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From the field to collections: Developing natural history collections and collection centers in a unique region of Saudi Arabia

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Abstract

The Royal Commission for AIUla (RCU) manages a region around the town of AIUla in north-west Saudi Arabia. AIUla has a rich archaeological heritage, with internationally important archaeology collections which are mainly stored in AIUla Museum. AIUla museum was built as a center of support for archaeological research, in the region, however, the development of a new natural history collections has meant that new approaches have had to be developed to record, research and preserve the rich diversity of wildlife and geology. As a result of this, there is a strong need to develop best practice protocols for collecting and storing natural history collections, so they are safeguarded for the future research and exhibition programs. However, the location and very dry conditions in the region present many challenges to the preservation of these collections. This paper outlines the progress of the challenges faced and how current published best practice advice and guidance has to be adapted to suit the different environment of AIUla.

Keywords: AIUla; Saudi Arabia; collecting; storage; procedures; protocols; policies

Introduction

The Royal Commission for AIUla (RCU) manages the region around the town of AIUla, covering an area of over 22,000km² in north-west Saudi Arabia (Figure 1). The region is classified as a desert, with around 21 mm (0.8 inch) rainfall per annum, and large varying temperatures reaching 50°C in the summer day and down to 0°C in the winter nights (Climate Data, 2024). Only 200km west of the Red Sea, AIUla has been an important trade route for thousands of years, as a strategic part of the Incense Trade Route through the Arabian Peninsula and as an important town on the Haj route. The region holds incredibly rich archaeological sites, dating back 200,000 years. It is where the capital of the ancient Kingdom of

Dadan, one of the most important sites for trade in Arabia, dating to around 3,000 years ago, can be found (MacDonald, 2018). The second largest Nabataean city, Al-Hijir (also known as Mada'in Salih, and Hegra) can be found in AIUla, and was the first site in Saudi Arabia that was designated a UNESCO World Heritage Site (Figure 2) (MacDonald, 1997; Ansary and Abu Al Hassān, 2001; Hausleiter, 2012).

As well as the internationally important heritage sites, AIUla has a rich and diverse natural heritage. The geology is a part of the Arabian Shield, which is composed of Precambrian igneous and metamorphic rocks, Palaeozoic sedimentary rocks,



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Figure 1. AlUla is located in the north west of Saudi Arabia, approximately 200km west of the Red Sea.

and Tertiary volcanic rocks (Hadley, 1987; Brown, Schmidt, and Huffman, 1989). The landscape varies throughout the region depending on the geology. In the south, jagged mountains and gravel plains dominate the land, and from central AlUla to the north, the sandstones create a different landscape of natural geological formations (Figure 3). The large variety of geodiversity has created numerous different environments for a range of endemic species of plants, insects, reptiles, mammals and birds to thrive, and over 50% of the county is protected under five nature reserves.

AlUla Museum was built as an archaeological museum and historically holds large archaeological collections, and the development of a natural history collection was not previously a priority. With the growing Wildlife and Natural Heritage team, and several new research projects across the region which involve collecting specimens, there was a strong need to develop best practice methods to enable the safe storage and preservation of the first natural history collections in AlUla. This paper outlines the ongoing work and challenges to develop and manage a natural history collection in a very dry environment.



Figure 2. One of the tombs carved into sandstone at Hegra. These tombs date to around 2000 years ago and are carved directly into the 500 million year old sandstone outcrops. (Photo by Jan Freedman)



Figure 3. One views of the stunning landscape of AlUla. The Cambrian and Early Ordovician sandstones have been naturally weathered by wind over millions of years to create beautiful features. (Photo Jan Freedman)

Royal Commission for AlUla

In 2016, Prince Mohammed bin Salman announced the Saudi Vision 2030, with the aim to improve the Kingdom's health care, infrastructure, education, infrastructure and tourism by 2030 (Vision2030, 2023). Investment has been put into mega-projects redeveloping areas, such as the Global Red Sea Project (The Red Sea Development Company, 2023), and other huge projects focusing on renewable energy (Reuters, 2018). The investment has also identified and acknowledged the internationally important heritage sites in the Kingdom, with several projects undertaking conservation work safeguarding heritage sites and redevelopments to allow tourists to visit (for examples see Arab news 2017; Arab News 2019; Forbes, 2019).

