THE CURATION OF ARACHNIDA COLLECTIONS IN ALCOHOL: AN INTERNATIONAL SURVEY

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Abstract.—The Natural History Museum, London (NHMUK), has a large Arachnida collection in alcohol. Although the NHMUK follows best-practice in alcohol collections standards, there are still standards that have yet to be agreed upon, e.g., the choice of optimum printer and ink for producing labels. In 2012, I designed a survey to establish how alcohol collections are curated in other institutions around the world. I sent a questionnaire relevant to all collection sizes, materials, and storage spaces to 49 institutions in 36 countries. Responses from 42 institutions indicated: (1) collection size did not determine specific procedure; (2) museums with the largest collections are not restricted to one geographic region; (3) funding was the primary determinant of equipment and storage method, which sometimes resulted in unsuitable conditions; (4) although some methods were similar (e.g., use of ethanol), factors such as materials and equipment among other issues varied widely; (5) several issues are universal, and further research and the development of standards are needed. The results will be used to inform the establishment of further standards at the NHMUK and may also be a useful source of information for other institutions with alcohol collections. Current and future work on collection standards at the NHMUK is discussed.

Key words.—alcohol, Arachnida, curation, survey

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Introduction

The Natural History Museum, London (NHMUK), has a large Arachnida and Myriapoda collection in alcohol (approximately 30,000 jars), which dates back to around 1840. The geographical coverage of these collections is wide, particularly in collection "hotspots," such as West Africa, and these collections maintain a large number of types, as well as historic material. During the last 170 years, different preservation methodologies have had varied success. The NHMUK has in the last few years established best-practice collections management standards for jar design, alcohol concentration, cabinet storage, and environmental conditions. However, other areas such as the optimum printer and ink for the production of critical collection labels remain unresolved. Certainly, across the discipline as a whole, there is a paucity of agreed standardized practices for computer printed labels (for example, see Daly and Jordan 1989, Sims 1990, Bentley 2004, Moore 2008). In 2012, I designed a survey to establish how Arachnida alcohol collections are curated in other institutions around the world. The results will be used to inform the establishment of further standards at the NHMUK and may also be a useful source of information for other institutions with alcohol collections.

The survey was designed to maximize information with limited questions and to ascertain collection size, collection materials used, curation methodology, and collections storage. Surveyed institutions were partly selected on the basis of holding Arachnida collections, with whom I had existing professional relationships. Other institutions were also included to ensure global representation and to represent collections of various sizes. I sent the survey to 49 institutions in 36 countries.

Forty-two institutions responded worldwide, which was an 85.7% success rate. Respondents and collection size are summarized in the appendix.

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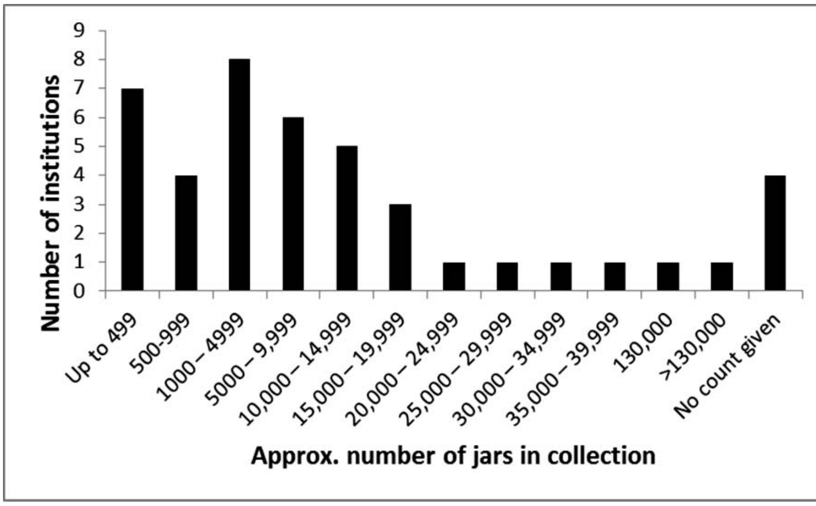

Figure 1. Summary of preservatives and concentration.

Survey Responses and Discussion

(1) Approximately How Many Jars Are in Your Collection?

Small arachnid specimens are routinely stored in vials or small tubes, which are then grouped into a larger jar or container filled with the same preserving fluid. The number of jars gives an approximation of the size of the collection. Most respondents estimated these numbers. While most responders provided the jar number, others provided another type of storage unit, such as the number of tubes. It was, therefore, necessary to roughly standardize different "units" to approximate jar numbers in order to enable a comparison of size among collections. The NHMUK uses a standard 75-ml Le Parfait jar. I estimated 32 tubes (75 × 19 mm) to equal a single jar. There are approximately 40 tubes in the Tupperware buckets used at the Museu Nacional, Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, Brazil.

At 30,000 jars, the NHMUK's collection is one of the largest, along with the KwaZulu-Natal Museum, South Africa (NMSA), Pietermaritzburg, South Africa. Collections ranged in size from fewer than 500 to over 130,000 jars.

One of the themes that emerged from this survey was that the size of the collection does not determine the procedures used, e.g., some large collections use handwritten labels or lack dedicated storage. In fact, nearly all of the procedures and materials used were not correlated to collection size. What was also clear was the largest collections (>25,000 jars) are not located in just one part of the world but are truly global.

(2) What Preservative Is Used in Your Wet Arachnida and Myriapoda Collections and at What Percentage?

