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Author(s): Freedman, J. & Gelsthorpe, D.

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The rediscovered collection of *Myotragus balearicus* Bate, 1909 (Artiodactyla, Bovidae) at Manchester Museum

Jan Freedman[1] and David Gelsthorpe[2]*

[1]*Curator of Natural History, The Box, Plymouth, 37 Tavistock Place, Plymouth, PL4 8AJ.*

[2]*Curator of Earth Sciences, Manchester Museum, The University of Manchester, Oxford Road, Manchester, M13 9PL.*

**Email for correspondence: David.Gelsthorpe@manchester.ac.uk*

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Abstract

New discoveries within collections with significant research value are being made each year. New scientific information and historical context is uncovered revealing rich collections stories for researchers and the public. This paper details a recently rediscovered collection of over 60 specimens of the Late Pleistocene mammal *Myotragus balearicus* Bate, 1909 at Manchester Museum, along with a very brief overview of the species and its discoverer, Dorothea Bate. Whilst the small collection may hold some research potential, there is a great opportunity to use the collection for university students and members of the public to learn more about the history of science, early female palaeontologists, and island evolution and extinction.

Keywords: *Myotragus balearicus*; island evolution; Dorothea Bate; Manchester Museum; museum collections.

Introduction

Museum collections contain a wealth of undiscovered stories for the public and opportunities for scientific advancement. Despite the ongoing curation of natural history collections, there are still many specimens in museums that remain unknown by curators and the research community.

In recent years, there have been numerous examples of specimens that have been 'rediscovered'. A number of ichthyosaur specimens in museums have recently been examined in detail, all for the first time since their acquisition. One specimen long thought to be an ichthyosaur cast, turned out to be a real fossil and a new species: *Ichthyosaurus anningae* Lomax and Massare, 2015 (Larkin and Lomax, 2015; Lomax and Massare, 2015).

Re-examination of ichthyosaur specimens has led to the identification of several other new species (for examples see Lomax, 2016; Lomax and Massare. 2016; Lomax, Massare, and Rashmiben, 2017; Lomax and Massare, 2018), as well as correctly identifying species that have been mis-identified (Massare and Lomax, 2013; Lomax, Evans and Carpenter, 2017).

The holotypes of the ice age cave hyena *Crocuta crocuta spelaea* Goldfuss, 1823 and the cave lion *Panthera leo spelaea* Goldfuss, 1810 from the Zoolithen Cave at Geilenreuth, Germany, were thought to be lost. Research by Diedrich (2008) has found these specimens, safely stored in two different museums: the cave hyena holotype in the

collections at the Goldfuss Museum of the Reinische Friedrich Wilhelms-Universität Bonn, Germany, and the cave lion holotype at the Museum fűr Naturkunde, Humboldt-Universität, Berlin. The holotype specimen of the cave bear *Ursus spelaeus* Rosenműller, 1794 from the same site was also thought to be lost, but was rediscovered in the collections at the Museum fűr Naturkunde, Berlin (Diedrich, 2009).

These are just a few examples of specimens that have been rediscovered or re-examined, demonstrating the importance of knowing what is held in museum collections. A large collection of rare sub-fossils (sensu Butler, 1994) were recently 'rediscovered' at Manchester Museum. This paper outlines the collection in detail, along with a very brief overview of the species, and the potential significance of the collection. One of the aims of this paper is to highlight this collection to the wider scientific and history of science research community, contribute to the known dataset for this species and add to the stories associated with the collection.

Myotragus discovery

M. balearicus was discovered by Dorothea Bate (1878-1951) in three coastal cave sites on the large Mediterranean Island of Mallorca (also called Majorca): Font de sa Cala (Cova de na Barxa, the holotype deposit for *M. balearicus*), near Capdepera; Cova des Coloms at Cap Farrutx, Artà; and near Cap Menorca, Alcúdia (Bate, 1914). One *Myotragus* bone was found at Cala Figuereta, near Santanyí (Bate, 1914), but the whereabouts of this specimen is presently unknown. This species was not just restricted to Mallorca, with a number of fossils found at the close by island of Menorca (Bate, 1914), and specimens have also been discovered on the two small islands just off Mallorca, Cabrera and sa Dragonera (Bover and Alcover, 2003).

