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Bandages for Bastet: a study of three Egyptian cat mummies

Abstract

Animal cults in ancient Egypt were popular especially in the Late and Greco-Roman periods, where tens of thousands of votive mummies were dedicated annually in catacombs in large necropolises. This article focuses on one of the resources required for the production of animal mummies, the textiles for bandages, in order to better understand the economic impact and organisation of animal cults. A study of three animal mummies from the National Museum of Denmark using computed tomography (CT) scanning and experimental archaeology calculated the quantities of textiles used for animal mummification. Two complete cat mummies contained entire cat skeletons while a separate head of a cat was modelled entirely from textile. The study demonstrates that at least 1 to 1.6 m² of textiles was used to wrap a cat mummy and that therefore large quantities of textile were required for animal cults. Textiles, in addition to other resources for mummification, were in high demand at large necropolises: their evidence offers new insights into one aspect of the complex process of mummification and emphasises the large economic and organisational scale of the animal cults.

Keywords: animal mummies, animal cults, linen bandages, textile production, computed tomography (CT) scanning

Introduction

This article reports the investigation of one resource for the animal cults: the textiles. It details the study of three animal mummies at the National Museum of Denmark to learn more about their contents, construction and bandages. Computed tomography (CT) scanning and experimental archaeology were used to calculate the quantities of textiles used for animal mummification and the time spent in producing them. Based on this study, the potential of CT-scanning as a non-destructive method for the study of textiles is evaluated. Finally, the evidence is used to discuss the use, reuse and economic and ritual role of textiles in animal cults.

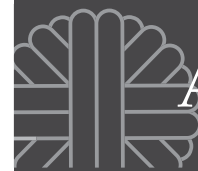
Animal mummies in ancient Egypt

Catacombs in ancient Egyptian necropolises have yielded and still contain hundreds of thousands and even millions of animal mummies (Ikram 2005; Nicholson et al. 2015). The numbers are so enormous that sources indicate that animal mummies were

even used as ship's ballast and subsequently sold as mummy-products as fuel, fertiliser and even medicine, pigments and paper (Elliott 2017). However, some were also collected as curiosities and have survived in museums and private collections around the world (Baber 2019).

Animal mummies can be divided into six categories: pet mummies, victual mummies, sacred mummies, votive mummies, false mummies and other mummies. Of these, the votive mummies were by far the most common and also form the most diverse group in terms of species with dedicated resting places. They include, among others, dogs, cats, ibises, raptors, crocodiles, and baboons (Ikram 2005, 2019). It is these votive mummies which are the subject of this study.

Animals were a part of the religious belief system of the ancient Egyptians. They were thought to be or contain a *ba*, part of the soul of their associated deity that would be active in both this life and the next one. Votive mummies were popular as they were believed to communicate messages to the gods (Bleiberg et al.



2013, 87-88). After death, animals were mummified and sold to pilgrims who dedicated them to their associated deity in the hope that their prayers would be heard (Ikram 2019). Dogs were, for example, associated with and dedicated to the dog or jackal-headed god Anubis, god of mummification and the afterlife, and cats to the protective goddess Bastet, represented as a cat or by a woman with a cat's or lion's head. Once a year, the dedicated mummies were escorted by priests to their resting place: catacombs carved out for the purpose or reused tombs (Ray 1976, 140).

Herodotus' accounts of the Egyptians' relationship to animals have given scholars the impression, that all animals were revered individuals (Malek 1997, 75) which, after a natural death, were mummified and brought to rest. However, evidence of strangulation and trauma has questioned this (e.g. Zivie & Lichtenberg 2005). The original interpretation is brought further into doubt by the incredible numbers of dedicated animals at large necropolises in Egypt such as Tuna el-Gebel, North Saqqara and Abydos (Kessler and el Halim Nur el-Din 2005; Nicholson 2005; Naville et al. 2014). The Dog Catacombs at North Saqqara may have contained up to eight million dog mummies buried over a few centuries (Nicholson et al. 2015) and the galleries of Tuna el-Gebel likely housed more than one million ibis mummies (von den Driesch et al. 2005). The number of animal mummies that were prepared annually is likely to have been in the range of tens of thousands. Such numbers have led scholars to suggest that a large scale production of animals for mummification took place. This idea is supported by written sources such as the archives of Hor of Sebennytos, who was a scribe born around 200 BCE. He, among others, served in Memphis, where ostraca (texts on potsherds) provided evidence of the administration of the ibis cult. These texts, discovered in the animal necropolis of North Saqqara, are known as *The Archive of Hor*. The archive mentions temple personnel in charge of different aspects of the breeding of ibises (Ray 1976). A papyrus letter (Cairo Zenon Papyrus 59451, Letter to Zenon from two Hierodouloi of Bubastis) mentions two men who are cat feeders in connection with the cat cult in Bubastis.

Votive animal mummies are normally dated to the first millennium BCE and declined in number after the Roman occupation of 30 BCE. They were particularly popular in the Late Period (747 to 332 BCE) and the Ptolemaic Period (332 to 30 BCE) (Ikram 2005), probably as a response to a period of foreign rule and a wish to return to traditional customs. Many animal mummies in European museums are without archaeological context and have not been dated by radiocarbon

analyses. Those which have been analysed in this way support a date to the Late and Greco-Roman periods (Burleigh 1980; Bleiberg et al. 2013; Wasef et al. 2015, De Moor et al. 2008), and indicate a possible change in the popularity of specific deities over this time period (Richardin et al. 2017).

Animal mummies provide important insights into the religious beliefs of the ancient Egyptians, techniques of mummification, and the economies of animal cults. There is no doubt that large-scale production would have required large quantities of not only animals, but also of fodder, vessels, oils, resins and textiles for bandages. In order to understand the full economic impact, organisation and extent of animal cults, it is important to gain insight into the resources needed to sustain them. In addition to the raw materials and how they were procured, it is necessary to estimate the labour used in their production or procurement. One of these resources was the textiles used during embalming and for bandages. Even though extensive quantities of ancient Egyptian textiles have been preserved by favourable conditions, they have not received appropriate scholarly attention, and only a few studies have focused on their role as bandages. However, a few recent studies indicate that bandages played both an important economic and ritual role in mummification (Riggs 2014; Drewsen 2019).

Bandages for mummification

The most commonly used textile fibre in ancient Egypt and the only one to have been reported from extant mummy bandages is flax (Bensen et al. 1979, 123). Most studies of bandages have been on those from human mummies. However, there are a few studies of bandages from animal mummies (e.g. Dunand et al. 2019, Tarek et al. 2019). Human mummies have shown wear and laundry marks (Hald 1946, Hall 1986), and it is therefore generally assumed that they were mostly made of reused textiles (Ikram & Dodson 1998, 153). Only exceptionally, as in the case of Tutankamun, were bandages produced specifically for wrapping (Winlock 1941, 10). Individual animal mummies have also been shown to contain bandages of different textiles, supporting the idea of reuse (Bleiberg et al. 2013, 127-128). While there is a general consensus on the reuse of textiles for animal mummies, it is unclear what quantities were needed and from where they came.