The preservatives used and their concentration are summarized in Figure 1. Ninety-three percent of institutions surveyed use 70–80% ethanol, while the remainder use either 90% ethanol or 70% ethanol denatured with isopropyl alcohol. Three institutions (Liverpool, Manchester, Wales) use 70–80% industrial denatured alcohol (IDA), (previously named industrial methylated spirit [IMS]), which is ethanol denatured with methanol. This is also what the NHMUK uses.

These UK institutions use IDA to avoid the extremely strict measures that would be imposed by Customs and Excise over holding quantities of ethanol within museums, as well as economic constraints. For example, VWR International (chemicals and laboratory suppliers) sells the equivalent of 5 L of absolute ethanol at £368, compared with 5 L of 96% ethanol denatured with 5% methanol at £76.50. Unfortunately, DNA is badly degraded in methanol (Post et al. 1993, Simmons 1995, Carter 2003).

Dilution.—Absolute or 95% ethanol makes specimens very brittle and fragile, so it is often diluted with water to prepare a 70–80% aqueous mixture that is used by many institutions (McGaw 2014). The responses, however, did not state whether the water was distilled or from the tap. If it is not glass distilled, the development of various kinds of precipitate/sediment can occur that can seriously affect smaller specimens. The pH/salt content of the water/preservative mix may well have negative implications for labels, gaskets, and specimens. DNA quality is also greatly reduced when ethanol/IDA is diluted with water (Quicke et al. 1999). It is therefore necessary to have a better understanding of what occurs during the water addition/dilution process. Ethanol concentration is also a factor when considering specimen size. For example, depending upon the body mass of spiders, Wildlife Information Liaison Development Society (WILDS, India) uses 70–80% ethanol with small spiders, while big spiders like tarantulas with large abdomens are first kept in 70% and later changed to 90%.

Protectants.—National Museums Wales (UK) adds 2% propylene glycol to IDA, because it acts as a protectant in case the specimen dries out, and it keeps proteins more flexible. Propylene glycol is also used in long-term storage of marine invertebrates at the American Museum of Natural History (AMNH), USA, and is used for the sorting of specimens at the Smithsonian Museum of Natural History (Smithsonian Institution 2014). Some institutions (e.g., AMNH) use propylene glycol to mail specimens internationally. At WILDS, Tamil Nadu, India, a drop of glycerol is added in each vial of small spiders to prevent complete desiccation.

Preservatives suitable for DNA storage.—A few museums use alternative preservatives to prevent degradation of DNA. For example, the Swedish Museum of Natural History (Stockholm, Sweden) uses what they term "Koenikes lösning (fluid)," a mix of glycerol, acetic acid, and distilled water for preserving Acari. Historically, the Florida State Collection of Arthropods (FSCA), Florida, USA, has used 70% isopropanol or isopropyl alcohol. As well as using 70–80% ethanol for the main collection, several institutions state that they use absolute ethanol for DNA material. Propylene glycol has been used for molecular work studies in the AMNH (USA). At the Royal Museum for Central Africa (RMCA, Belgium), legs are kept in 96% ethanol at -24°C. The Sarawak Museum (Sarawak, Malaysia) uses 80% pure absolute alcohol or ethanol (diluted from 99.9%) so that the preserved materials can be used for DNA studies in the future (Simmons 1995, Carter 2003). RMCA, Tervuren, Belgium, used to use ether to denature their ethanol, but now uses 3% isopropyl alcohol because it is considered to be less harmful to DNA, since DNA is insoluble in isopropyl alcohol (Logsden and Loke 1999).

Solutions for dealing with evaporation of alcohol.—As with several institutions, the Museum of New Zealand has a regular monitoring program across their ethanol collections to detect problems with evaporation. At the Bishop Museum (USA), it was observed that evaporative loss of preservative fluid can be minimized by taping the jar lids with Bakelite®, which loosens with fluctuating environmental conditions (Simmons 1999). As a result, it has been observed that there is now no significant difference between

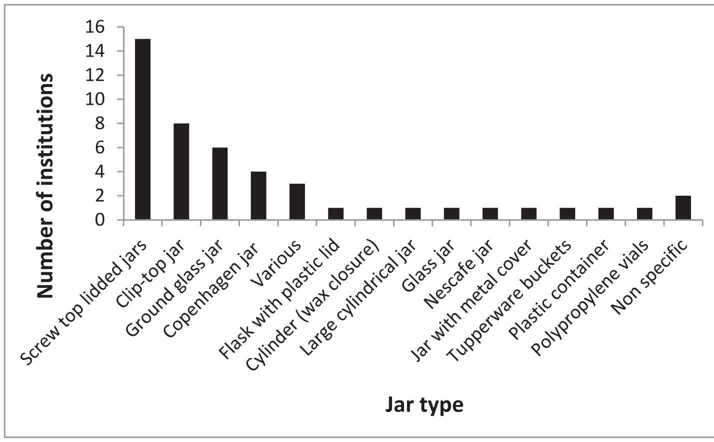

Figure 2. Summary of jar designs used.

the ethanol concentration of Bakelite and polyphenylene ether (PPE) lidded jars. Steigerwald and Laframboise (1996) also found that evaporative loss rate was reduced significantly with the application of polypropylene-acrylic adhesive tape over the jar–lid junction. Museum d'Histoire Naturelle (MHN, Switzerland) places Parafilm® over the opening of the jar before closing the lid to reduce evaporation and protect the metal lid from corrosion.

(3) What Design of Jar Is Most Common in Your Collection?