The county of AlUla is one of the major tourist destination projects, researching and protecting the heritage for people around the world to enjoy by creating the world's largest Living Museum (Vision2030, 2023). The Royal Commission for AlUla (RCU) was established in 2017 to preserve the heritage, and develop the region as an international tourist destination (BusinessWire, 2017). Along with the internationally important heritage sites, RCU has the additional focus to preserve the natural landscape, including the wildlife and geological landforms across the county.

Natural History Collections

Historically, the Museum of AlUla, now under the management of RCU, has primarily focused on archaeological collections because of the incredibly rich archaeology in the region. The county has been open to archaeologists and researchers for more than 40 years, providing archaeologists access to archaeological sites for excavation and research. These archaeology collections are well documented, and stored in buildings built in the mid 1980s. There are a small number of geological samples in the collections, mostly relating to archaeological sites. With this main focus on archaeology, the procedures and policies developed by the RCU Collections team for archaeological collections, with no procedures for the management, preservation and development of a natural history collection.

The Wildlife and Natural Heritage team within RCU consists of zoologists, botanists, and geologists who provide expert advice on the protection of AlUla's five nature reserves, study the geology, the flora and fauna, and are developing museums and visitor centers to highlight the globally important wildlife that can be found here (Figure 4). The team have developed several research projects in the region, studying the wildlife and geology, developing new lists of species and detailed geological maps. Working with external experts to collect and identify species and geological

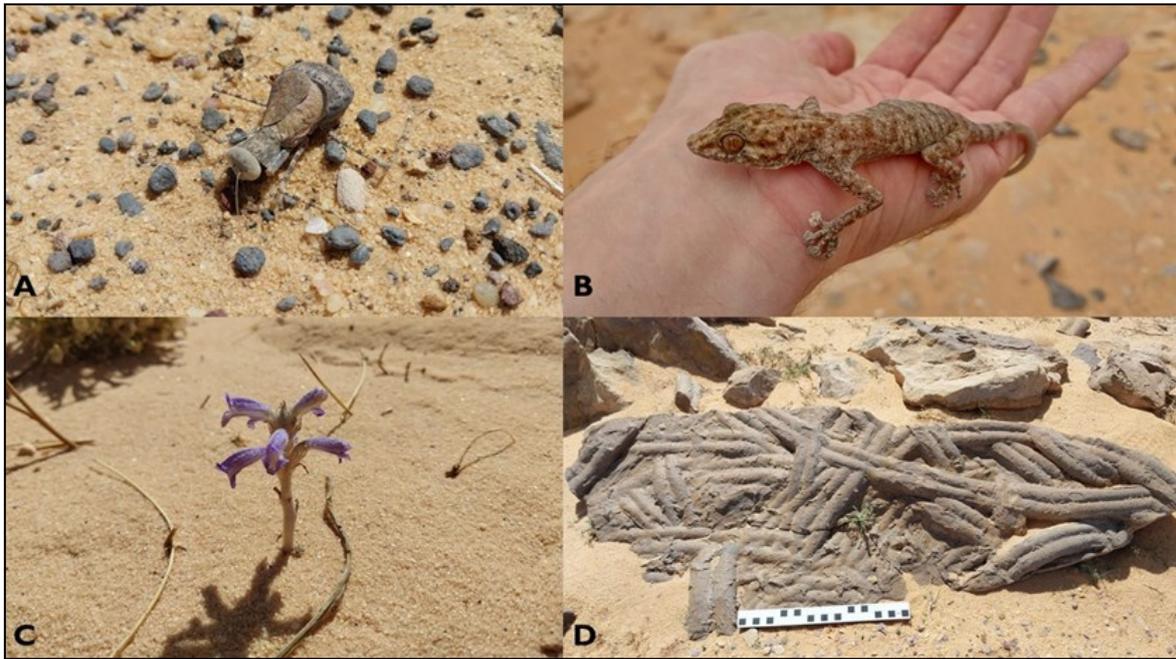


Figure 4. A selection of the natural history of AIUla. (A) Pebble mantis (*Eremiaphila zetterstedti* Beier, 1942). (B) Fan-footed Gecko (*Ptyodactylus* sp. Anderson, 1898). (C) the parasitic plant, nodding broomrape (*Orobanche cernua* Löffling, 1758). (D) *Cruziana* trace fossils. (Photos Jan Freedman)

samples, the team is beginning to build a large natural history collection.

