hone, D.W. E., Taylor, M.P., Wynick, D., Viscardi, P.W., Gostling, N. 2011. Running a Question-and-Answer Website for Science Education: First-Hand Experiences. Evolution: Education and Outreach 4(1):153-157

The online learning and outreach resource Ask A Biologist (AAB; http://www.askabiologist.org.uk/) has been operating for three years, and this paper reports our initial experience of running the site. To date, AAB has answered and archived online over 3,500 questions from the general public with contributions from more than 50 researchers, and attracted an estimated audience of half a million, all with relatively minimal investment. Simply, questions are posted by visitors to the site, and one or more of our registered academic experts then provide their answers which are available for all to see and browse. The system is simple and provides direct contact between the public and scientists on subjects that are guaranteed to be of interest. In this paper, we review the benefits and drawbacks of such a system based on our first-hand experiences, detailing how the site was originally conceived and built and how it operates. We offer this as a model for future projects and to highlight both the benefits and pitfalls of such a system.

Larkin, N., R. 2010. Literally a 'mammoth task': The conservation, preparation and curation of the West Runton Mammoth skeleton. *Quaternary International.* 228.

The skeleton of the West Runton Mammoth is one of only a very few Mammuthus trogontherii skeletons known globally. It is the most complete skeleton of this species known, was excavated in primary context, is well preserved and represents an important stage in mammoth evolution. Therefore this skeleton and the associated specimens from the 1995 excavation at West Runton required relevant levels of conservation, preparation and curation appropriate to material of this importance. As the material is sub-fossil in nature (i.e. not mineralised), biomolecule retrieval techniques may be used on the specimens in the future, and therefore it was necessary to preserve the biochemical and geochemical integrity of the material and invasive conservation procedures such as consolidation were therefore kept to a minimum. However, due to weathering and trampling at the time of burial and subsequent compaction of the sediment the bones were mechanically weak, fragile and vulnerable once excavated. Given the huge size and substantial weight of the larger bones, innovative storage solutions had to be devised to create appropriate permanent supportive storage media. Whilst considering suitable conservation strategies, investigations into certain materials lead to experimentation with techniques. This project demonstrates the importance of having a well-funded post -excavation conservation programme employing a preparator–conservator not only to appropriately stabilise and conserve the physical material for detailed study but also to conserve information that might otherwise be lost e.g. orientation of bones when found, or the preservation of sedimentary structures. In addition, familiarity with the material resulting from several years of preparing the bones under a microscope has revealed important aspects of the material– relating often to taphonomy and pathology – that might otherwise have been missed.

Larkin, N. R. & Norton, P. E. P. 2010. The Pliocene and Pleistocene mollusc archive at Norwich Castle Museum. Bulletin of the Geological Society of Norfolk. no.60, 3-35.

This paper is one in a series on recent projects researching and documenting the geology collections of Norfolk Museums and Archaeology Service. It describes three years of work databasing the P. E. P. Norton Collection, formed between 1961 and 1978 whilst researching the East Anglian early Pleistocene Mollusca and those of associated sites, with comparative and reference specimens from the Pliocene, Pleistocene and Holocene of NW Europe and Iceland. Several of the collection sites no longer exist. The resulting database, of 1925 records and 4500 images, the collection itself and associated documents together with unresearched material donated to the British Geological Survey, form an accessible resource for future documentation of other specimens or collections. The database records 'monstrosities', 'attacked' and parasitized shells, new findings on Macoma balthica, and taxa which require further examination. The database forms a 'Digital Monograph' including illustrations of not only the best but also the least identifiable shells. A preliminary survey of other mollusc collections in Norwich Castle Museum, mainly from the 19th Century, is also summarized together with a brief guide to other institutions possessing cognate material. The limitations of the collection are discussed. Suggestions for new approaches in future work are included, with particular emphasis on the need to build up new collections with modern tools and methods and a finer resolution of stratigraphic detail and site description. New directions may include biomass estimation and other palaeoecological studies. An Appendix lists many of the earlier mollusc collectors and the location their stored material.