Jar types used are summarized in Figure 2. The most commonly used jar design by far is a glass body with a close-fitting top: screw-top lid (plastic, metal, or Bakelite); a "clip-top" lid (wire clamp seal, e.g., Le Parfait jar); a ground-glass lid; or a flexible plastic cap (e.g., Copenhagen jars). Silicone inserts such as those used at Southwest University (SWU), Chongqing, China, are used in conjunction with plastic caps since they are corrosion resistant, plus the caps can be easily opened, tightened, and renewed. Various other containers are used, which range from used coffee jars (Museo Nacional de Historia Natural del Paraguay [MNHN]), glass cylinders with wax closures (Naturalis, Leiden [Netherlands]), to Tupperware buckets in UFRJ (Brazil). Properties of the various jars are discussed below. The most common jar design in the NHMUK collections is ground glass, with a quite a few clip-top jars, some Copenhagen jars, and a few Bakelite screw-top jars. There is an on-going program for the replacement all of the Copenhagen jars and Bakelite jars, with clip-top jars.

(4) What Design and Size of Jar Is Preferred and Why?

Jar design.—Cylindrical shaped jars with a wide, flat base and a wide unrestricted neck were used the most. The two most popular jar designs were clip-top jars and a glass body with a plastic screw-top lid (nine institutions for each design). The Facultad de Ciencias, Universidad de la Republica (UdelaR), Montevideo (Uruguay), used plastic covers rather than metallic ones since they did not oxidize. Three institutions (7.1%) preferred plastic jars. For the purpose of this survey, plastic polyethylene terephthalate (PET) jars and plastic cylindrical containers with wide necks are grouped together under plastic jars. Some institutions are replacing their plastic-lidded jars with either ground-glass or clip-top jars, because they are considered to be more reliable (RMCA, Belgium). The Bishop Museum (USA) has found that 5% of their storage containers (which have Bakelite lids)

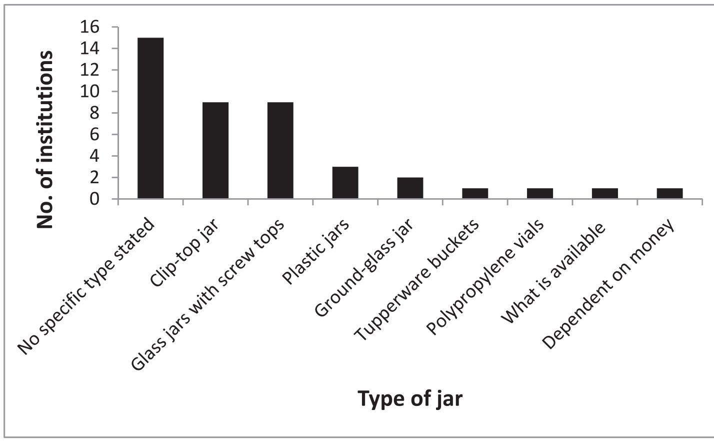

Figure 3. Summary of preferred jar type.

show complete evaporative loss of the fluid preservative and desiccation of specimens. Ground-glass jars are preferred by two institutions (4.8%) because they are considered to be safer for the specimens, and the condition of plastic screw caps long-term is questionable (NHM, Austria). One institution preferred Tupperware® buckets, one institution preferred poly vials since they were seen as easy to handle and monitor, one institution chose just on availability, and a further choice was based on the institution's economic situation. The designs of jar preferred at the NHMUK are clip-top jars (also known as Kilner or Le Parfait jars, depending on the name of the manufacturer) because they are affordable and have fairly straight sides with a very wide neck; and ground-glass jars greased with Vaseline®.

Size of jars.—Where stated, jar sizes used were 30 ml, 50 ml, 100 ml, 125 ml, 250 ml, 350 ml, 400 ml, 500 ml, 600 ml, 1 L, and 2 L. At the NHMUK, the most commonly used jar size is 750 ml, because it comfortably houses the most commonly used tube size (75 mm $\times$ 19 mm) with space above for preservative. Five hundred milliliter jars are most commonly used for single specimens of theraphosids (tarantulas) and to house only a few tubes. Larger jars are used for centipedes. Aspects that affect the choice and size of jars include commercial and local availability, cost, specimen size and morphology, size and number of vials the jar must accommodate, ease of extracting individual vials or tubes, collection space available (larger jars result in more efficient use of space), and stability of shape.

Design of jar most preferred.—Jar types preferred are summarized in Figure 3. Although only preferred by two institutions surveyed, various personal communications have indicated that ground-glass jars are considered to be best for collections because there are no rubber or plastic components that degrade over time, and they have a good seal if the lid is greased with petroleum jelly. They are therefore long-lasting (Muséum National d'Histoire Naturelle [MNHN], Paris). Bakelite is considered to be a poor material for jar lids because it is a phenol-formaldehyde polymer, which is prone to embrittlement (Simmons 1990).

(5) If Using a Clip-Top Jar, What Seal/Gasket Is Used?

Gaskets used.—Twenty-seven institutions (64.3%) do not use clip-top jars and so have no need for gaskets. Of those that do, the gasket supplied with the jar (usually red or orange rubber) is used most frequently (five institutions: 12%). Four institutions (AMNH, USA; Smithsonian Institution, National Museum of Natural History [NMNH] USA; the Natural History Museum of Denmark [NHMD], University of Copenhagen; and Tel Aviv University [TAU], Israel) and NHMUK use nitrile rubber. Other gaskets used are made from silicone, neoprene, and plastic.

Problems.—There appears to be a fairly widespread dislike of the rubber gaskets that are supplied with clip-top jars, as well as other gasket materials. Several institutions stated that gasket problems have resulted in them using jars that do not require gaskets, e.g., Raffles Museum of Biodiversity Research (RMBR), NMSA, and the Institute of Zoology, Wroclaw University (Poland). The gaskets supplied with the jars were observed to leach red dye into the specimens over a short space of time (RMCA, Belgium). Others stated that the gaskets became brittle and cracked (UFRJ, Brazil; Bishop Museum, USA), hardened (RMBR), and melted (NMSA). Silicone gaskets were observed to allow quick evaporative loss due to significant gas exchange (AMNH, USA).