The collection of the National Museum of Denmark includes about 35 mummies or mummified specimens of several different species, including cats, reptiles, birds and fishes. Of these, two are complete cat mummies and one is a modelled head of a cat. These



a



b



c



d

Fig. 1: The three specimens from the National Museum of Denmark, Copenhagen: a) The modelled head of a cat (AAa 96) from the top; b) AAa 96 from the bottom; c) Cat mummy AAa 114; d) Cat mummy AAa 6 (Images: a & b - Søren Greve, c - Anne Haslund Hansen and d - Torben Eskerod)



were considered a relevant comparative evidence for the role and quantity of textile wrapping for archaeological material found in animal catacombs in general, and for disintegrated textiles, which do not enable thread counts or counts of layers, in particular. This is, for example, the case for the wrappings of dog and cat mummies from the recently analysed Dog Catacombs at the sacred animal necropolis of Saqqara (Brandt 2019; Nicholson et al. 2015).

Cat mummies are found at several burial places dedicated to cats in ancient Egypt, such as Bubastis, a city carrying the name of Bastet, and at the Bubasteion of Saqqara (Lenglet 1989, 20-22; Delvaux & Warmenbol 1991, 137-139; see map in Ikram 2005, xvii) and cats were particularly popular in the Ptolemaic Period (Malek 1997). Studies indicate that a large proportion of the cats died at a young age either as kittens or juveniles. While the cause of death is not clear for all cats, some demonstrate cranial fractures or dislocation of vertebrae consistent with strangulation, suggesting that they were killed for mummification (Armitage & Clutton-Brock 1981, 195; Zivie & Lichtenberg 2005, 117, Pl. 5.5).

Analyses of the cat mummies at Bubasteion in Saqqara revealed two types: 1) "Skittle-mummies" with the forepaws elongated along the torso and the hindlegs curled up along the abdomen and the tail between the legs and resting on the abdomen; and 2) a more naturally shaped cat with individually wrapped limbs (Zivie & Lichtenberg 2005). Museum specimens around the world vary in size (e.g. a specimen at Cairo Museum measures 24 cm in length (Gaillard & Daressy 1905, 95) whereas a specimen (inventory number 37.1991Ea-c) at Brooklyn Museum, New York, US, measures more than 80 cm in length), the wrapping style (from basic overlapping strips to elaborate geometric patterns), the use of coloured bandages, and modelled or painted facial features.

As previously mentioned, many of these museum specimens lack information about their find context and precise dating, which make it difficult to speculate about regional or chronological styles of wrapping. However, the elaborate geometric styles on animal mummies are often dated to the Roman period because human mummies from this era display a similar wrapping style (Bleiberg et al. 2013, 136). Nevertheless, a radiocarbon date of a cat mummy with geometrical wrappings, suggests that this wrapping style was used before the Roman period (De Moor et al. 2008, 110).

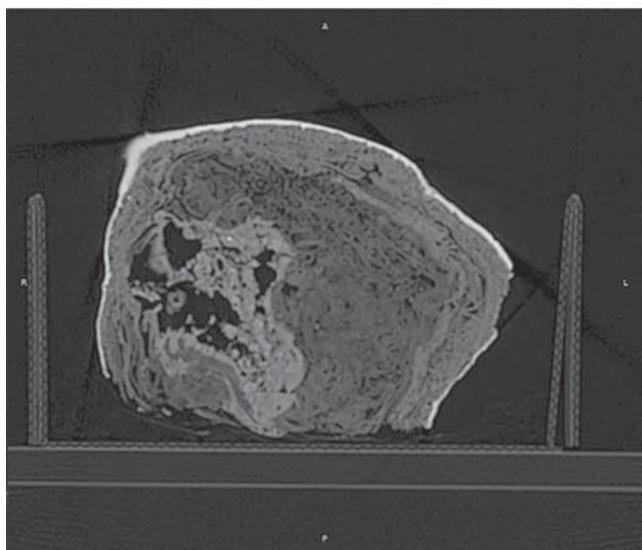
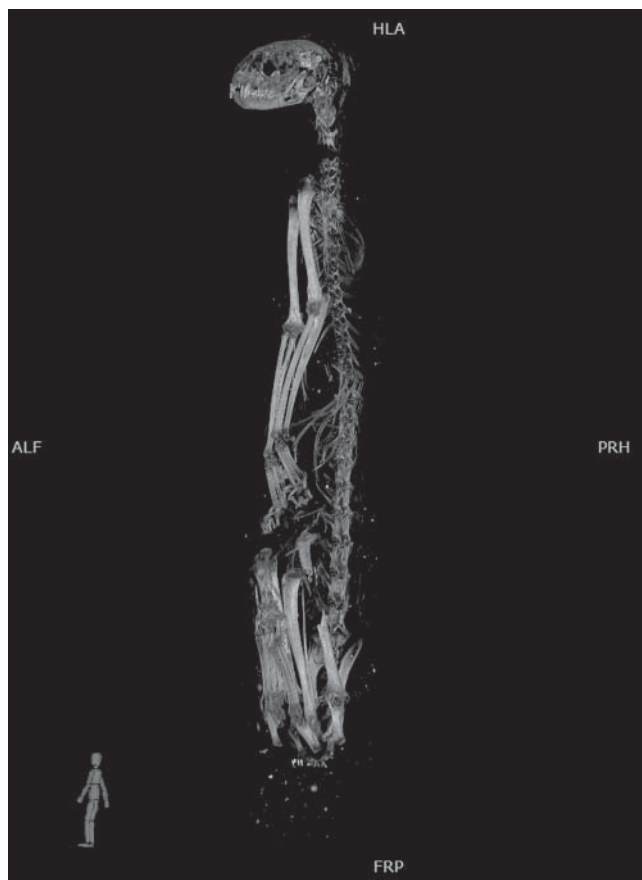
The National Museum of Denmark's two cat mummies and the head of a cat mummy were submitted for further analysis (fig. 1 a-d). One of the cat mummies

(inventory number AAa 6) was collected by Carsten Niebuhr during the Royal Danish Expedition to Arabia 1761-1767 (Hansen 2016, 88-89). It may have come from Saqqara, as the expedition is known to have purchased items from local farmers in this area (Hansen 2016, 52-53). The mummy is approximately 63 cm long and its outer layer is of broad bandages in a clearly different colour to that of the layer below. It was x-rayed in 2002. A second cat mummy (inventory number AAa 114) was donated to the museum in 1858/1859 by the shipbroker A. J. Polack, who was stationed in Alexandria (Buhl & Christensen 1969). The mummy is approximately 62 cm long and was x-rayed in about 1968, when it was documented that it contained a complete cat skeleton. The cat is wrapped in narrow bandages and covered by a black substance. The sculptured head of a cat (inventory number AAa 96) was also donated by A. J. Pollack in 1856/1857. The head was probably once attached to a cat mummy. It is covered with plaster which is gilded and painted. Judging from the bottom of the head, it is not possible to identify either bone or tissue.

