Re-curation of the seed plants fluid collection at the Natural History Museum

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Abstract

Over three thousand seed plants fluid collections stored at the Natural History Museum have recently been re-curated. We have addressed the condition and conservation needs of the specimens by replacing broken jars/lids, rewriting labels and topping up the specimens with 70% IMS. The collections are from countries around the world representing 189 families and 1359 taxa (genus and species). There are 41 type specimens as well as some important orchids from the 1930s. An index to the collections has been compiled in an Excel spreadsheet and by making these collections accessible on the Museum's public data portal at (https://data.nhm.ac.uk/dataset/the-seed-plants-fluid-collection-at-the-natural-history-museum), we would like to draw attention to experts in various family groups such as Orchidaceae and families unknown where further taxonomic identifications would help us to determine the collections and enhance our floristic knowledge around the world.

Keywords: Biodiversity, Fruits, Formalin, Fluid preservation, Herbarium specimens, 70% IMS, Re-curation

Introduction

Preserving specimens in fluids is one of the methods of plant preservation (Davies *et al*. 2023). In wet forests, it is extremely useful to preserve specimens in fluids which could be dried later to prepare herbarium sheets. Specimens preserved in fluids help in studying 3D structure of a flower or fruit as compared to dried herbarium sheets. It is also useful for anatomical studies or botanical illustration. Our seed plants fluid collection consists of ca. 3,000 fruits, flowers and seedlings stored in glass jars and plastic bottles of diverse sizes. The collections are stored in an environmentally controlled room at 17 degrees with a relative humidity between 40-50% (cool storage environment maximises the life of fluid preserved specimens. Greater humidity than 65% raises risk of mould and change in preservation concentration. Other factors such as H & S seal to the door are in place to protect from risk of fire. Fire and smoke detectors as well as vapour detector systems are also in place (Collins, 2014)). The collection ranges from late 17th century to the current era and it continues to grow with material incorporated with recent acquisitions.

These collections were previously stored in various fluid mediums such as Formalin, 70% IMS (industrial methylated spirit), and some had unknown liquids. Many bottles have tiny labels of the old family/genus numbers as per Bentham and Hooker system of arrangement. These labels are in distinct colours based on the geographically coloured regions followed in the General Herbarium. (Fig. 1).

Fig. 1. Twenty-six geographical regions used for filing specimens in the folders in storage cabinets in the General Herbarium at NHM. The labels on the folders follow the colours for the countries respectively. These labels are also found on the jars in the fluid collections with family/genus numbers (as per Bentham and Hooker system of arrangement).

Although small, this is an important collection representing different families with some important type specimens. We also have the lectotype of the world's largest flower- *Rafflesia arnoldii* R.Br. (BM001122243) collected by Arnold and Raffles (Fig. 2).

There are some important type specimens of orchids collected by C. E (Cedric Errol) Carr (1892 – 1936), a New Zealand botanist, specialising in orchids. In 1933 and 1934 he worked at the Kew Herbarium before travelling to Papua New Guinea, spending several years collecting there before his death in 1936 due to black water fever. After his death over 4,000 of his orchid collections and detailed descriptions of the specimens were given to the Singapore Herbarium (SING). We house some of Carr's specimens, and some of the duplicate sets of specimens are at ZE Botanischer Garten und Botanisches Museum, Freie Universität Berlin (B),