Solutions.—Some institutions that use the supplied gaskets take steps to mitigate their negative effects; for example, Università degli Studi di Padova (UNIPD, Italy) cover the rubber gasket with a soft plastic to protect the gasket from hardening and cracking, and Instituto Nacional de Biodiversidad (INBio, Costa Rica) stores their specimens in plugged vials to prevent them from coming into contact with the alcohol in the jar, which reacts with the gasket. Replacement of the supplied gaskets with a better alternative has been a solution for some institutions. For example, the AMNH (USA) has previously experimented with rubber, neoprene, and various other varieties of seals that were supplied with the clip-top jars. Currently they use white archival nitrile rubber gaskets. I observed similar problems with supplied gaskets in the NHMUK collections. I was recommended nitrile rubber gaskets by NMNH (USA) approximately 12 years ago and found that they have lasted much longer than other rubber types. However, even these have started to show signs of cracking after 5 to 7 years. This is due to a reaction between the gasket and the methanol in the IDA used in the jars (polymer expert Mark Johnson, Metroseal UK and R.H. Nuttall UK, pers. comm., March 2010). The Rubber Chemical Resistance Chart of the Mykin, Inc. website (a global leader in rubber/seal engineering) supports this communication by reporting that the compatibility of methanol with nitrile is unsatisfactory. However, it also states that the compatibility of ethanol with nitrile is doubtful. Although this is not ideal, it still demonstrates that methanol has a greater negative effect on nitrile than ethanol (Mykin Inc. 2014). Conversely to the NHMUK, the NMNH have used nitrile gaskets for years and never found a problem (T. Coffer, pers. comm., 29 March 2010), but this may be because they use ethanol rather than IDA. Another alternative gasket material is natural rubber, which does not contain color and is found to be particularly good with stored ethanol; these are used by RMCA (Belgium). Other museums are in the process of change, and the area of gaskets is still up for discussion.

(6) How Is the Jar Labeled (e.g., Internal Label) and What Materials Are Used?

Label position.—Over half of the institutions (66.7%) only use internal labels, six use both internal and external (14.3%), four only external (9.5%), three were nonspecific (7.1%), and one did not respond. At the NHMUK all newly produced labels are internal, whereas most existing labels are external with some additional old internal labels.

Label materials.—Of the institutions that responded, 14 (33.4%) use specially manufactured archival papers internally. These are varied and include laundry tag manila, bond cloth paper, thesis 100% rag, goatskin parchment, Swedish archive, conqueror connoisseur ivory matte, Resistall, Byron Weston ledger, and Filipaper Filicoat. Resistall, as used by the NHMUK and NMNH (USA), has been found to be acidic (NMNH). Nonspecific archival papers used include ethanol paper and drawing paper. The RMCA (Belgium) uses Teslin®, which is a microporous, dimensionally stable, single-layer, polyolefin synthetic material. The porous, uncoated nature of Teslin substrate allows inks, adhesives, coatings, and laminating films to penetrate into its structure, forming strong interlocking bonds with the substrate, and can be used in different types of printers (PPG Industries 2014). Of the institutions that use nonarchival labeling, two use self-adhesive paper for external lid labels; the remaining use normal paper, tracing paper, rice paper, cardboard, external Dymo® tape, and index cards.

The most commonly used printer for labels is a laser jet (four institutions: 9.5%), followed by three institutions (7%) that use an HP inkjet, three that use a nonspecific printer, and one that uses a typewriter. Two institutions (4.7%) use a thermal printer, and two use a nonspecified laser printer. A couple of institutions use extra heat on their laser printed labels to ensure that the toner embeds into the paper. In addition, the NMSA (South Africa) bakes goat skin labels for longevity. The questionable quality of labels produced by laser printers is highlighted in a Natural History Collections Listserv (NHCOLL-L) discussion about specimen labels in ethanol. The State University of New York College of Environmental Science and Forestry (ESF), Syracuse, USA, has observed that laser-printed labels are of good quality (i.e., no loss of print after a 10-year period) if printed on 100% rag paper and then heated until the carbon melts into the fibers of the paper. If not heated, the ink flakes off (NHCOLL-L 2002). Zala et al. (2005) argue that heating labels in a microwave appears to be ineffective, but the application of heat to bind pigment to paper in a laser printer, thus producing labels of durability, cannot be disputed. Hillyard and Beccaloni (2002) argue, however, that the baking of labels is an undesirable complication.

At the NHMUK, an alcohol insoluble, waterproof pigmented ink in an HP Desk Jet 510 was used on Resistall® paper to label the Arachnida collection until 2009, when it was phased out, due to costs and the need for streamlining the number of printers used. Since then, labels have been handwritten in black Pigma Micron pen, while a suitable replacement printer and ink can be found, as the current printer available has water soluble ink, and so is unsuitable for wet collections. Several respondents stated that they use waterproof ink, e.g., Iziko South African Museum. The importance of using alcohol insoluble and waterproof ink is well documented (e.g., Simmons 1999).

Handwritten labels.—Twelve institutions (28.6%) handwrite their labels. This is broken down into nine institutions writing mainly in Indian-based ink and three mainly in pencil. Interestingly, handwritten labels are not related to a smaller size of collection; they are produced in collections across the entire size range.

(7) If Your Old Jar Has an External Label, What Do You Do with the Label When You Replace the Old Jar (e.g., Glue It onto the New Jar)?