Methods

The textile surfaces were examined using a Dino Lite Edge 3.0 digital microscope to record the spin direction of the thread, thread counts and weave. The mummies were CT scanned using a Siemens Somatom Definition AS CT Scanner at the Department of Forensic Medicine, University of Copenhagen. CT scanning is a radiographic technique which uses X-rays to visualise the internal structures of an object. The different tissues absorb the X-rays passing through the bodies differently and this effect is known as attenuation. The materials with a high density, such as compact bones, inhibit the passage of the x-ray and are visualised in white or light grey. The materials with lower densities, such as soft tissues or bandages, allow the majority of x-rays to pass through, and are visualised in black or grey. Air spaces are rendered in black.

The following scanning and reconstruction settings were applied: 120 kV, 300 mAs, slice thickness 0.6 mm, pitch 0.45, slice increment 0.4 mm and a sharp reconstruction algorithm (Br 59). The field of view was kept as small as possible, resulting in a pixel size of circa 0.4 mm. The CT images were visualised using Myrian version 2.2.1 (www.intrasense.fr), while the post-processing of the images were carried out using Mimics version 22 (<https://www.materialise.com/en/medical/mimics>). Mimics software allows the segmentation, i.e. isolation, and 3D visualisation of the different structures, such as the bones and bandages of the mummies based on their



attenuation (Villa et al. 2019). A series of 3D models of the bones and the external surfaces of the cats was generated using the volume and surface rendering visualisation techniques. In addition, 2D and 3D linear measurements, angles and external surface areas were obtained directly from Mimics, as CT scanning provides 3D scaled information. The scans were used

Fig. 2: CT scans of the cat mummies showing that two contained complete cat skeletons and that the cat head was modelled in textile: a) AAa 114; b) AAa 6; c) AAa 96 (Images: Chiara Villa)

for zooarchaeological observations, to visualise the internal constructions, and to assess the number of layers and their surface areas. The age-at-death of the cats were estimated based on the fusion state of the long bones as evaluated from the CT images using Smith (1969) as a reference.

Results and discussion

Zooarchaeological observations

The two complete mummies (AAa 114 and AAa 6), were shown to contain entire skeletons of cats, whereas the modelled head AAa 96 was constructed entirely of textiles and covered with plaster to form a cartonnage (fig. 2a to fig. 2c).

The mummy AAa 114 contains the articulated skeleton of a juvenile cat of approximately 62 to 84 weeks (fig. 3). The cat's skull is fractured on the left side, and the cervical vertebrae are discontinuous (between the third and the fourth vertebrae, there is a gap of 1.2 cm). The mummy AAa 6 contained the very

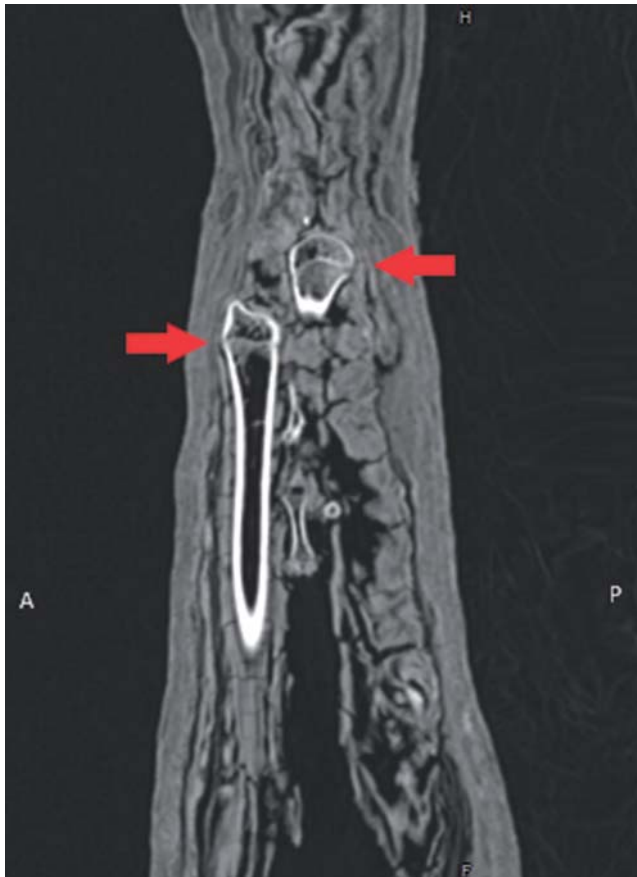


Fig. 3: CT image of the shoulder area, showing epiphyses of the humeri of AAa 114 which are not yet fused. The arrows indicate the well-visible line of fusion (Image: Chiara Villa)

fragmented skeleton of an adult cat. This individual also showed cervical discontinuation (there is a gap of 2.1 cm between the first and the second cervical). This mummy also showed dislocation of the fourth and fifth lumbar vertebrae. Both mummies have long museum histories with potential undocumented handling and examinations. It is therefore likely that the injuries are post-mortem, although trauma to the head and cervical vertebrae fits well with the evidence from other collections of cat mummies, which point to violent rather than natural deaths. Both cats seem to have been eviscerated as no remains of the internal organs were seen.

Construction of the cat mummies

Both of the complete cat mummies are skittle mummies. They are roughly equal in length (63 cm and 62 cm). However, the juvenile (AAa 114) is constructed with a textile extension of approximately 5 cm underneath the bottom of the cat. The original surface of AAa 114 is mostly lost, but can be observed in a few places as

brighter and thinner than the layers below and in some places folded bandages are visible (fig. 4). The bright surface was already noted as missing on its arrival at the museum in 1858/1859. The current surface now mainly consists of overlapping homogenous bandages about 2.5 cm wide saturated with a black resinous substance. This may have formed a stiff or sticky base for the construction of the geometrical pattern. The brighter original outer bandages form various patterns. Traces of crossing bandages appear on the mummy's neck, while the top of the head has bandages forming a square-ish pattern. The body seems to have been decorated with horizontal bandages. These lighter fragments are likely to be the outermost layer. The ears of the mummy were modelled, but only the lower part is preserved (fig. 4c).

The other mummy (AAa 6) had looser and broader bandages of about 5 cm, of which the single outer layer is brighter and the inner layers slightly darker. By looking at the two cats in cross-sectional CT images, it was clear that the number of bandage layers used varies over the body. For example, AAa 6 had a flatter shape on one side underneath the shoulder girdle than on the other. This part is packed with more layers of linen to even out the shape and make it look symmetrical. The looser structure of the bandages of AAa 6 is seen in other cat mummies (e.g. British Museum, London, UK, inventory number 79.5351, Smithsonian National Museum of Natural History, Washington, US, inventory number 156306) and seems to represent a specific and recognisable style, distinct from AAa 114, which may have originally had a geometrical pattern covering its body. It is very likely that future dating and possible pinpointing of provenance for animal mummies may reveal that different styles are related to chronology or different workshops.