As the external experts are brought in on contract from a range of institutions and companies around the world, there was a strong need to begin standardising the methodologies for collection, preparation and storage of specimens to ensure that they were prepared and preserved in the best possible conditions to answer our research questions and for exhibition development. The current archaeological procedures and guidelines were not written to cover natural history collections, so the authors, supported by colleagues in the Wildlife and Natural Heritage team, have begun to develop best practice guidelines for natural history collections. The aim is to standardise all the collecting of natural history collections, so that they are deposited with all the data associated with the specimen, and stored in the best way so as to preserve them for RCU's future research and exhibition programs.

Developing best practice

AIUla presents a number of unique challenges for storage and management of natural history collections. These include the lack of infrastructure for storage, lack of experienced and professional staff to prepare and manage these collections, and the varying standards that are being applied to the collection and preservation of these collections. By

2026, RCU will have established a centralised storage facility, developed to LEED Gold, Estidama Pearl 4, which guides and rate the sustainability performance of a given development throughout its lifecycle from design through construction to operation. (AbdelAzim and Aboul-Zahab, 2017; Ongreening, 2024).

Natural history collections are not only an important record of a country's ever-changing biodiversity, but an important resource that can be used to preserve ecosystems at risk and to rebuild a damaged ecosystem (for example see, Lane, 1996; Lamov, Keith, and Hochuli, 2009; Alagon, Sandlos, and Wiersma, 2012; León-Lobos, et al., 2012; Arzuza Buelvas, 2018; Gann, et al., 2019; Wildman, et al., 2022) The development of a properly integrated collection based natural history facility is important for the future management and preservation of the Saudi Arabia's biodiversity: such a storage facility would provide an important central resource for biodiversity and collections-based natural history research in the region. The new natural history collections will preserve a morphological and genetic record of the region's biodiversity.

To ensure the collection is fully representative of AIUla's biodiversity and geodiversity and safely preserved for the future, the following elements are required:

- A fully integrated strategy that aims to preserve the bioinformatical and geo-informatical data and objects, in the landscape, nurseries and collections of AIUla.
- Detailed understanding of the different data sets, samples and materials needed to fully record the biodiversity and geodiversity of the area.
- Resources to preserve the collected samples, and associated data sets that are a record of the region's environment.
- Experienced and knowledgeable staff who can ensure the maintenance and development of these objects and data.
- Facilities for staff and appropriate housing for the collections to ensure they are preserved for the future.
- The infrastructure to ensure that the data and collections are fully integrated and accessible to regional, national and international users.

There are relatively few collections based natural historians working in the Kingdom of Saudi Arabia, and no national collection. With the exception of the Geological Survey of Saudi Arabia, geological collections, and small herbariums in the Jazan Region, and in Riyadh managed by the National Center for Vegetation Cover, there are very few natural history collections which safeguard the country's fragile biological or geological diversity to international standards. Consequently, there are no facilities available to properly prepare and store the range of materials and objects and few trained staff that can prepare and maintain these collections to global standards.

A critical element of developing such a collection is to have staff who are knowledgeable about the long-term preservation and management of these collections. These staff will need a range of skill sets from taxidermy and plant mounting, to DNA sampling and collection storage and preservation. There are very few preparation and conservation staff in Saudi Arabia who are experienced in managing and working with natural history collections. RCU is therefore developing a new group of young, trained staff to support the management and preservation of these collections, alongside natural history specialists within the RCU Collections Section who are working hard to conserve the regions fauna, flora and geoheritage.

There is no integrated methodology or strategy for collecting and preservation of collections and natural history materials across in Saudi Arabia. Similarly, the materials and equipment needed to correctly store and preserve the wide range of natural history collections are very difficult to

source inside the Kingdom and generally need to be imported from outside Saudi Arabia. RCU is currently implementing a coordinated strategy for collecting which combines a collecting strategy with the future use of collections as Voucher, Research or display materials. The aim to ensure the preservation of collections for future generations with relevant staff, storage and technical facilities required to support these collections.

Standards and best practice applied in Saudi Arabia?