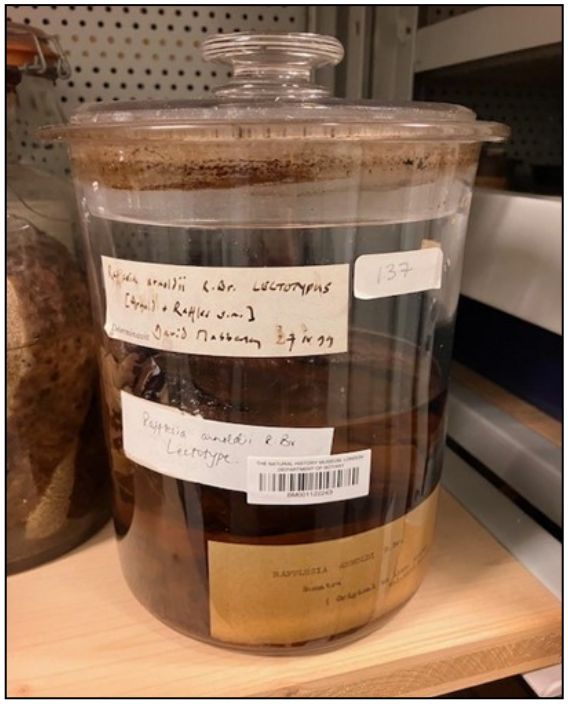

Fig. 2. Lectotype of Rafflesia arnoldii R.Br., (BM001122243) collected by Arnold & Raffles in Indonesia and determined by David Mabberley in 1999.

Naturalis Biodiversity

Center (L), The New York Botanical Garden (NY), and Australian National Herbarium (CANB). These collections are important and provide us knowledge of the flora from Southeast Asia.

There are some specimens which have corresponding herbarium specimens, however there are also some specimens for example *Utricularia gibba* L. (BM013786221) where although there is cross reference to herbarium specimen, there is no herbarium specimen in the General Herbarium, but a label is present with a note "see specimen in spirit". There are some interesting specimens with common names such as Bullock's heart (referring to *Annona squamosa* L., BM000086201) Fig 3., and there's a label of *Solanum mammosum* (BM000642022) used as cockroach poison Fig. 4. The lids of the bottles of type specimens are painted in red (Fig.5) for quick visual inspection and retrieval.

The collections needed Re-curation as pointed out earlier by (Prakash, 2019). Although not enough procedures for re-curating botanical spirit material exist compared to zoological material, we followed Simon Moore (1999), and we have now standardised and re-curated the collections in 70% IMS and use the term "fluid material".

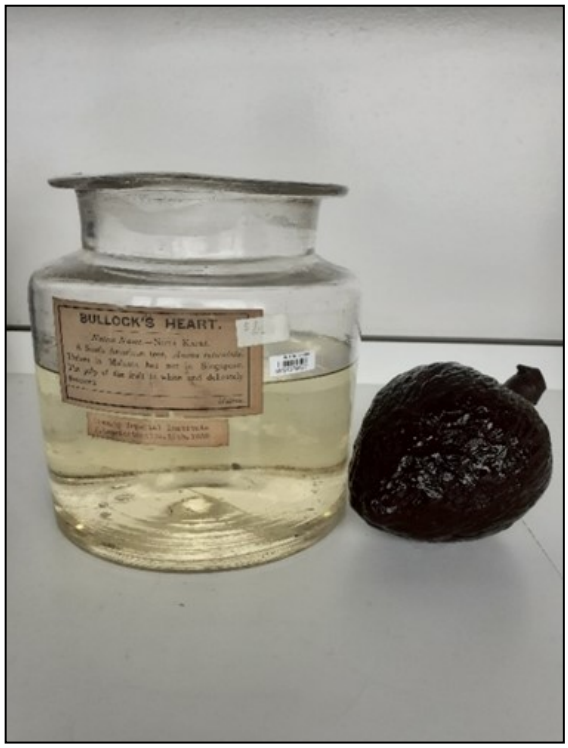

Fig. 3. Bullock's heart (refers to the shape of the fruit of Annona squamosa L., BM00086201)

Fig. 4. Label information showing Solanum jamaicense Mill. determined as S.mammosum L., with the fruit next to it, which is used as cockroach poison (BM000642022).

We provide an update on these collections, how these have been curated and the collections are available on our website (https://data.nhm.ac.uk/dataset/the-seed-plants-fluid-collection-at-the-natural-history-museum). We hope that more people interested in these collections will be able to make use of these collections for their research and help us to update the collections by adding their determinations; for example, some families are well represented such as Orchidaceae, yet many specimens are yet to be determined. We encourage experts from around the world to examine these collections and advance our biodiversity knowledge.

Fig. 5. Lids of bottles containing type specimens painted in red for ease of visualisation and retrieval for physical examination.

Materials and methods

At the outset, a Gantt chart was prepared listing all the tasks/objectives to be achieved in a time bound manner. This project was executed in three stages: first the re-arrangement of specimens as per jar size; then databasing and labelling; and lastly, topping up the bottles and jars with 70% IMS.