Item AAa 96 is an example of the complete construction of a body part from textile. The inner elements consist of irregular textile scraps covered by a series of smooth layers, creating a base for the gilded cartonnage. The ears are shaped individually by the use of folded cloth around a core. An example (inventory number E 11475) at Penn Museum (Philadelphia, US) shows a similar inner construction. The head may have belonged to a complete mummy, with the body containing a cat or cat bones, or a mummy with no zooarchaeological content. So-called "false" mummies are well-known from ancient Egypt. These refer to mummies that were produced in antiquity, but are empty or contain only parts of an animal. Many elaborately wrapped mummies have been shown to fall into this category. Preliminary results indicate



Fig. 4: Details of the construction of AAA 11: a) The uppermost brighter bandages; b) The geometrical pattern on the mummy's neck; c) The remains of the modelled ears (Images: Anne Haslund Hansen)

that an ibis mummy (inventory number 7461) at the National Museum of Denmark contained a few bones, probably a wing, and a row of hollow tubes, most likely large feathers (Persson 2017). Whether it is correct to call them false is a matter of debate because there are various ways to interpret them. The *Archive of Hor* mentions irregularities in the ibis cult, leading to the imprisonment of six servants and the supervision of the ibises' preparation to ensure the packing of "one god [in] one vessel" (Ray 1976, 77-78, 143). This text has been interpreted as evidence of the servants deliberately cheating with the contents of jars in the production of ibis mummies. Another suggestion is that, for the Egyptians, parts of the animal would symbolise the whole and that a mummy with a partial body would not be fake to them (e.g. Ikram

2019, 181-182) or that wrapped parts could derive from particularly valuable individuals (Bleiberg et al. 2013, 134). Alternatively, empty mummies could be explained by the large-scale production of animal mummies leading to a shortage of available animals.

Calculation of surface area

For AAA 114, the external surface of the mummy measures 0.19 m². The number of layers of bandages were measured at nine different points on the mummy on axial CT images. These varied from three to nine layers (fig. 5). A conservative estimate of an average of five layers to cover the body was used. The estimate of the quantity of textile used for an animal mummy therefore equals 1 m². It should be noted that this estimate does not include the brighter outer layers

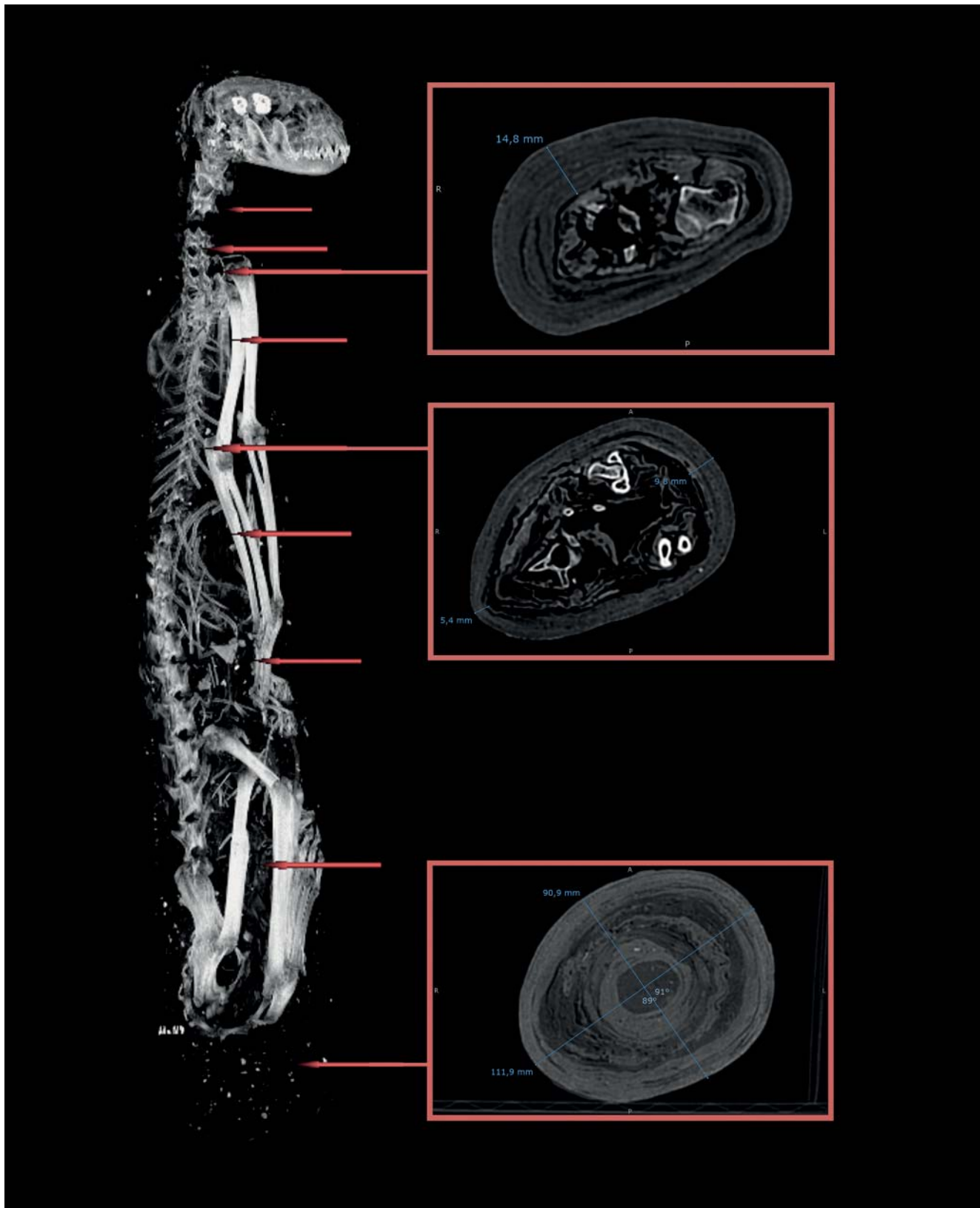


Fig. 5: Cat mummy AAa 114 with locations of cross-sections where the layers of textile were counted indicated (Image: Chiara Villa)