Bate was one of the earliest women to be employed as scientific staff at the British Museum (Natural History) (now the Natural History Museum, London) in 1898, and worked there for 50 years, mostly as a volunteer before made a permanent member of staff at the age of 69 at Tring in Hertfordshire (Shindler, 2005). Although initially undertaking a variety of work with bird skins and preparing a large diversity of fossils, she began to explore the Mediterranean islands in search of fossils, initially at her own expense (Shindler, 2005). Bate made significant finds on several these islands, and substantial contributions in Late Pleistocene to Early Holocene island fauna (Shindler, 2004).

Overview of *M. balearicus*

Myotragus arrived on Mallorca around 5 and a half million years ago (Bover *et al.*, 2014), when the Mediterranean Sea was almost completely dry, and the Mediterranean islands were connected to the mainland through exposed land bridges (Clauzon *et al.*, 1996; Manzi *et al.*, 2013). Flooding of the Mediterranean through the Gulf of Gibraltar severed contact from mainland populations, where it evolved in isolation (Bover *et al.*, 2014; Mas *et al.*, 2018).

It was a small animal, measuring just 50cm high at the shoulder (Figure 1) (Bover and Alcover, 1999; van der Geer, Lyras and de Vos, 2010). The small skull had two small, slightly curved horns growing

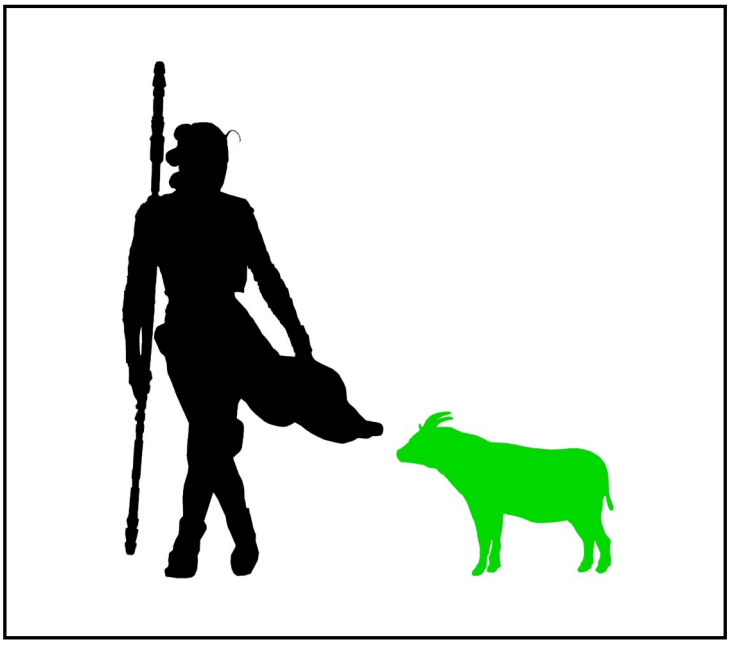

Figure 1. The enigmatic Myotragus balearicus *compared to a human 182cm tall. Measuring just 50cm at the shoulders,* M. balearicus *underwent dramatic reduction in size as a response to island evolution.*

backwards from the frontal bone (Figure 3A, C, D) (Bate, 1914). The lower jaw had two large continuously growing incisors (Figure 3B), similar to that seen in rodents (Bate, 1909), but it also very unusual for an Artiodactyla and not found in any extant species, and as with other caprines there are no incisors on the upper jaw. *Myotragus* most likely ate everything that it could, including tougher plants (Jordana and Köhler, 2011; Jordana *et al.*, 2013), with the continuously growing incisors beneficial to this varied vegetation diet. Whilst orbital sockets in all other caprines are located on the side of the heads, in *Myotragus* they are facing forwards like those of carnivores.

The post-cranial skeleton demonstrates more anatomical peculiarities, which Andrews (1915), Bover & Alcover (1999), Bover, Fornós and Alcover (2005), Spoor (1988a), Spoor (1988b) describes in detail. The humerus (Figure 3G) and femur are both reduced in size, being very short and thick. All limb bones are short and robust, with the radius and ulna not as robust as the femur and humerus. The metacarpus, metatarsus and phalanges are all short and very thick. The smaller body size in *Myotragus* shows the limb bones developing extreme shortening and increased robustness, which are likely a result of a predator-free environment, with this species losing the need for speed (Spoor, 1988a; Spoor, 1988b).