RCU's current approach to collection and storage is on a project-by-project basis. The collecting and packaging techniques are ad-hoc and based on the established practice of the differing groups contracted in to undertake field work and collecting for the research project. RCU outsources most of its activities to external companies, including Biopolis and RBG Edinburgh who bring their own 'best practice' to the collection development activities. Importantly there is no agreed protocol to manage the objects from field to storage, which would ensure that objects are correctly tracked into the collections, undergo a coordinated preparation and preservation process, and then stored in the correct environmental conditions to ensure their stability. While the collecting practice is to a high international standard, the packaging, storage, and process for moving the specimens to RCU storage for research need to be improved. The lack of agreed pipeline processes for handling, sampling and stabilising these, in particular when the research teams plan to undertake a range of morphological and genetic studies on these items, can lead to loss of data.

At the beginning of 2023, RCU held a workshop in Paris to review natural history collection conservation and collecting standards, working with staff from the Wildlife and Natural Heritage team, the French partners of RCU, AfAlula, and several external experts who had worked with RCU in the past. Our aim was to improve RCU's approach to the collection, storage and sampling methodologies, and to improve its data collection and retention.

The workshop defined the need to develop:

- standards that reflected the needs of the natural history collections collected in a dry desert environment.
- service contracts to develop better delivery of collections care and collection management.
- develop training in natural history conservation and collections management.

Object Stability and the environment

There is a lot of material in the literature about best practice environmental conditions for storing natural history collections (for example, see Child, 1994; Carter and Walker, 1999). However, although they can be treated as initial guidelines, they cannot be followed for preservation of many types of natural history specimens that are collected in AIUla region, as the environment outside is very different to other regions of Saudi Arabia, and the regions from which traditional conservation standards are derived. Generally, conservators have observed that organic and inorganic material, from AIUla are found to be more stable at a lower RH range than would be considered practical for items in a collection developed and stored in for instance, in Europe or North America. While they are more brittle, material was seen to deteriorate more quickly even after slow acclimatisation to what would be considered standard humidity levels of 40-60% relative humidity. Because the stability ranges of materials collected in the region appear to be different to those traditionally found in Europe or North America, RCU has developed environmental guidelines for items collected in AIUla. These initial guidelines show how we are having to review our approaches to stabilisation and storage of collections and rethink how we collect and then stabilise and store natural history collections.

The environment in AIUla is dry, over the last few years ranging between 18 and 28 % RH, with external temperatures ranging from the low single figures during the night-time in winter to the high 40s and low 50s in high summer. The climate is also changing and over the last 18 months the area has seen increasing rainfall which has changed the environmental conditions so that in the last year average humidity has been rising to 35% RH in the spring and early summer months.

Traditionally, collection storage rooms have only been temperature controlled, as most materials collected from the area are more stable at the lower relative humidity conditions that they are found in, and transferring them into higher humidity environments causes serve problems. Because there was only seasonal change in humidity outside, the collection storage environment very much mirrored the relative humidity's outside conditions. As there is no humidity control in place, and collection spaces are being subject to broader ranges of humidity, collections teams are now starting to observe changes in collections that were not seen in the past.

To document the changing environment and to

enable the teams to assess the effects of the changing climate on collections, RCU has developed an integrated environmental monitoring platform to track the changes in climate across the county, both outside and inside buildings. The data from this system is helping the conservation teams to put in place better passive environmental control mechanisms that improve our management of the storage environment, while also meeting our goal to keep energy usage down and maintain a sustainable storage environment.

Staff are now reviewing how we can adapt 'international best practice', for the preservation of the range of natural history materials. The starting point for this has been the Clothworkers best practice documentation, which looked at the standards currently being used in Europe and North America for preparing and conserving natural history materials (Collins, 2015). The best practice documentation is based on information collated on Botanical materials (for example, Royal Botanical Gardens, Kew, 2023), DNA sampling and storage pipelines, skins and osteology, herpetology, wet collections (Cersoy, et al., 2020; Neumann et al., 2022), entomology, and geological materials (Garret, 1989; Duckworth, Genoways, and Rose, 1993; Child, 1994; Carter and Walker, 1999). These standards are being drawn into a new guideline for natural history collections in the Kingdom of Saudi Arabia, that will define best practice in terms of documentation, preparation and preservation and storage techniques. These standards that are being developed by RCU are by their nature, 'living documents' that are reviewed on a yearly basis and updated as the teams learn more about how to stabilize objects to maximize the data they hold and a new pieces of data are required. This work includes the development of pipeline process maps required to ensure objects are better preserved for research e.g. DNA, proteomics etc., and exhibitions and display, so we can build a more sustainable collection that is of practical use for future generations (Rogers, et al., 1990; Hammond, Spanswick, and Mawn, 1996; Gemeinholzer, et al., 2011; Campbell, et al., 2012).