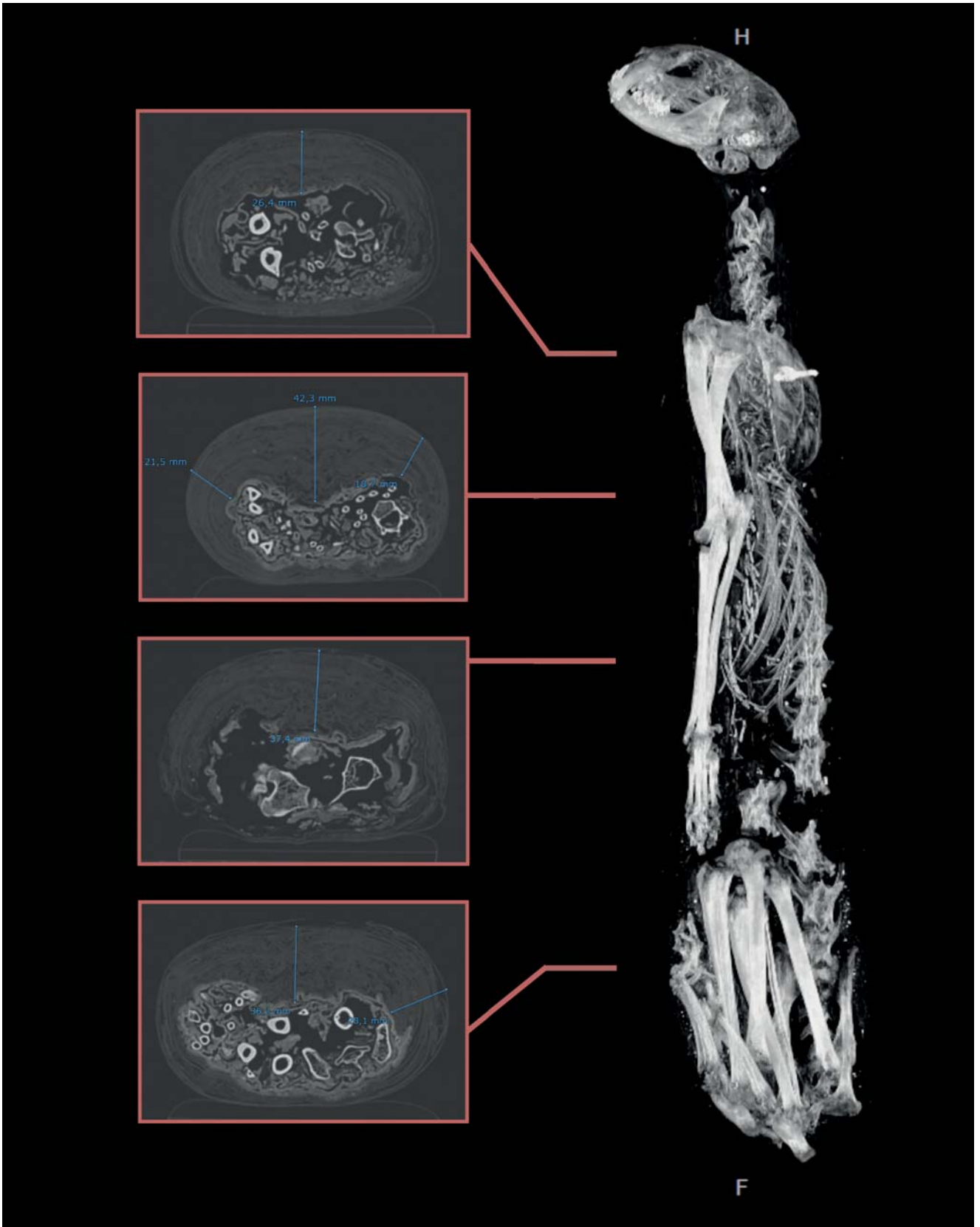


Fig. 6: Cat mummy AAa 6 with locations of cross-sections where the layers of textile were counted indicated (Image: Chiara Villa)



which have been removed. The total used must therefore have been considerably larger.

For AAa 6, the external surface of the mummy measures around 0.23 m². The number of layers at four different points along the mummy were measured.

They varied from five to 11 layers (fig. 6). Using a conservative estimate of seven layers, the quantity of textile used for the mummy equals 1.61 m². This excludes the textile packing used to even out the shape of the body.



Fig. 7: Overview of AAa 114 and Dino-Lite photographs of bandages. The black bars are 1 mm long (Images: Luise Ørsted Brandt and Anne Haslund Hansen)

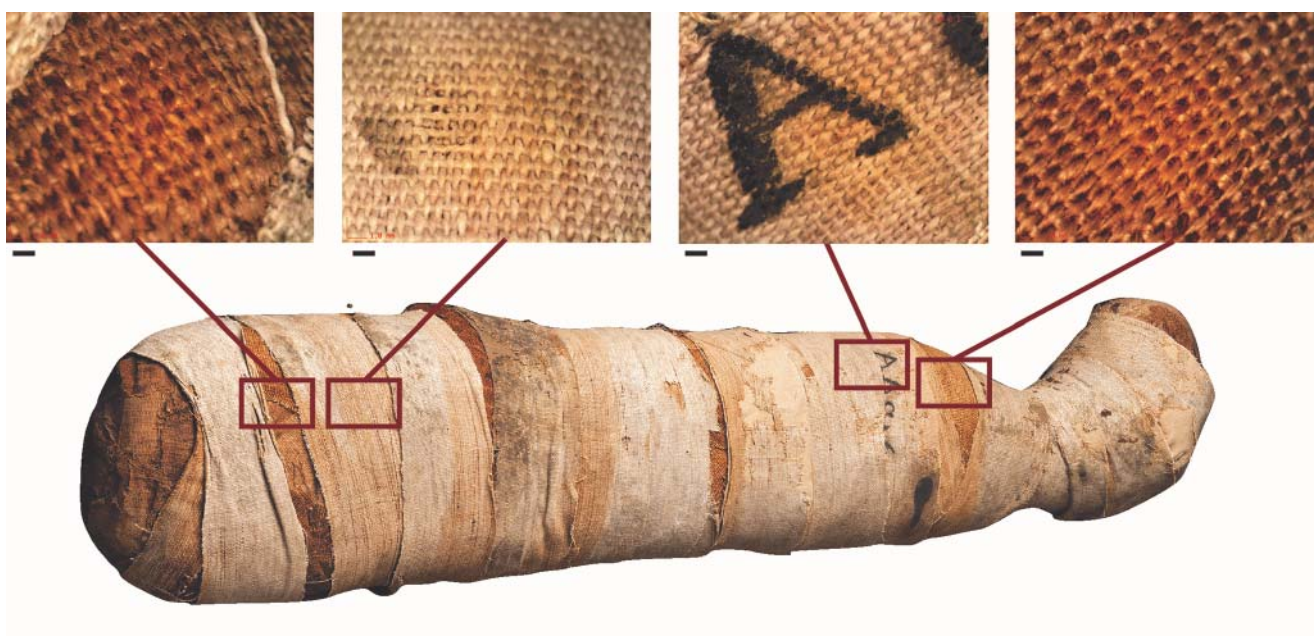


Fig. 8: Overview of AAa 6 and Dino-Lite photographs of bandages. The black bars are 1 mm long (Images: Torben Eskerod and Luise Ørsted Brandt)



AAa 114	Description	Place	Weave	Spinning direction	Thread count threads per cm*
Sample 1	Black current surface	Body of mummy	Tabby	S	13 / 32
Sample 2	Light overlying layer	Body of mummy	Tabby	S	18 / 36
Sample 3	Light overlying layer	Head of mummy	Tabby	S	20 / 40
AAa 6	Description	Place	Weave	Spinning direction	Thread count
Sample 1	Inner bandage	Shoulder girdle	Tabby	S	9 / 22
Sample 2	Inner bandage	Bottom of body of mummy	Tabby	S	9 / 22
Sample 3	Outer bandage	Body of mummy, lower	Tabby	S	14 / 28
Sample 4	Outer bandage	Body of mummy, upper	Tabby	S	13 / 31

Table 1: Results of the visual inspection using Dino-Lite. * It was not possible to recognise the warp or weft, although the most dense thread system is likely to represent the warp.

External inspection of the bandages

Photographs of the external textile surface of AAa 114 and AAa6 were taken in places where the surface was large enough to provide evidence for threads per centimetre, and as flat as possible to avoid distorting the image. Places where the bandages did not appear to be stretched were preferred (fig. 7 and fig. 8).