Larkin, N. R., Lee, J. R., and Connell, R. 2011. Possible ice-rafted erratics in late Early to early Middle Pleistocene shallow marine and coastal deposits in northeast Norfolk, UK. *Proceedings of the Geologists' Association*. 134.
Erratic clasts with a mass of up to 15 kg are described from preglacial shallow marine and coastal deposits (Wroxham Crag Formation) in northeast Norfolk. Detailed examination of their petrology has enabled them to be provenanced to northern Britain and southern Norway. Their clustered occurrence in coastal sediments in Norfolk is believed to be the product of ice-rafting from glacier incursions into the North Sea from eastern Scotland and southern Norway, and their subsequent grounding and melting within coastal areas of what is now north Norfolk. The precise timing of these restricted glaciations is difficult to determine. However, the relationship of the erratics to the biostratigraphic record and the first major expansion of ice into the North Sea suggest these events occurred during at least one glaciation between the late Early Pleistocene and early Middle Pleistocene (c.1.1–0.6Ma). In contrast to the late Middle (Anglian) and Late Pleistocene(Last Glacial Maximum) glaciations, where the North Sea was largely devoid of extensive marine conditions, the presence of far-travelled ice-rafted materials implies that earlier cold stage sea-levels were considerably higher.

Limbert, M. 2012. Bird-related Collections at Doncaster Museum & Art Gallery: A description and Bibliography. *Lapwing Special Series.* No 16. Doncaster and District Ornithological Society.
Five Yorkshire Museums have prepared accounts of bird-related museum collections, including Leeds City Museum/Leeds Museum Resource Centre, the Dorman Museum, Middleshrough Museum, Clifton Park Museum, Sheffield Museum, and the Yorkshire Museum. To this ornithological list can now be added a sixth museum, Doncaster Museum & Art Gallery, although ironically the Natural Science department was closed down on 31 March 2011. A 30-page synopsis and bibliography (Limbert, in press) is to be published in 2012 by the Doncaster & District Ornithological Society. This was largely completed before departmental closure, and its preliminary sections incorporate an historical outline 1900-2011, including the associated Doncaster Zoo. The synopsis is organized under six headings: 'Spirit-preserved specimens', 'Birds' eggs', 'Skulls and bones', 'Study skins', 'Mounted taxidermy' and 'Photography and taxidermy archives/ materials'. These are succeeded by an extensive bibliography. **Details of availability of an offprint can be obtained from Michael Limbert (martin.limbert@googlemail.com).**

MacDonald, S. & Ashby, J. 2011: Campus Treasures. *Nature*: 471,164–165.
University museums contain some of the richest and most extraordinary collections in the world, from Charles Darwin's Galapagos finches at the University of Cambridge, UK, to Louis Agassiz's vertebrate palaeontology specimens at Harvard University in Massachusetts. Such collections can draw on excellent resources — academic minds, vast libraries and student enthusiasm. But now that universities are increasingly required to demonstrate their impact on society, their museums must also claim a new role as vital public spaces.
Aiming to do just that, the Grant Museum of Zoology at University College London (UCL) reopens to the public this week after an eight-month closure while it moved to a new building. With the extra space in its new home, as its directors we intend to make it a vibrant place for experiment and dialogue by offering provocative, interactive and regularly changing displays. The museum retains its Victorian cabinets, crammed with skeletons and specimens in jars, with many coming out of storage for the first time — including dozens of primate and carnivore skeletons, newly rediscovered dodo material and a rare pterosaur fossil. But we will also pilot new ways of engaging visitors with science and scientists.
Full text here: http://www.nature.com/nature/journal/v471/n7337/full/471164a.html

Notton, D. G. 2011. A new practical method for profiling and topping up alcohol preserved entomology collections. *NatSCA News* 21. pp.44-98.
Key aspects of recent research into topping up entomology spirit collections are summarised. A new method of profiling alcohol preserved collections is presented and its use as a diagnostic tool is discussed. A novel tool is also presented as a reference table for calculating the concentration of topping up alcohol, which allows the regulation of preservative alcohol concentration within close limits. The method can be used for remedial and routine topping up and can be adapted to the needs of different collections (an abridged version of Notton, 2010. *Collections Forum* 24(1-2): 1-27).