Re-arrangement of specimens

The first step was to re-arrange specimens in the storage cabinets. Specimens were organised by jar/bottle size to maximise space and efficiency rather than choosing taxonomic arrangement. The cabinets were labelled 1-5 with arrangement from left to right and the shelves from top to bottom. Numbered trays were used to organise specimens within wooden shelves. The weight of specimens was also considered, placing lighter specimens on top shelves and bigger and heavier jars lower

down for ease and safety. We used blue trays for the easy handling and retrieval of medium sized specimens. Smaller bottles were stored in plastic boxes which were stacked up on shelves. Bottles that did not fit in trays/boxes or which were very heavy were directly placed on the shelves. (Fig.6 & 7).

Fig. 6. Combination of bottles stored in blue trays and without trays directly on shelves.

Fig. 7. smaller bottles stored in plastic boxes.

Databasing

The collection was initially taken through a process of visual examination and recording. This involved inspecting each specimen container, recording the label details present outside and any other information on the inside of the container in an excel spreadsheet. This information often consisted of the collector number and Geographical Region identifiers (Fig. 1). The genus and species names, and any details about the provenance of the specimen were recorded if shown.

In some cases, the collector's number could be used to look up the collection record in the archives at NHM. This was notably found with C. E. Carr's collection from Papua, where NHM holds the collector's records and notes concerning most of the items collected. This additional information was added to the database and included key details about location and environment where the specimen was found, which was often not included on the specimen container label.

A currency detecting microscope x60 and light was used for labels that were difficult to read. Websites such as IPNI (2024), POWO (2024) and Tropicos (2024) were used to ensure currently accepted species names and spellings were correct. POWO (2024) was used most as it lists synonyms too. Tropicos (2024) was consulted when we did not find names in IPNI (2024) or POWO (2024).

The data input method was first to clean the jars/ bottles using a dry tissue removing any dirt or dust collected. Then in some cases where required, wet/damp tissue was used but care was taken to avoid the labels as the water might ruin them. The tissues were disposed safely in relevant bins as hazardous waste in the lab. The jars and bottles were inspected and yellow sticky notes were attached to them if maintenance was needed during the topping up stage, e.g. cracked/broken glass or damaged lids. Barcodes were then placed either vertically or horizontally on jars to ensure ease of scanning. In addition, barcodes were placed close to any other labels to maximise view of the specimen inside the jar. We often washed the lids of the bottles with plain water to get rid of dirt, a special sink was used to avoid water contamination.

Table 1. Key title headings used to capture specimen data in the spreadsheet, their examples and descriptions.

Title Heading	Example	Description
Cabinet Number	1	Explaining which of the five cabinets the specimen can be located. Labelled 1-5 left to right.
Shelf Number	1.1	Explaining which shelf the specimen can be located on. The first number corresponds to the cabinet and the second to the shelf. Labelled top to bottom in ascending order.
Tray/box Number	1	Explaining which tray the specimen can be located in. Labelled from left to right in ascending order per shelf.
Barcode Specimens	BM…..	Giving each specimen an individual barcode number. Barcodes were scanned rather than typed to avoid any human error.
Family/Genus Number	57/1	Some of the jars had old family/genus numbers as per Bentham & Hooker system of arrangement. Often when no label was found, this helped us to identify the specimen. Coloured labels based on geographical regions (1-26) are used in the General Herbarium, e.g. white for Asia, yellow for Central America and green for Australia.
Family Name	Araceae	This is to help identify and categorise the specimen. If someone wanted a plant from a specific family/genus they could search it and find all the species we have of that family.
Taxa Name	Genus and species name	The name to help to identify the taxa. If someone wanted a specific species, they would be able to see if we had it in our data base and any information.
Country	Panama	The place the specimen was collected from. If it was not on the label 'Unknown' would be used.
Locality details	Box Island off Tamian Lake, Titicaca. Alt: 12,500 ft. Island of Taman.	More specific details about where the specimen was collected from. This could help us understand the physical geography of the collection location. If there was no data 'sin.loc.' was used.
Habitat notes	Dry rocky ground	Any notes left on the label to help us understand more about the environment the specimen was collected from.
Plant description	Perennial to 3m; leaves triangular in cross section, c 1/2 m long; fruit long (c 5cm), cylindrical; flowers with 3 brown recurved bracta, 2 green petals upright, 1 large spurred labellum +/- white with pink markings.	We recorded detailed information on the plant describing the habit, leaves, fruit and any other decipherable information from the label.
Name of the Collector	Nancy C. Garwood	Who collected the specimen. 'Anon' for Anonymous would be used if there was no collector name.
Collector Number	1242	The number the collector gave to the specimen. If this information was not on the label we would write 's.n.' (means 'no number').
Collection date	20/10/1988	This is the date the specimen was collected (DD/MM/YYYY). If this information was not on the label we would put 'sin.dat.'
Notes	Corresponding material in general herbarium.	Any other information on the jar or label.
Identification notes	Looks like a pine tree	This recorded information for any specimens that had no identifying details. We recorded any additional notes/labels on the jars which might help curators/researchers identify the specimens.