It was very successful and adapted uniquely to life on the islands without predators. Its overall body size was much reduced (Figure 1), which, following Foster's rule, has been seen in many species of herbivores that have been isolated on islands (Foster, 1964). Other examples include dwarf elephants on Cyprus (Bate, 1903), dwarf hippos on Crete (Evans, 1925), the Cretan dwarf mammoth (Bate, 1907; Herridge and Lister, 2012), and even within our own Genus, with *Homo floresiensis* Brown *et al.* 2004 (Brown *et al.*, 2004). Isolation from populations on the mainland, a lack of predators, a smaller land mass, and more available food led to relatively rapid and extreme evolution of mammals on islands (Foster, 1964).

Myotragus became extinct around 4,035 years ago (Bover *et al.*, 2016). The cause of its extinction has been hotly debated. Climate changes on the islands of Mallorca and Menorca have been suggested to be the main driver (Lull *et al.*, 1999; Jalut, *et al.*, 2000; Pérez-Obiol *et al.*, 2000; Pérez-Obiol *et al.*, 2001), however there are some researchers whom favour humans as the main cause of their extinction (Ramis and Bover, 2001; Bover and Alcover, 2003; Bover *et al.*, 2016). There is currently no evidence to suggest that *Myotragus* and humans overlapped, and the exact cause of the extinction of *M. balearicus* is unknown (Ramis and Bover, 2001; Bover and Ramis, 2005).

The collection of *Myotragus balearicus* at Manchester Museum

Manchester Museum is one of the largest university museums in the UK with over 4.5 million specimens dating back to 1820s. The collection includes natural history, archaeology, ethnography and Egyptology.

A collection of 60 bones of *Myotragus balearicus* were recently discovered in the collections store room. The collection was purchased from Dorothea Bate for £10, brokered by Dr Charles Andrews of the British Museum (Natural History) in October 1914 (Figure 2). Dr Andrews was a curator in the Department of Geology, who worked with fossil mammals from around the world (Woodward, 1924), and published a detailed monograph of *M. balearicus* (Andrews, 1915). The type specimens of *M. balearicus* are held at the Natural History Museum, London.

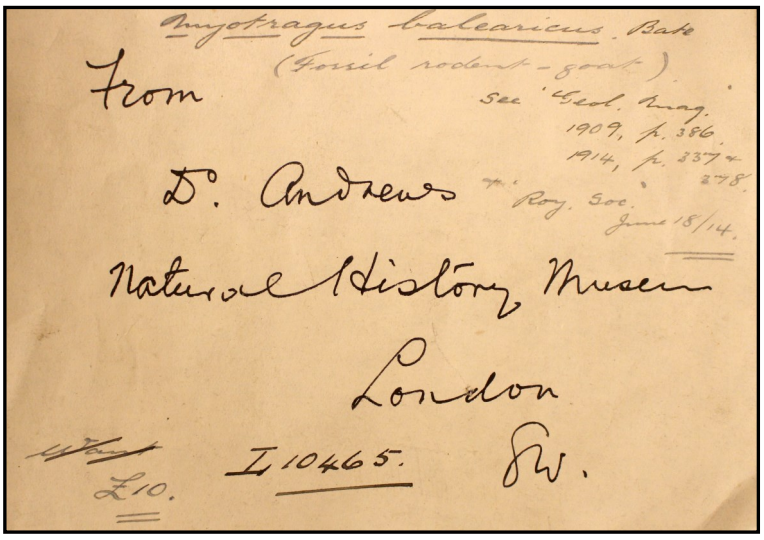

Figure 2: The accompanying label with the Myotragus collection at Manchester Museum. The label has been annotated by an unknown person with the publication details and the £10 price with 'Want' crossed through (possibly implying they were sent on approval). Image Manchester Museum.

Figure 3: A selection of Myotragus balearicus *specimens held in the collections at Manchester Museum, all previously unfigured. (A) Skull with fine grained cave earth still attached (L10465.1); (B) Left mandible (L10465.9); (C) Horn-core (L10465.5); (D) Horn-core (L10465.7); (E) 7 incisors from the lower jaw (L10465.22); (F) Right tibia (L10465.41); (G) Left humerus (L10465.31). Scale bar = 1cm. Images Manchester Museum.*

The specimens were accessioned in October 1914 soon after they were purchased for the Museum. The accession register records the following information:

'L. 10465, Oct, *Myotragus balearicus,* Majorca, Purchased £10 from Miss Bate'

Although there is no field locality information with the collection, the good preservation and lack of stalagmite coating on this collection is also noted in the fossils described by Bate (1914). The fossils are most likely from three possible sites in the Jurassic Limestone: Fuente de la Cala (Cova de na Barxa, the holotype deposit for *M. balearicus*), near Capdepera Mallorca, Cuevas de los Colombos, Cap French, or a cave near Cavo de Menorca, Alcudia. Future work on the isotopic signatures on this collection may provide more information about the site they were discovered.