The black layer of bandages on AAa 114 appeared homogeneous so one spot was used for the calculation of the thread count because the glossy reflective surface was hard to photograph. All fabric weaves are tabby and the thread s-spun (table 1). Tabby weaves and s-spinning were very common in ancient Egypt as well as for the majority of extant ancient Egyptian textiles (Vogelsang-Eastwood 2000). All weaves are faced, meaning they have more threads in one direction (warp or weft) than the other. The thread counts vary from 9 x 22 threads/cm to 20 x 40 threads/cm. Both mummies have at least two different types of weaves represented which is as documented for other animal mummies (Bleiberg et al. Bruni 2013, 127-128). Both mummies have the coarser weave innermost and the finer one on top, where it could be seen.

Calculation of working time

Based on the thread counts, the time spent producing the linen cloth for the bandages was calculated. The calculations are based on the inner bandages for both mummies because, for AAa 114, this is the quality of the extant bandages, and for AAa 6, this is the quality of the majority of the bandages (except for the one or two outermost layers). The production time is an important aspect when considering textiles as

one of the necessary resources for the animal cults. Unfortunately, no experiments determining the time spent producing textiles with Egyptian tools are known to be published. Therefore, if one wishes to gain an impression of the time invested, one has to use the few published experiments available, which may of course not be directly comparable to ancient Egyptian technology. A major obstacle is that the use of different technologies may provide differing production times. In addition, in experimental archaeology, modern craftspeople will have a different expertise and skills from ancient craftspeople: for example, efficiency has been shown to vary even between modern spinners (Mårtensson et al. 2006). It is therefore important to emphasise that such experiments always provide approximations of the time spent in textile production. Nevertheless, they have been extremely valuable in indicating the many processes involved in textile production and that collectively they represent very time-consuming work. Future experiments using ancient Egyptian technology may provide a closer approximation. The experiments in spinning and weaving linen by Ejstrud et al. 2011 at Ribe Viking Center (Denmark) using Viking Age technology are used here because they are currently the only known published examples using flax, and they have been used previously to estimate textile production time in ancient Egypt (Drewsen 2019). The most common spinning equipment used in ancient Egypt was, as in this experiment, a drop spindle (Salem and Al-Khalek; Vogelsang-Eastwood 2000, 272). Sources for the looms used in weaving in the different eras are few, but, most likely several different types were



in use simultaneously. In the New Kingdom, 16th to 11th century BCE, both the horizontal loom and the vertical two-beam loom seem to have been in use in Egypt, and in the Ptolemaic and Roman periods, the warp-weighted loom was in use at sites dominated by a non-Egyptian population (Mossakowska-Gaubert 2020). It cannot be determined which loom was used for the cat mummies' textiles, as the bandages have no selvages, and they may come from multiple different looms. Therefore, two calculations for the weaving time of tabby are used here: one using a warp-weighted loom (Ejstrud et al. 2011) and one using calculations for a reconstruction of the Chalcolithic Period linen shroud of The Cave of the Warrior, in the southern Levant, with a ground loom (Levy & Gilead 2013). The Ejstrud et al. tests showed that a modern experienced spinner can spin an average of about 56 m of thread per hour and that an experienced weaver can produce an average of 5 cm of fabric (to a width of 95 cm) per hour on a warp-weighted loom (Ejstrud et al. 2011, 62, 67). Levy and Gilead's calculations suggest that a team of five (two skilled weavers and three children) can produce a 7 m linen textile (to a width of 2m) in 480 hours, that is 5 cm in 1.37 hours for each of the five persons, on a ground loom (Levy & Gilead 2013, 42). The thread count of 13/32 threads per cm is equal to a total of 4,500 m of spun yarn for the bandages of AAa 114. Using the estimate of 56 m thread spun per hour, this equals 80 hours of spinning. With an approximate 1 m width, weaving 1 m² would have taken about 20 hours following Ejstrud et al. and about 34 hours following Levy and Gilead. The experiment at Ribe Viking Center was performed with 22 warp threads and 12 weft threads per cm and Levy and Gilead's calculations are based on a thread count of 12/17-18. A higher number of warp threads might have extended the required time. In total, therefore, at least 100 hours was spent spinning and weaving the bandages for cat mummy AAa 114. This is based on a conservative minimum quantity of textile and does not take the missing outer layer into account. This also excludes time spent harvesting and processing the flax and setting up the loom (Ejstrud et al. 2011; Levy & Gilead 2013), which were also time-consuming processes involving many different steps (Vogelsang-Eastwood 2000, 269-271; Andersson Strand 2012).

For item AAa 6, the bandages with a thread count of 9/22 are estimated to contain 3,100 m of spun yarn per square metre. That equals 4,991 m and 89 hours of spinning for the conservatively estimated number of layers, excluding the textile packing. The thread count of the inner layer is approximately equal to the set up used by Ejstrud et al. and results in 32 hours spent

weaving the linen, and about 55 hours following Levy and Gilead. In total, using the proposed experiments with their inherent approximations, spinning and weaving of the bandages would require 121 or 144 working hours, respectively.

Even with the above described difficulties of using such experiments, it is clear that the working time invested in producing such bandages must have been enormous using either a warp-weighted loom or a ground loom. Droß-Krüpe discusses the use of time spent to weave linen based on Egyptian papyri from the Roman period. Her estimation that one weaver can produce 1 m² of linen in 107 hours supports the substantial use of time spent on weaving (Droß-Krüpe 2011, 82).

Consumption of textiles by animal cults

The quantities of textile used may vary between and within animal species according to their size and depending on whether the bandaging was meticulous or cursory. Nevertheless, the minimum estimates provided for the cat mummies at the National Museum of Denmark indicate a high demand for linen for wrappings. This could have been in the range of tens of thousands of square metres every year for a single catacomb such as the Dog Catacombs of Saqqara or the Ibiotapeion of Tuna el-Gebel. In large necropolises with multiple cults, the demand for textiles for bandaging must have been immense. The numbers provided here do not take the linen used during mummification before the final wrapping into account. The high demand for textiles at necropolises is also demonstrated by the Sarapieion archive's evidence of Ptolemais, son of Glaukias, who served as a detainee in the Memphite Sarapieion at Saqqara in the second century BCE (Thompson 2012, 209-212). Here, he profited by trading in cloth because linen was in high demand for shrouds, padding and bandages for mummies. Judging from this description, at least some of the textiles that entered embalming workshops were purchased, although it can be speculated that others were donated as offerings.

The calculations provided here confirm the well-established notion that textile production was a time-consuming process in ancient society and the time invested in textile production in ancient Egypt must have been enormous. The prices of textiles are described in several sources. They varied very much depending on quality and garment type (e.g. Thompson 2012, 210-211). A trade in second-hand textiles also seems to have made up part of the market (Janssen 1975). However, the linen qualities described are difficult to match to linen found in the archaeological record. It is



therefore not straightforward to estimate the economic value of the bandages. Since textiles were circulated and reused to a large extent, even recycled textiles must have had a reasonable value. This is supported by a papyrus including a price list of the items found in a Greco-Roman embalmer's cache which lists linen cloth as the most valuable resource (Ikram & Dodson 1998, 105). The *Archive of Hor* also states a price for bandaging of mummies (Ray 1976, 145). However, the value of the currency listed is unknown.