Seventeen institutions do not have external labels on their jars (40.5%). Of the institutions that do replace old jars, most do not retain the old label (10–23.8%). There are a variety of processes for dealing with the old label:

- photographing the old label and keeping the image
- placing the old label into the new jar

- placing the old label in plastic and adhering it to the outside of the new jar
- storing the old label in a folder
- sticking the old label on the new jar
- heat sealing the old label and placing it into the new jar
- putting the old jar (complete with old label) into a new jar

MNHN (Paraguay) attaches its labels externally with plastic bands or similar to enable the jars to be reused. They further state that the labels are generally discarded unless there is extensive or valuable information. All historic jars in the NHMUK collection have external labels written in Indian ink. Once the data were copied from the old labels to create new internal labels, they were removed by soaking in water, which also removed the adhesive. They were then cleaned in IDA and added to the inside of the new jar. Although this prevented the problem of label disassociation, because the paper was of low wet strength, these labels were often badly damaged through subsequent handling. Upon investigation and consultation with NHMUK curators, as well as international colleagues, it was decided to house the old removed labels in conservation-grade plastic (polyester) pockets in a ring-binder and to keep the binder at the start of each appropriate collection. Where there is a change in nomenclature, new labels are written and placed with the old labels, in order to enable cross-referencing. These labels are now being scanned and the images uploaded on the NHMUK database as part of the recuration process. As well as being an easy reference for collections users, this process will further prevent disassociation from the original jars.

(8) If Using a Computer-Printed Label, What Computer and Ink Are Used?

Eleven institutions (26.2%) do not use computers to produce tube or jar labels. Wroclaw University (Poland), MNHN (Paraguay), Sarawak Museum, WILDS (India), and Oxford Museum (UK) all handwrite labels due to the problem of unknown reliability of computer printed labels long-term. Laser jets and inkjets are used by nine institutions each (21.4%). Four institutions (9.5%) are nonspecific about the printer they use; four use a laser printer; two (4.7%) use a thermal printer; and two use a dot matrix printer. The AMNH responded that they have been using PCs and Epson 24 pin dot matrix printer model LQ 590 but replaced the ribbon cartridges with archival ink. Two institutions print their labels and then photocopy them, one uses a sputter laser, and one gave no response.

Few institutions stated the ink used, but those that did specified the following inks: Ultra Chrome K3 in an Epson Stylus; HP56 cartridge in an HP 5550 laser jet; and HP 364 in an HP Photosmart ink jet.

(9) If Tubes Are Used within a Jar, What Are They Made from, and What Is the Stopper Type?

All institutions surveyed use glass tubes. The Iziko South African Museum also uses plastic tubes with screw-tops lids, and the Swedish Museum of Natural History, Stockholm, Sweden, also uses plastic PET tubes. The majority of institutions use cotton wool as a stopper (23–54.7%), with 17 using polythene stoppers (40.5%) and one using rubber stoppers.

When using cotton wool as tube stoppers, it is essential to make sure it is properly inserted. If it is too loose it will drop out, and the specimens will follow suit (J.B. pers.

obs.). MNHN (France) notes that the cotton wool should not be inserted too tightly either because that would create a lack of diffusion of alcohol between the tube and jar contents. The NHMUK uses Samco brand glass tubes with polythene stoppers. If the diameter of the tube is greater than 19 mm, then cotton wool is also used because plastic stoppers of a larger size have a tendency to pop out. However, the Museum of New Zealand has changed from Samco to dram sized vials made by Research Products International stating that they find them good value for money and of better quality, and the stoppers fit better. They still use Samco vials for larger specimens, although the smaller sized vials are still abundant in the collection housing the older specimens. The Bishop Museum (USA) finds problems with rubber stoppers due to the stoppers dissolving or swelling in ethanol, and the majority of their collection is stoppered with cotton. Similar problems were encountered at the NHMUK, and all rubber-stoppered tubes have now been replaced.

(10) Are the Tubes Inverted in the Jar?

Most institutions (22) invert their tubes within the jars, with most using cotton wool stoppers.

There appears to be a relationship between the type of stopper and tube inversion, with tubes with cotton wool stoppers generally being inverted, while those with rubber stoppers are not. When specimens come in contact with cotton wool, damage may occur, and specimens have lost limbs or become embedded in the wool. The NHM (Austria) and MNHN (Paraguay) both commented that this happens. RMBR (Singapore) also comments that specimens drop out of tubes when the stoppers have degraded and become confused with other specimens within a jar, so they do not invert tubes. The Museum of New Zealand argues that inverting tubes is not necessary since their ethanol concentration monitoring program has determined that leaving tubes right-side up with the stoppers is effective. However, a regular monitoring program, although ideal, is often not feasible, and, thus, a different approach, such as inverting tubes, is necessary. Both the NHMUK and NMSA (South Africa) have large collections with approximately 30,000 jars, so a regular monitoring program would be very difficult to implement, and it is impossible to guarantee that the jars will be topped up on a regular basis. They therefore invert tubes, so that they do not immediately dry out should the alcohol leak or evaporate from the jar unnoticed. Whether an institute inverts its tubes may depend upon the size of jar. For example, MNHN (Paraguay) inverts except when there are several layers of tubes, and if this is the case they only invert the top layer.

(11) How Are the Tubes Labeled, and What Materials Are Used?

Label materials.—A range of products are used for tube labels including archival paper (used by 18 [43%)] institutions), heavy weight paper, tracing paper, Teslin, copier paper, and cardboard (used by one institution). MHN (Switzerland) cited economic constraints as the determiner for which paper was used, due to the large volume of labels needed. Furthermore, they cite problems that occur due to products no longer being supplied. For example, "Japanpost," 80–90 g/qm (produced by the Austrian company Neusiedler) was of better quality than the current material but is no longer produced.