The bones are exceptionally well preserved, but often incomplete with breakages (Figure 3). The fragmented skull (L.10465.1, Figure 3A) has cave-earth embedded in the back of the skull, which is fine grained and pink-brown in colour. The cave earth contains a number of broken bone fragments, indicating that the bones in this collection may have been broken prior to, or after deposition, rather than during excavation. The collection includes most of the skeletal elements of *M. balearicus*, representing at least five individuals (Table 1).

Significance and potential of the collection

Specimens of *M. balearicus* have been used for research from the collections in at least the Natural History Museum, London, the Institut Mediterrani d'Estudis Avançats, Mallorca, the Societat d'Història Natural de les Balears, Mallorca, the Deia Archaeological Museum, Mallorca, the Museum Belear de Ciéncies Naturals, Mallorca, the Institute of Earth Sciences, Utrecht, the American Museum of Natural History, New York, and the National Museum of Natural History, Smithsonian Institution, Washington D.C. (for example: Spoor, 1988a; Spoor, 1988b; Waldren, 1999; Lalueza-Fox *et al.*, 2002; Bover, Quintana and Alcover, 2010; Jordana *et al.*, 2013). These collections have allowed detailed work to be carried out in an attempt to answer many questions about the natural history of this species, and island evolution in general. Whilst this collection at Manchester Museum is not a significantly large compared to these other institutions, this collection offers some new research potential and is another piece of the jigsaw illustrating the work of Dorothea Bate.

There is nothing to suggest these specimens have been examined by researchers since their sale to Manchester Museum in 1914. They have not been previously published and are not included in the catalogue of type and figured specimens (Jackson, 1952). The specimens have been overlooked for over 100 years. Their association with the pioneering female scientist, Dorethea Bate means they are of historical, if not scientific, significance.

Element	Number of bones	Accession number
Skull and fragments	8	L.10465.1, L.10465.2, L.10465.3, L.10465.4, L.10465.19, L.10465.20, L.10465.21, L.10465.23
Horn-cores	4	L.10465.5, L.10465.6, L.10465.7, L.10465.8
Left jaw	1	L.10465.9
Right jaw	4	L.10465.10, L.10465.11, L.10465.12, L.10465.13
Thoratic vertebrae	18	L.10465.14, L.10465.15
Lumbar vertebra	3	L.10465.16, L.10465.17, L.10465.18
Incisors	6	L.10465.22
Molars	1	L.10465.22
Metacarpals	6	L.10465.24, L.10465.25, L.10465.26, L.10465.28, L.10465.33, L.10465.34
Right femur	1	L.10465.38
Proximal right femur	3	L.10465.27, L.10465.35, L.10465.38
Proximal femur	1	L.10465.44
Distal left femur	1	L.10465.36
Left radius-ulna	1	L.10465.39
Distal right radius-ulna	1	L.10465.45
Right ulna	2	L.10465.40, L.10465.41
Left ulna	2	L.10465.42, L.10465.29
Proximal right radius and ulna	1	L.10465.55
Proximal right radius	1	L.10465.30
Left humerus	1	L.10465.31
Distal left humerus	1	L.10465.43
Right humerus	1	L.10465.37
Distal phalanx	5	L.10465.56, L.10465.57, L.10465.58, L.10465.59, L.10465.60
Tarsal	16	L.10465.46
Rib	1	L.10465.61
Sacrum	3	L.10465.48, L.10465.49, L.30465.50
Scapula	4	L.10465.51, L.10465.52, L.10465.53, L.10465.54
Bone fragments	11	L.10465.47

Table 1: The complete list of skeletal elements of Myotragus balearicus *held at Manchester Museum.*

This collection has a lot of untapped potential for use in education and display for students and for visitors. Connecting real objects with people in new ways is a powerful way to tell stories and give an insight into the passions of their collectors. The bones have recently been used in teaching undergraduate biology students about dwarfism in island species, prior to their fieldwork in Mallorca. These specimens open the door to illustrate a range of different topics, including: the history of science, female palaeontologists, island evolution and extinction. The Natural History Museum, London, which holds the type material for *M. balearicus*, is currently the only museum to display this genus in the UK, and this rediscovered collection offers many possibilities of reaching numerous new audiences.

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