Notton, D. G. 2011. The availability and validity of the name *Forpus flavicollis* Bertagnolio & Racheli, 2010, for a parrotlet from Colombia. *Bulletin of the British Ornithologists' Club* 131(3): 221-224.
The recent description of the Yellow-necked Parrotlet *Forpus flavicollis* Bertagnolio & Racheli, 2010, from a photograph taken in Colombia has generated extensive discussion among ornithologists about methods of description through illustrations and lack of deposited type specimens. This note aims to clarify these issues on the availability and validity for this scientific name.

Notton, D. G. 2010. Maintaining concentration: A new practical method for profiling and topping up alcohol-preserved collections. *Collection Forum* 24(1-2): 1-27.
A new method of profiling alcohol preserved collections is presented and its use as a diagnostic tool is discussed. Some previous methods for topping up are reviewed and a new method is proposed. A novel tool is also presented - a reference table for calculating the concentration of topping-up alcohol - which allows the regulation of preservative alcohol concentration within close limits. The method can be used for remedial and routine topping up and can be adapted to the needs of different collections.

Notton, D.G. 2010. International Commission on Zoological Nomenclature website: *Frequently Asked Questions*. http://iczn.org/category/faqs/frequently-asked-questions.
Commonly asked questions about Zoological Nomenclature, and the International Code of Zoological Nomenclature including: How should zoological names be written?; What are type specimens for?; What is the difference between availability and validity of names?; I think I have a new species, how can I get it named?; If a name is incorrectly spelled, what do I do?; Who is the type of *Homo sapiens*?; Should I use Phylocode?

Notton, D.G. 2010. A catalogue of types of Platygastridae (Hymenoptera, Platygastroidea) at the Muséum National d'Histoire Naturelle, Paris, with brief notes on the history of the collection. *Zootaxa* 2358: 1–24.
The types of 42 nominal species of Platygastridae (Platygastroidea) in the collection of the Muséum national d'Histoire naturelle, Paris are catalogued. One new combination is established, and one name is reinstated as a valid, available name. Brief notes are provided on the collections and type material of Joseph-Étienne Giraud, Jean-Jacques Kieffer, Paul Marchal and Jean Risbec.

Ross, A. J., Mellish, C. J. T., York P. V. and Crighton, W. R. B. 2010. Burmese Amber. pp. 208- 235 In Penney, D. (ed). *Biodiversity of Fossils in Amber from the Major World Deposits*. Siri Scientific Press, Manchester, 304 pp
http://sirisci entificpress.co.uk/Documents/Biodiversity%20of%20fossils%20in%20amber%20volume%20info%20from%20catalogue.pdf
Burmese amber is a remarkable substance and arguably the most important amber for studying terrestrial diversity in the mid-Cretaceous. After 1934, little was published on Burmese amber until 2000, when a thematic set of papers was published in the Bulletin of the Natural History Museum, Geology Series. This triggered world-wide scientific interest in this amber and nearly 150 papers have been published in the last decade, mostly on its insect inclusions. Renewed mining has enabled material to be exported to the West and many new taxa have recently been described.

Simmons, M.J. and Taylor, M.A. (2011) "Francis Buchanan White, the Scottish Naturalist" in *Ten Taysiders-Forgotten Figures from Dundee, Angus and Perthshire*, Abertay Historical Society No. 51.
That the natural history collection in Perth Museum & Art Gallery is recognised as a collection of national significance to Scotland is largely due to the vision, passion and collecting of one man, Francis Buchanan White. White trained as a doctor but instead of following that profession he devoted himself to the study of natural history. He has been described as "one of the greatest naturalists Scotland has ever produced". His

interests and expertise were broad and he was an active field naturalist collecting and studying specimens of the fauna and flora of Scotland, especially from his home county of Perthshire. His research and fieldwork was in pursuit of knowledge about "distribution and its causes" and resulted in published notes and papers on both zoological and botanical subjects in every year of his adult life. Through his interest and enthusiasm he was to found and promote a number of important Scottish natural science societies but beyond the world of natural history White is not well known and his specialist achievements deserve a wider audience.

Stuart, A. J., and Larkin, N. R. 2010. Taphonomy of the West Runton Mammoth. Quaternary International 228.