Printers.—Four institutions (9.5%) use an unknown laser printer, an ink jet, and an unspecified printer. The remaining institutions use a variety of alternatives: photocopier, thermal printer, typewriter, laser jet, sputter laser printer, and a dot matrix printer. Some institutions "bake" their labels to create a greater permanence.

Handwritten.—Fifteen institutions (35.7%) handwrite their tube labels. Ten (23.8%) use an archival ink (Indian ink, Staedtler, Rotring, and Pigma Micron pens are all grouped together), and five (11.9%) use pencil. The RMBR (Singapore) has found that even old labels are legible when written in pencil. Handwritten labels are found across all sizes of collections. As with many institutions, the NHMUK handwrites primary data labels with Pigma Micron pen on Resistall paper for all Arachnida and Myriapoda recuration projects due to the unknown longevity of printer inks currently used in Entomology collections.

Photocopying.—Two institutions use a photocopier to produce labels: MHN (Switzerland) and the Russian Academy of Sciences (RAS, Russia), because they believe that the photocopier uses more heat than a printer, so the pigment penetrates deeper into the paper and does not come off as easily. However, there is little in the literature about this method of label production.

Information.—Only one institution, NHMD (Denmark), stated that barcodes were used on the tube labels alongside a human readable code. Two institutions also include their museum's acronym: NHMD (Denmark) and the Museum of Comparative Zoology (MCZ), Harvard University, USA. Museum acronyms are also included on new labels at the NHMUK. The Western Australian Museum also adds registration numbers in Indian ink to printed data labels in case the printed labels deteriorate in the future.

(12) What Storage Do You Use for Your Collection?

Just over a third of the responding institutes have a dedicated store room(s) for their arachnid collections; the Swedish Museum of Natural History has an underground storeroom. There is no correlation between size of collection and use of dedicated storage. All of the NHMUK alcohol collections are kept in purpose-built storerooms, which are temperature controlled. Two institutions use dehumidifiers in their storerooms: SWU (China) and Museo de Invertebrados de la Universidad de Panamá (Panama).

Ten institutions (23.8%) use steel cabinets; eight (19%) use open metal shelving; and seven of these (16.6%) use compactors/moveable shelving on runners (both open shelving and closed cabinets, which are either metal or wood). Caution is raised by the Sarawak Museum that movable shelving should not be an automated system in case the collection needs to be accessed during a power outage. The MHN (Switzerland) expresses concern over the risk of fire due to a spark from an electric compactor motor. Two institutions (4.7%) use open wooden shelving; two have wooden cupboards; one (2.4%) has their types in a separate cabinet. The Arachnida and Myriapoda collections at the NHMUK are housed in plastic trays, on wooden shelves in closed metal cabinets. Four institutions report that the storage of their collections protects specimens from earthquake damage by using a raised lip on the edge of shelves (e.g., Museum of New Zealand; FDACS (Florida, USA); Universidad Nacional Autónoma de México (UNAM, Mexico), and Lincoln University (Lincoln, NZ). Indeed, the 2-cm lip on the Lincoln University shelves prevented jars from falling off during the earthquake in September 2010, which measured 7.1 on the Richter scale. The Museum of New Zealand and the FDACS (Florida, USA) also have earthquake bars. Earthquake damage mitigation within museum collections is well documented, particularly with cabinets and placement of objects (see for example Ertürk 2012, Podany 2008).

Funding

Not surprisingly, funding was found to be the major determiner for what equipment and storage method was used, which often resulted in less than suitable collection storage, such as recycled coffee jars used by MNHN (Paraguay), the second largest Arachnida collection in the survey.

Similarities and Differences

The greatest concurrence within materials and methodology was in the use of ethanol (92.8%) (Question 2). Other similarities include: internal label use (66.7%), lack of use of clip-top jars (64.3%), use of cotton wool as tube stoppers (54.7%), and inversion of vials in jars (see questions 3, 4, 6, and 9). There were more dissimilarities than similarities. Institutions varied often in the type of materials and equipment used: jar design, size of jars, label paper, printers and inks, cabinets, and shelf designs (see questions 3, 4, 6, 8, and 12). Other dissimilarities were found in methodology, for example, the curation of detached external jar labels (see question 7).

Common Concerns

It was clear from the survey results that there are some universal problem areas that require further research and for which standards should be established. The problem of agreed standards regarding optimum printers and inks is evident from the findings of the questionnaire. Various problems with rubber gaskets were highlighted, i.e., brittleness, cracking, hardening, melting, and seepage of dye into the alcohol. In addition, a large selection of papers are being used, and not all of them are archival.

Current and Future Work at the NHMUK

The results and conclusions reached in this report have been used to inform several of the various research projects currently being undertaken and planned.

- Research is currently being undertaken to establish the optimum printer, printer ink, and paper combinations to produce conservation-grade labels for future use in the collections across the museum. In 2014 I undertook a survey of printers and inks used in the Life Sciences to establish which printers and inks should form a baseline for testing. It identified printers that people found to perform well (e.g., Epson models WF3010, B-500DN, BX305F, and BX3051 all using DURABrite ink) and those that did not (e.g., Deskjet D5560).
- Staff from the NHMUK have worked together with over 100 individuals from the UK, Europe, and further abroad on a project to establish standards in the care of Natural History Collections and to develop training for staff who are responsible for these collections across the UK. The project has currently established three “living” documents on standards in the care of wet, botanical, skins, and taxidermy collections. These documents are now online and open to development by those engaged in the project (Collins 2014).
- Within the NHMUK, a museum-wide Wet Collections Group (WCG) has recently been established (July 2014) to enable staff working with alcohol collections to discuss issues that can then be taken forward by management. As a result, several areas were highlighted. These include: (1) Research on chemical effects on DNA to enable a decision to be made about the possible use of ethanol to replace IDA; reassessment

of collection management policies and development of standards for the digitization of wet collections, including the research into barcodes for tube labels (as used by NHMD, Denmark) with an additional human readable number; plus health and safety protocols for the storage of collections outside of storerooms. (2) Investigation into the composition and pH of all label papers commercially available in the UK, including Resistall, which is widely used within the Life Science collections. (3) Research rubber and IDA compatibility in more detail; undertake more detailed Fourier transform infrared (FTIR) spectroscopy analysis, which analyzes and identifies materials and/or contaminants (Thermo Nicolet Corporation 2001) on new and used gaskets of different types currently being used within the Life Sciences collections, as well as other commercially available analyses, to establish the optimum gasket.