The mummies studied here each consisted of at least two different qualities of textile, which confirms previous studies showing that several qualities were available for the embalmers. It also indicates that they might be made of reused textiles, as with other mummy bandages. That high numbers of textiles were used for human mummies has been acknowledged for a long time: e.g. the 375 m² of cloth used for the mummy of Wah (Vogelsang-Eastwood 2000, 295). However, the present study shows that high numbers of textiles were also needed for animal cults, that the quantities required in necropoles was much more substantial than hitherto recognised, and that reused textiles must have made up a significant part of the resources needed in the embalming workshops. The quantities calculated here illustrate that textiles were of great importance in the animal cults. It may be that their role extended beyond the practical use of enclosing the remains to a ritual role in transforming them and aiding their passage into the afterlife (Riggs 2014).

Concealing and displaying

All of the three specimens investigated demonstrate how textiles were used to mould and change the appearance of the body of the mummy. In AAa 6, textiles were used to make the body more symmetrical, probably to make it more appealing to the pilgrims who would buy it. The textile bottom of AAa 114 could have had the function of stabilising the mummy if it was to be displayed standing or it could simply have been applied to make it appear larger. The properties of textiles make them ideal for modelling, which is clear in the construction of the modelled head AAa 96. For some skittle cat mummy types (of which there are multiple variations), textiles were used to enhance ears, which were important for their appearance and recognition as cats. In this way, textiles were used both to conceal the true content of the mummies (not symmetrical or missing faunal content) but also to appeal to the pilgrim through specific and recognisable characteristics with a desirable and aesthetically pleasing shape. The exterior appearance of the animal

mummies therefore seems to have been of great importance. This is supported by the placement of the finer bandages outermost. Since elaborately wrapped specimens sometimes do not contain faunal content, it is worth speculating on whether the exterior was actually more important in determining the price of the mummy than the interior.

In general, the shaping of the cats, with even exteriors and straight bodies and heads, adhere to some of the basic principles of Egyptian art, namely symmetry and frontality (Robins 1997, 19-24). In this way, the wrappings helped to create a shape which was considered to be the ideal image of the animal (Riggs 2014, 89). The compact wrapped shape would provide protection for the body in an actual and symbolic way. A wrapped body was associated with the appearance of the venerated and the divine (Riggs 2014, 144-146). It seems that the use of textiles was an aid to the mummy's perceived ability to act as a vessel for prayer.

Conclusion

This study has demonstrated that CT scanning was a non-destructive and rewarding method by which to provide a broad set of data on three specimens from the collection at the National Museum of Denmark. Furthermore, the method proved successful for the specific purpose of calculating the quantity of textile used to wrap two cat mummies and has potential for the calculation of cloth used on mummies in general. The scans showed that the two cat mummies contained complete cat skeletons, while the head was modelled entirely in textile. It was possible to estimate the age of the cats, although the precise cause of death could not be determined. The images offered good opportunities for studying the construction of the mummies, including the probable preparatory black layer of AAa 114, which may have been an optimal surface for its geometrical wrappings. The two complete items seem to represent two distinct types of cat mummy: a tightly bound mummy with modelled facial features and a more loosely wrapped mummy. It is likely that, in the future, radiocarbon dating and studies of provenance may reveal whether such types can be associated with different geographical areas or workshops or date to specific time periods.

This study also demonstrated that large quantities of textile were required for animal cults and must have made up a much needed and valuable resource at large necropoles. The textiles were, however, just one of the resources required at the embalming workshops. Nevertheless, their evidence sheds light on the complex process of mummification and emphasises



the economic and organisational requirements of the animal cults. In the future, further studies of resources for animal mummification will add to this picture.

This study is valuable for the documentation and future preservation of the mummies. Many museums contain objects collected prior to controlled excavations. This study has shown that interest in such objects can be revived by means of new methods and multidisciplinary object-based research. It is hoped that the present study will, alongside archival research, contribute to the mapping of how, and from which sites, artefacts were collected and subsequently dispersed in the “pre-archaeological” period.

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Bibliography

- Andersson Strand, E. (2012) The textile chaîne opératoire: using a multidisciplinary approach to textile archaeology with a focus on the Ancient Near East. *Paléorient*. [Paleorient and CNRS Editions, CNRS Editions], 38(1/2), 21–40.
- Armitage, P. L. & Clutton-Brock, J. (1980) An investigation of the mummified cats held by the British Museum (Natural History). *Masca Journal Philadelphia, Pa*, 1(6), 185–188.
- Armitage, P. L. & Clutton-Brock, J. (1981) A radiological and histological investigation into the mummification of cats from Ancient Egypt. *Journal of archaeological science*, 8(2), 185–196.
- Baber, T. T. (2019) Early Travellers and the Animal ‘Mummy pits’ of Egypt. Exploration and Exploitation of the Animal Catacombs in the Age of Early Travel. In: Porcier, S., Ikram, S., and Pasquali, S. (eds) *Creatures of Earth, Water, and Sky. Essays on animals in ancient Egypt and Nubia*. Leiden: Sidestone Press, 67–86.
- Benson, G. G., Hemingway, S. R. & Leach, F. N. (1979) The analysis of the wrappings of mummy 1770. *The Manchester Museum Mummy Project*. Leeds: Maney and Son, 119–136.
- Bleiberg, E., Barbash, Y. & Bruno, L. (2013) *Soulful creatures: animal mummies in ancient Egypt*. New York: Brooklyn Museum.
- Brandt, L. (2019) Hundenes katakomber i Sakkara. *Sfinx*, 42(4), 4–7.
- Buhl, M.-L. & Christensen, O. (1969) De gamle ægyptere og røntgenapparatet. *Nationalmuseets Arbejdsmark*, 141–150.
- Burleigh, R. (1980) Radiocarbon dating of animal remains from Egypt. *MASCA Journal (Mummification Supplement)*, 1(6), 188–189.
- Delvaux, L. & Warmenbol, E. (1991) *Les divins chats d’Égypte*. Leuven: Peeters.
- De Moor A., Verhecken-Lammens C. & Verhecken A. (2008) *3500 Years of Textile Art*. The Collection ART in Headquarters. Tielt, Lannoo.
- Drewsen, A. (2019) Spinning for the gods?: Preliminary observations on prehistoric textile production at Hierakonpolis, Egypt. *Archaeological Textiles Review*, 61, 3–13.
- von den Driesch, A., Kessler, D., Steinmann, F., Berteauxand, V. & Peters, J. (2005) Mummified, defied and buried at Hermipolis Magna – the sacred birds from Tuna el-Gebel, Middle Egypt. *Ägypten und Levante / Egypt and the Levant*. Austrian Academy of Sciences Press, 15, 203–244.
- Droß-Krüpe, K. (2011) *Wolle – Weber – Wirtschaft: Die Textilproduktion der römischen Kaiserzeit im Spiegel der papyrologischen Überlieferung*. Harrassowitz Verlag, Weisbaden
- Dunand F., Lichtenberg, R., Callou, C. & Letellier-Willemin, F. (2019) Des chiens et des bandelettes. In: Porcier, S., Ikram, S., and Pasquali, S. (eds) *Creatures of Earth, Water, and Sky. Essays on animals in ancient Egypt and Nubia*. Leiden: Sidestone Press, 145–153.
- Ejstrud, B., Andresen, S., Appel, A., Gjerlvsen, S., & Thomsen, B. (2011) *From Flax to Linen: Experiments with Flax at Ribe Viking Centre*. Syddansk Universitet. Marinarkæologi.
- Elliott, C. (2017) Bandages, Bitumen, Bodies and Business- Egyptian mummies as raw materials. *Aegyptiaca. Journal of the History of Reception of Ancient Egypt*, (1), 26–46.
- Gaillard, C. & Daressy, G. (1905) La faune momifiée de l’antique Égypte. *Catalogue général des antiquités égyptiennes du Musée du Caire*. Impr. de l’Institution Française d’Archéologie Orientale.
- Hald, M. (1946) *Ancient Textile Techniques in Egypt and Scandinavia: A Comparative Study*. *Acta Archaeologica*, vol. XVII, Ejnar Munksgaard, København, 49–99.
- Hall, R. M. (1986) *Egyptian textiles*. Shire Egyptology. Aylesbury: Shire Publications.
- Hansen, A. H. (2016) *Niebuhr’s Museum: Artefacts and Souvenirs from the Royal Danish Expedition to Arabia 1761–1767*. Copenhagen: Forlaget Vandkunsten.
- Ikram, S. (2005) *Divine creatures: animal mummies in ancient Egypt*. Cairo, New York: The American University in Cairo Press.
- Ikram, S. (2019) Shedding New Light on Old Corpses. Developments in the Field of Animal Mummy Studies. In: Porcier, S., Ikram, S., and Pasquali, S. (eds) *Creatures of Earth, Water, and Sky. Essays on animals in ancient Egypt and Nubia*. Leiden: Sidestone Press, 179–191.