We captured the data under 16 columns headings in our spreadsheet as shown in Table 1.

Topping up

Decision Making Model for the conservation and restoration of fluid preserved specimens by van Dam (2004) was used to help us decide which specimens and jars needed to be conserved and restored.

Based on the survey by Prakash (2019), we decided to use 70% IMS to preserve the specimens. Practical skills learnt on Fluid preservation course taught by Simon Moore in 2015, literature by Moore (1999), decision-making model by van Dam (2004) and personal visit by Prakash to BR (National Botanic Garden, Belgium) and K (Royal Botanic Garden, Kew) a few years ago helped to decide the best protocols in topping up. A 70% IMS (70 parts IMS and 30 parts deionised water) solution was made from 80% IMS.

We wore protective clothing (lab coats) and used safety glasses while topping up.

Any original alcohol liquid in the jars was poured into a waste bucket, using a small sieve to ensure none of the specimen was lost. The waste alcohol was eventually safely disposed following the protocols of disposing hazardous material (safety data sheets needs to be filled in which provides information on the type of fluids whether it is IMS, Formalin or mixed).

Some jars contained Formalin and were dealt with appropriately and the topping up was checked for a cloudiness which can occur when IMS is added to previous Formalin preserved items/mixed fluids with various densities.

Jars and their lids were inspected to see if new containers were necessary. If so, all labels were transferred. Soaking old jars in warm water helped to remove labels easily, ensuring they were kept in the best condition. Some corks became brittle and disintegrated while trying to remove them, sometimes resulting in cork pieces falling into the jar; however, due to corks low density in comparison to most of the specimens they could be removed easily. Suitable lids were used to replace the cork, if not whole jars were replaced.

Specialised universal stopper jar openers in large and small sizes, designed by van Dam in collaboration with the Natural History Museum (Fig. 8) were used to remove any glass lids which had oblong or circular knobs on the top suitable for being gripped by this tool. Otherwise, the team resorted to various methods for opening lids including manual twisting, levering and hot water soaking. Corks often disintegrated and had to be dug out, Kilner lids sometimes included completely perished sealing rings or welded shut sealing rings which had to be dug out and prised open. Some glass jar knobs broke off when using the lifting tool or the jar rims broke off under the pressure of the lifter on a weakened rim. Many of Carr's specimens were stored in glass tubes within wooden boxes. These tubes had cork stoppers which had become too brittle and usually needed replacing however the tubes were a non-standard size for our modern stoppers, so the specimens often had to be rehoused in modern/new tubes. The wooden boxes were retained for historical reasons and interest (Fig. 9).

Fig. 8. Universal stopper jar opener designed by Andries J. van Dam in collaboration with the Natural History Museum, London.

Topping up was undertaken in a laboratory with an integrated extraction system, using a plastic bottle with a long spout (Fig. 9) for smaller bottles and jars were used for medium/large bottles. Once the new 70% IMS fluid had been added to the specimens the jars or tubes were resealed using existing or replacement tops. Glass stoppers were sealed with a layer of petroleum jelly applied around the rim and around the tops, replacement Kilner seals were used where feasible or sometimes the specimen had to be rehoused if a

Fig. 9. Topping up small vial with a plastic bottle with long spout, the vial is kept in wooden box (likely used for transporting).

suitable seal could not be found. Other screw top, plastic press on tops or rubber corks were largely reused and sealed with petroleum jelly.