- In the responses, it was noted that Research Products International tubes (as used by the Museum of New Zealand) perform better than Samco tubes. Indeed, recent personal communications received from NHMUK staff state that the lids are looser fitting in recent batches of Samco tubes, resulting in very fast evaporation rates. Establish whether Research Products International tubes are available for sale in the UK, and, if so, test them for quality against Samco tubes.

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Literature Cited

Bentley, A.C. 2004. Thermal transfer printers—Applications in wet collections. *SPNCH Newsletter* 18:1–2, 17–18.

Carter, J. 2003. *The Effects of Preservation and Conservation Treatments on the DNA of Museum Invertebrate Fluid Preserved Collections.* M.Phil. thesis, National Museum of Wales. www.museumwales.ac.uk/media/16607/MPhil-DNA-preservation.pdf (26 May 2016).

Collins, C. 2014. Notes from the Cloth Makers Foundation Workshop on Benchmark Standards for the Preservation on Wet Collections. *Conservation and Collections Care*, The Natural History Museum, London. http://conservation.myspecies.info/node/36 (26 May 2016).

Daly, H.V. and C.L. Jordan. 1989. Computer generated collections labels: They are fast but will they last? *Insect Collection News* 2(2):27.

Ertürk, N. 2012. Seismic protection of museum collections: Lessons learned after the 1999 earthquakes in Turkey. *Journal of the Faculty of Architecture* 29(1):289–300. http://jfa.arch.metu.edu.tr/archive/0258-5316/2012/cilt29/sayi_1/289-300.pdf (26 May 2016).

Hillyard, P.D. and J. Beccaloni. 2002. Computer generated labels for wet collections. The Biology Curator 23:11–13.

Logsden, J.E. and R.A. Loke. 1999. Propyl alcohols. Pp. 1654–1656 in *Kirk Othmer Concise Encyclopedia of Chemical Technology*, 4th ed. (J.I. Kroschwitz, ed.). John Wiley & Sons, Inc., New York. 2196 pp.

McGaw, S. 2014. *Preserving Macroinvertebrate Samples*. EcoAnalysts Inc. http://www.ecoanalysts.com/sample.php (26 May 2016).

Moore, S.J. 2008. Another update on computer printed inks and papers for internal labelling fluid preserved specimens. *NatSCA News* 15:36–40.

Mykin Inc. 2014. *Rubber Chemical Resistance Chart*. Mykin Inc. http://mykin.com/rubber-chemical-resistance-chart (26 May 2016).

NHCOLL-L. 2002. *Number 1580 RE: Specimen Labels in Ethanol.* http://mailman.yale.edu/pipermail/nhcoll-l/2002-April/000921.html (26 May 2016).

Podany, J. (ed.). 2008. Advances in the Protection of Museum Collections from Earthquake Damage: Papers from a Symposium Held at the J. Paul Getty Museum at the Villa on May 3–4, 2006. Getty Publications, Los Angeles. 240 pp.

Post, R.J., P.K. Flook, and A.L. Millest. 1993. Methods for the preservation of insects for DNA studies. *Biochemical Systematics and Ecology* 21(1):85–92.

PPG Industries. 2014. *Teslin Substrate Technical Data.* http://www.teslin.com/pdfs/2874_Teslin_TDS_600-1800_03-14.aspx (26 May 2016).

Quicke, D.L.J., R. Belshaw, and C. Lopez-Vaamonde. 1999. Preservation of hymenopteran specimens for subsequent molecular and morphological study. *Zoologica Scripta* 28(1–2):261–267.

Simmons, J.E. 1990. Speaking of lids... more on bakelite. ASIH Curation Newsletter 10:5.

Simmons, J.E. 1995. Storage in fluid preservatives. Pp. 161–186 in *Storage of Natural History Collections: A Preventative Conservation Approach* (C.L. Rose, C.A. Hawks, and H.H. Genoways, eds.) Society for the Preservation of Natural History Collections, Pittsburgh. 458 pp.

Simmons, J.E. 1999. Storage containers and labels for fluid-preserved collections. *Conserve O Gram* 11/4. http://www.nps.gov/museum/publications/conserveogram/11-04.pdf (26 May 2016).

Sims, L. 1990. An analysis of the suitability of various laser and impact printer generated labels for wet label storage. *American Society of Ichthyologists and Herpetologists Curation Newsletter* 10:2–3.

Smithsonian Institution. 2014. *Museum Collection Management Terms and Invertebrate Specimen Processing Procedures: Methods of Fixation and Preservation. Smithsonian National Museum of Natural History.* http://invertebrates.si.edu/USAP2/usapspec.html (26 May 2016).

Steigerwald, M. and S. Laframboise. 1996. Tape application: A jar sealing method for reducing ethanol evaporation in fluid-preserved collections. *Collection Forum* 12(2):45–54.