Examining current published best practices for the storage of different types of natural history collections, such as those mentioned above, allow for baselines to be worked from, and developing these standards to suit the environment specific to AIUla. This will also enable the teams collecting natural history specimens in the field to ensure when materials are collected on contract that there are standardised and agreed practices in place to ensure that holistic preservation of objects and their proper documentation. This not

only includes the storage, but also the labels that are associated with the specimens when they come into the RCU collections. Historic locality information has been incorrect, misspelt, or not complete (McEachern and Niessen, 2009), so any collecting that is undertaken includes templates of labels that will be used for each specimen.

The new best practice guidelines being developed will include:

- Collecting policies highlighting the types of material we want to collect for future research and education uses.
- Standardised labelling for all types of natural history collections, so that researchers or external organisations undertaking field collection will collect with the correct information.
- Environmental standards for preservation and storage natural history items and associated Samples.
- Pipelines for collection, packaging, processing and handling of natural history materials.
- Preparation procedures for herbaria, zoological and entomological items.
- Conservation and Preservation procedures for natural history.

These new guidelines will also define protocols and control mechanisms that are being developed for a new collections facility in AIUla. The new 25,000 m² facility will be the first Collection and Conservation Facility of its type in the Middle East. Benchmarked against a range of international facilities including, Smithsonian, Museum Support Centre (MSC), and Louvre Liévin, it will include 5000m² footprint for storage space. This new collections store will include dedicated DNA storage space, plus dedicated and specialist space for herbaria, geological and palaeontological, and zoological collections. This will be a unique facility for collections support in the Middle East that will provide new benchmark conditions for preservation of natural history collections as well as a center for developing training courses in natural history collection preservation in the middle east.

Summary

The Kingdom of Saudi Arabia does not have published guidelines or standards for collecting or storing natural history collections. These procedures and protocols that are being developed for the collections in AIUla can be used as a best practice for the safeguarding of collections in the Kingdom for the future. This is the time to develop procedures and policies for natural history collections for RCU. Because natural history collections here are very new,

there are very few historic backlogs, or poor collections that need serious conservation work. Producing collecting policies, labelling standards, and conservation standards now, means that all collections will be collected and stored in the best possible conditions, preventing any deterioration of the specimens.

Several global digitization programs have amazes enormous amounts of data from museum collections, including iDigBio (Integrated Digitized Biocollections), DiSSCo (Distributed System of Scientific Collections), GBIF (Global Biodiversity Information Facility) and ALA (the Atlas of Living Australia). Recently these organisations are working more closely together to enhance the data available for researchers (Nelson and Paul, 2019). Available online, and accessible anywhere in the world, researchers can use the historic information from museum collections to undertake huge amounts of work, examining habitat destruction, extinction, ecological loss, and climate change, on the global scale (Raes, et al., 2019). However, this global scale research has gaps in the data. In some instances, the data is there, but not uploaded due to time and financial constraints. In other case, the data is not there because it hasn't been collected yet, like in Saudi Arabia. There is a huge gap in the global record for zoological, botanical and geological specimens across Saudi Arabia. Historically there have been very few collections amassed, and even less made available digitally. Developing natural history collections in AIUla not only helps understand the biodiversity and geodiversity at a regional level, but also at the global level, and the data that is associated with thee specimens will enhance the studies by researchers around the world.

There is a richness of wildlife and geology that has only very recently been opened up for research in the Kingdom of Saudi Arabia. By developing collections here, there will be a baseline for conservation initiatives and long term strategies to help protect environments across the region. Additionally, these collections provide a rich archive of data that cannot be found anywhere else in the world.

This has created a unique opportunity to develop best practice standards from the beginning. These collections can be used for research, education, display and more, and by working towards best practices that are developed for this unique environment, will ensure that these specimens are preserved for the future. The richness of the biodiversity and geodiversity is only just beginning to be explored.

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