- Ikram, S. & Dodson, A. (1998) *The mummy in ancient Egypt: Equipping the dead for eternity*. London: Thames and Hudson.
- Janssen, J. J. (1975) *Commodity Prices from the Ramesside Period*. Leiden: E. J. Brill.
- Kessler, D. & el Halim Nur el-Din, A. (2005) Tuna al-Gebel: Millions of Ibises and Other Animals. *Divine Creatures Animal Mummies in Ancient Egypt*, 120–163. doi: 10.5743/cairo/9789774248580.003.0006.
- Lenglet, G. and Institut royal des sciences naturelles de Belgique (1989) *De Katten van de Farao's: 4000 jaar goddelijke gratie. Tentoonstelling onder de hoge bescherming van Hare Majesteit de Koningin. Catalogus, 27 oktober 1989 - 25 februari 1990*. Bruxelles: Koninklijk Belgisch Instituut voor Natuurwetenschappen.
- Levy, J. & Gilead, I. (2013) The Emergence of the Ghassulian Textile Industry in the Southern Levant Chalcolithic Period (c. 4500-3900 BCE). In: M.-L. Nosch, H. Koefoed and E. Andersson Strand (eds.) *Textile Production and Consumption in the Ancient Near East*. Oxford: Oxbow Books, 26-44.
- Malek, J. (1997) *The Cat in Ancient Egypt*. London: British Museum Press.
- Mossakowska-Gaubert, M. (2020) A new kind of loom in Roman Egypt? How iconography could explain (or not) papyrological evidence. In Mossakowska-Gaubert, M. (ed.) *Egyptian textiles and their production: 'word' and 'object'*. Lincoln, Nebraska: Zea Books 13-21.
- Mårtensson, L., Andersson, E., Nosch, M.-L. & Batzer, A. (2006) Technical Report Experimental Archaeology, Part 2,2, Whorl or bead, 2006. Tools and Textiles – Texts and Contexts Research Program. The Danish National Research Foundation's Centre for Textile Research, University of Copenhagen.
- Naville, É., Loat, W. L. S. & Eric Peet, T. (2014) *The Cemeteries of Abydos*. Cambridge: Cambridge University Press.
- Nicholson, P. T. (2005) The Sacred Animal Necropolis at North Saqqara. *Divine creatures: Animal mummies in ancient Egypt*. Cairo, New York: The American University in Cairo Press, 44–71.
- Nicholson, P. T., Ikram, S. & Mills, S. (2015) The Catacombs of Anubis at North Saqqara. *Antiquity*. Cambridge University Press, 89(345), 645–661.
- Persson, C. P. (2017) See inside three Egyptian mummies. *ScienceNordic*, 12 April. Available at: <https://sciencenordic.com/archaeology-denmark-history/see-inside-three-egyptian-mummies/1444715>. Accessed 17 June 2020.
- Ray, J. D. (1976) *The Archive of Hor: texts from excavations*. Oxford: University Press.
- Richardin, P., Porcier, S., Ikram, S., Louarn, G. & Berthet, D. (2017) Cats, Crocodiles, Cattle, and More: Initial Steps Toward Establishing a Chronology of Ancient Egyptian Animal Mummies. *Radiocarbon*, 59 (2), 595–607.
- Riggs, C. (2014) *Unwrapping Ancient Egypt: The Shroud, the Secret and the Sacred*. London, New York: Bloomsbury Publishing.
- Robins, G (1997) *The Art of Ancient Egypt*. Cambridge, Massachusetts: Harvard University Press.
- Selem, M. A. M. & Al-Khalek, S. A. (undated) *Egyptian Textile Museum*. Ministry of Culture.
- Smith, R. N. (1969) Fusion of Ossification Centres in the Cat. *Journal of small Animal Practice*, Vol. 10, 1969, 523-530.
- Tarek, A., Abdel-Rahman, M., Mohamed, N., Khairy, A. & Abedellatif, A. (2019) Study of Different Wrapping Types on Ibis Mummies from Tuna-el-Gebel, Hermeopolis. In: Porcier, S., Ikram, S., and Pasquali, S. (eds) *Creatures of Earth, Water, and Sky. Essays on animals in ancient Egypt and Nubia*. Leiden: Sidestone Press, 315-322.
- Thompson, D. J. (2012) *Memphis under the Ptolemies. Second edition*. Princeton and Oxford: Princeton University Press Princeton.
- Villa, C., Frohlich, B. & Lynnerup, N. (2019) The Role of Imaging in Paleopathology. In: *Ortner's Identification of Pathological Conditions in Human Skeletal Remains*. Elsevier, 169–182.
- Vogelsang-Eastwood, G. (2000) *Textiles. Ancient Egyptian Materials and Technology*. Cambridge: Cambridge University Press.
- Wasef, S., Wood, R., El Merghani, S., Ikram, S., Curtis, C. Hollande, B., Willerslev, E., Millar, C.D. & Lambert, D.M. (2015) Radiocarbon dating of Sacred Ibis mummies from ancient Egypt. *Journal of Archaeological Science: Reports*, 4, 355–361.
- Winlock, H. E. (1941) *Materials used at the embalming of King Tut-'Ankh-Amun*. New York: The Metropolitan Museum of Art.
- Zivie, A. and Lichtenberg, R. (2005) The cats of the goddess Bastet. *Divine Creatures: animal mummies in ancient Egypt*. Cairo and New York: The American University in Cairo Press, 106–119.

Internet sources

Penn Museum, Philadelphia, US, inventory number E 11475 <https://www.penn.museum/sites/artifactlab/files/2013/08/Cat-head-above-below.jpg> (accessed 16 June 2020)

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