A substantially complete skeleton of a huge male mammoth *Mammuthus trogontherii* (estimated weight in life 9 tonnes) was excavated from the West Runton Freshwater Bed (the Cromerian stratotype) at West Runton on the North Sea coast of Norfolk, UK, over the period 1990–1995. The high standard of excavation of the skeleton and subsequent careful preparation and conservation provides much detailed evidence relevant to the taphonomic history of the mammoth assemblage. The wear on the molars indicates that it was about 41 years old at the time of death compared with a life expectancy of about 64, so that it had died prematurely. The fact that the West Runton Mammoth had sustained a severe injury to its right knee, which would have left it disabled and debilitated, might have led indirectly to its premature demise. The dead animal appears to have lain on its right side in shallow water and waterlogged silts, and soon after death the skin probably began to split exposing the ribs on the left side and the ends of the neural spines of the vertebrae to scavenging by spotted hyaenas, and perhaps also other animals. The feet were also extensively chewed at an early stage. Subsequently the skeleton appears to have been dismembered and scattered – the smaller bones probably by scavengers – and hyaenas further chewed the bones. At various stages hyaena coprolites were deposited around the carcass. Other mammoths, like modern elephants probably attracted to the remains of their own kind, were presumably responsible for moving the larger and heavier bones, skull and tusks, and removing the left tusk from the skull. They also appear to have extensively trampled the site, pushing bones down into the sediment and producing numerous scratches (inferred trampling marks). The mandible and left ulna were subaerially weathered where they protruded above the water and silt, while the similarly exposed top of the skull disintegrated in situ as the silt built up around it. The West Runton Mammoth and associated finds provide unique information on the palaeobiology of both spotted hyaena Crocuta crocuta and 'steppe' mammoth M. trogontherii in the early Middle Pleistocene.

West, C. & Ashby, J. 2011: "How many animals are in the room?" *Creative Teaching & Learning*: 2.1: 22-27

The key to outreach that is effective and engaging is discovery-based learning, developed from an exploratory model. UCL Museums & Collections house a great range of objects and are a fantastic resource supporting teaching and learning at UCL and in our community. Our outreach work, using object-based learning linked to the Primary school curriculum, is the focus of this article. It is largely delivered by an outreach educator employed by UCL, who takes museum artefacts into schools and delivers workshops of about an hour with a class of up to thirty children. The artefacts are used as inspirational focal points around which curriculum topics are discussed, along with discussion of university life.

Viscardi, P.W., Sakamoto, M. & Sigwart, J.D. 2010. How long is a piece of *Strix*? Methods in measuring and measuring the measurers. Zoomorphology 129(3):185-194

An experiment to quantify intra- and interobserver error in anatomical measurements found that interobserver measurements can vary by over 14% of mean specimen length; disparity in measurement increases logarithmically with the number of contributors; instructions did not reduce variation or measurement disparity; scale of the specimen influenced the precision of measurement (relative error increasing with specimen size); different methods of taking a measurement yielded different results, although they did not differ in terms of precision, and topographical complexity of the elements being considered may potentially influence error (error increasing with complexity). These results highlight concerns about introduction of noise and potential bias that should be taken into account when compiling composite datasets and metaanalyses.

schools resources, music concerts, evening lectures and tours), but also to trial new developments (such as a medicinal garden and photographic competition) to help inform future decisions about programming and resources. Valuable lessons were learned from this experience, ranging from the practical (such as how well do text-panels last outdoors) to the somewhat ethereal (such as identifying where weaknesses arise in chains of communication and responsibility when working in an inter- and intra-organisational collaborative framework). The outcomes have been very positive in developing partnerships and collaborations; improving the science offer to the Horniman's audience; raising the profile of project partners through the success of the photographic competition (which received excellent coverage from the national press), and raising awareness of Darwin's life and his contribution to science.

Viscardi, P.W. 2010. If you jump on a bandwagon, hold onto the reins. Museums Journal 110(08):p17
Wide scale public engagement campaigns such as the Darwin bicentenary can create work that has little lasting benefit. It is important to minimise this wasted effort by approaching campaigns with clear objectives, flexibility and forward planning. By taking control it is possible to further institutional goals and achieve legacy outcomes whilst supporting a wider campaign.

This new section aims to point out articles of interest to NatSCA members. Please email the full reference and abstract of any articles that you think may be useful to include in the next issue of *NatSCA News* to;

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