Thermo Nicolet Corporation. 2001. *Introduction to FTIR Analysis.* Thermo Nicolet Corporation. http://mmrc.caltech.edu/FTIR/FTIRintro.pdf (26 May 2016).

Zala, K., N. Pentcheff, and R. Wetzer. 2005. Laser-printed labels in wet collections: Will they hold up? *Collection Forum* 19(1–2):49–56.

Appendix

Responding institutions by country (approximate collection size and contacts in parentheses).

Australia

- Commonwealth Scientific and Industrial Research Organisation (CSIRO), Canberra (660 jars; Bruce Halliday).
- Western Australian Museum (WAM), Perth (15,000–19,999 jars; Mark Harvey).
- Queensland Museum, Brisbane (5,000–9,999 jars; Robert J. Raven).

Austria

- Naturhistorisches Museum (NHM), Wien (20,000–24,999 jars; Verena Stagl).

Belgium

- The Royal Museum for Central Africa (RMCA), Tervuren (5,000–9,999 jars; Rudy Joque).

Brazil

- Museu Nacional, Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro (500–999 jars; Adriano B. Kury).
- Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre (1,000–4,999 jars; Luiz A. Campos).

China (P.R.)

- Southwest University (SWU), Chongqing (>499 jars; Zhi-Sheng Zhang).

Costa Rica

- Instituto Nacional de Biodiversidad (INBio), Heredia (1,000–4,999 jars; Carlos Viquez).

Denmark

- Natural History Museum of Denmark (NHMD), University of Copenhagen, Copenhagen (10,000–14,999 jars; Nikolaj Scharff).

France

- Muséum National d'Histoire Naturelle (MNHN), Paris (10,000–14,999 jars; Wilson R. Lourenço).

Germany

- Museum für Naturkunde (MfN), Berlin (25,000–29,999 jars; Jason A. Dunlop).

India

- Wildlife Information Liaison Development Society (WILDS), Coimbatore, Tamil Nadu (>499 jars; Manju Siliwal).

Israel

- Tel Aviv University (TAU), Tel Aviv (>499 jars; Sergei Zonstein).

Italy

- Università degli Studi di Padova (UNIPD), Padova (>499 jars; Lucio Bonato).
- Museo Civico di Storia Naturale "Giacomo Doria," Genova (1,000–4,999 jars; Maria Tavano).

Japan

- Ibaraki University, Ibaraki (>499 jars; Cahyo Rahmadi).

Malaysia (Sarawak)

- Sarawak Museum, Kuching (jar numbers not provided; Charles Leh Moi Ung).

Mexico

- Universidad Nacional Autónoma de México (UNAM), Mexico City (5,000–9,999 jars; Oscar F. Francke).

Netherlands

- Naturalis, Leiden (10,000–14,999 jars; Karen van Dorp).

New Zealand

- Entomology Research Museum, Lincoln University, Lincoln (>499 jars; Cor Vink).
- Museum of New Zealand Te Papa Tongarewa, Wellington (500–999 jars; Phil Sirvid).

Panama

- Museo de Invertebrados de la Universidad de Panamá (MIUP), Panamá, (jar numbers not provided; Diomedes Quintero).

Paraguay

- Museo Nacional de Historia Natural del Paraguay (MNHN), San Lorenzo (>130,000 jars; John Kochalka).

Poland

- Institute of Zoology, Wrocław University, Wrocław (jar numbers not provided; Wanda Wesołowska).

Portugal

- Museu Nacional de História Natural e da Ciência, Lisbon (MUHNAC) (>499 jars; Sergio Henriques).

Russia

- Russian Academy of Sciences (RAS), Moscow (5,000–9,999 jars; Sergei Golovatch).

Singapore

- Raffles Museum of Biodiversity Research (RMBR)—as of April 2014 changed to the Lee Kong Chian Natural History Museum (1,000–4,999 jars; David Court).

South Africa

- KwaZulu-Natal Museum, South Africa (NMSA), Pietermaritzburg (30,000–34,999 jars; Audrey Ndaba).
- Iziko South African Museum, Cape Town (jar numbers not provided; Dawn Larsen).

Sweden

- Swedish Museum of Natural History, Stockholm (1,000–4,999 jars; Gunvi Lindberg).

Switzerland

- Museum d'Histoire Naturelle (MHN), Geneva (35,000–39,999 jars; Peter Schwendinger).

Thailand

- Department of Biology, Chiang Mai University (CMU) and entomology collection of Queen Sirikit Botanic Garden, Chiang Mai (500–999 jars; Pakawin Dankittipakul).

UK

- National Museums Liverpool, Liverpool (1,000–4,999 jars; Tony Hunter).
- Manchester Museum, University of Manchester, Manchester (15,000–19,999 jars; Dmitri Logunov).
- Oxford University Museum of Natural History (OUMNH), Oxford (5,000–9,999 jars; Amoret Spooner).
- National Museum Wales, Cardiff (10,000–14,999 jars; Julian Carter).

Uruguay

- Facultad de Ciencias, Universidad de la República (UdelaR), Montevideo (1,000–4,999; Fernando Pérez-Miles).

USA

- American Museum of Natural History (AMNH), New York, New York (>130,000 jars; Lou Sorkin).
- Florida State Collection of Arthropods (FSCA), Gainesville, Florida (1,000–4,999 jars; GB Edwards).
- Museum of Comparative Zoology (MCZ), Harvard University, Massachusetts (15,000–19,999 jars; Laura Leibensperger).
- Bernice Pauahi Bishop Museum, Honolulu, Hawaii (15,000–19,999 jars; Shepherd Myers).
- Smithsonian Institution National Museum of Natural History (NMNH), Washington, DC (10,000–14,999 jars; Dana M. De Roche).