Some labels had to be rewritten due to poor handwriting, brittle labels, where jars had broken and when labels would not come off despite soaking in warm water. We used an archival pen and Resistall paper to write these new labels.

Results

Data captured in the spreadsheet is presented as an index to the collections and is now available on the public domain at https://data.nhm.ac.uk/dataset/the-seed-plants-fluid-collection-at-the-natural-history-museum. Index to the collections is arranged as per family alphabetically. One can locate the collections taxa wise and looking at the cabinet/shelf/tray number on the righthand side of the table. Taxa names as recorded originally have been checked for current taxonomy and where names have changed, they are reflected in new determination. Country, locality details, habitat notes, plant description, name of the collector (s) followed by collection number, collection date and registration numbers (barcode numbers) of the specimens databased have also been given. Several specimens have corresponding herbarium sheets in the General Herbarium. Type specimens are highlighted in red.

The data will be eventually ingested in Ke-EMu, the Museum's database system.

Discussion

Around the world, digitisation efforts have increased rapidly in the last few years. By making these collections accessible in the public domain, we hope that interested researchers will be able to make the best use of them and advance our scientific knowledge. Although we found 41 types, it is possible that there are some specimens as yet unidentified type specimens in our collection.

The largest collection is from an American tropical botanist- Nancy Garwood (b.1949) (over 700 bottles) which consists of some carpological material collected from Panama as well as seedlings. She is recorded as having co-collected with many people during this time and specialised mainly in Spermatophytes.

The earliest recorded collection is dating back to 14/01/1803, a *Browniana* (BM013782085) collected by Robert Brown from Australia (Chapman et al. 2001).

We encountered several problems while working on this project such as illegible or undecipherable handwritten labels, missing information, incorrect spelling of species names, degraded labels, no labels, no collector information and difficulties determining geographical area of species collection. Some of these problems were overcome by using museum archives consisting of collectors' notebooks for cross reference purposes. Otherwise, the team resorted to the internet to research using whatever data could be gleaned from the tubes and jars. Following recording issues, the main problems revolved around the jars' condition and accessing samples for topping up with fluid. In instances where some jars were difficult to open, we used lid lifters, levers or hot water slowly poured over the lid to loosen the lid, we also drilled a small hole in the lid of the bottles to release pressure and open the bottles. In some cases, the jars were broken (kept in plastic bags and smashed gently with a small mallet for health and safety) and both the jars and labels had to be replaced. Cork stoppers were usually replaced as were Kilner seals. We soaked the labels in warm water, some came out easily which we stuck on new bottles. However, in some cases, the paper was brittle, and the label was lost,

so we wrote new labels on acid free Resistall paper with archival ink. We envisaged having used ca. 700 litres of IMS to these collections and around 300 new bottles of various sizes. We got some monies (ca. £4500) from the curation budget to curate these collections (buying boxes, bottles and trays, see supplier details listed under references). We also got some supplies of bottles (spare ones) from our other departmental colleagues.

In the near future, we wish to upload all the possible resources such as field notes by C.E. Carr, in the dataset: https://data.nhm.ac.uk/dataset/the-seed-plants-fluid-collection-at-the-natural-history-museum. We hope that these collections will be imaged in the future.

Finally, we feel happy that we have managed to restore the collections to their original glory and make these collections accessible to all.

Conclusion

We have addressed the curation and conservation needs of the seed plants fluid collections. In total 3,072 specimens have been re-curated by replacing broken jars/lids, rewriting labels and topping up the specimens with 70% IMS which are now virtually available on the Museum's public domain at: https://data.nhm.ac.uk/dataset/the-seed-plants-fluid-collection-at-the-natural-history-museum.

189 families are represented with Orchidaceae representing the highest number of specimens followed by unknown families, then Rubiaceae, Melastomataceae, Moraceae, Piperaceae, Fabaceae, Araceae and other families. There are 1359 distinct counts of taxa name (genus and species names) with unknown taxa having a count of 492 taxa, followed by Orchidaceae with 335 taxa, Impatiens with 21 taxa, and other taxa with lower numbers. There are a few gymnosperms as well. 41 types from various countries around the world have also been recorded.

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