

A Radiological and Histological Investigation into the Mummification of Cats from Ancient Egypt

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An examination has been carried out on a series of wrapped mummified cats from Ancient Egypt that are held in the British Museum (Natural History). The cats, which were unprovenanced and undated, were presented by Sir Flinders Petrie at the beginning of this century, but they were not registered in the collections and have never been described. Radiocarbon dates have now been obtained for two of the cats and radiographs have been taken of each one to establish its identification and age at death. Attempts were made to reconstitute the skin tissue and samples of hair were studied by electron microscopy.

Keywords: ANCIENT EGYPT, THE LATE PERIOD, PTOLEMAIC PERIOD, ABYDOS, DENDERAH, BRITISH MUSEUM (NATURAL HISTORY), MUMMIFIED CATS, *FELIS CHAUS*, *FELIS SILVESTRIS LIBYCA*, *FELIS BUBASTIS*, RADIOCARBON DATING, RADIOLOGY, HISTOLOGY, AGEING, RECONSTITUTION OF SKIN TISSUES, SKELETONS, HAIR FIBRES.

Introduction

Cats are the most familiar of the Egyptian mummified animals and at the end of the last century so many were excavated that boatloads were exported from Bubastis and other sites, either to be spread upon the ground as fertilizer or, it is said, for use as ballast. Considering the huge numbers of cats that were removed from Egypt at this time, rather a small proportion has survived in museum collections. At the British Museum (Natural History) there is a total of 244 skulls and wrapped mummies, one of the skulls being the sole relic of a consignment of 19 tons of mummies that were imported to Britain.

Besides this one skull that came to the Museum from the Royal College of Science in 1900 (No. 90.3.7.1.) there is a series of 190 skulls of cats from Gizeh that were presented by Sir Flinders Petrie in 1907 (Nos. 7.8.3.1–150 and 163–202). Three of these skulls are much larger than the rest and can be clearly identified as *Felis chaus* whilst the remaining 187 have been ascribed to *Felis silvestris libyca*, the sand cat (Figure 1). They are, however, mostly rather larger than the present day Egyptian wild cat of this species (Morrison-Scott, 1952).

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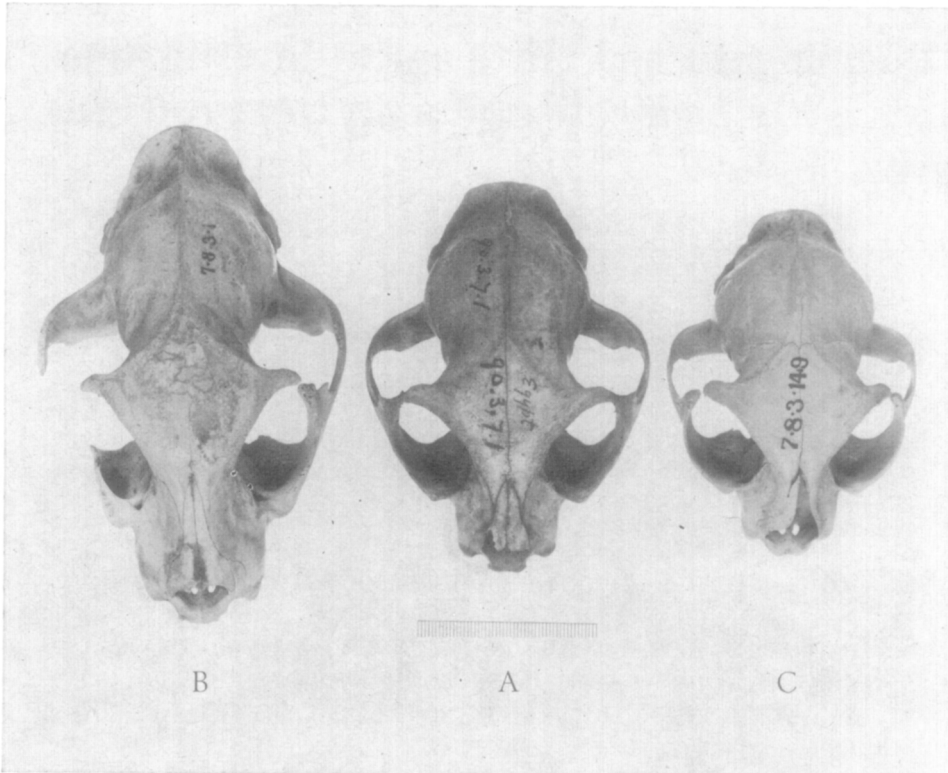


Figure 1. The skulls of three mummified cats from Ancient Egypt in the British Museum (Natural History): A—*Felis silvestris libyca* unprovenanced. B—*Felis chaus* from Gizeh. C—*Felis silvestris libyca* from Gizeh.

Felis chaus, the jungle or marsh cat, is a medium sized felid with a long head and short tail. It is found in North Africa and Asia. In Egypt this cat can be reddish yellow in colour but throughout the rest of its range it is usually grey (Figure 2). *Felis silvestris libyca*, the common wild, or sand cat of Egypt and western Asia is a smaller cat with a relatively much longer tail (Figure 3). In Egypt it is usually sandy-coloured, rather like the modern domestic breed of "Abyssinian" cat, and it is this race, or its domesticated form, that is assumed to be represented in the Ancient Egyptian paintings of cats. There is indeed good evidence to indicate that it is this subspecies of *Felis silvestris* that has played a major role in the ancestry of all modern domestic cats and there is no indication that any other species of cat, including *Felis chaus*, has been involved in the domestication process (Kratochvíl & Kratochvíl, 1976).

What is puzzling, however, is that the mummified cats in the British Museum (Natural History) are mostly rather larger than the modern *F. s. libyca*. This fact was noticed by Ehrenberg as early as 1833 when he described the mummified cats that he saw, and named *Felis bubastis*, as being halfway in size between *Felis chaus* and the modern domestic cat. It is strange that the mummified cats should be larger if they are a domesticated form of the African wild cat because in general the domesticated form of an animal is considerably smaller, especially in its cranial capacity, than its wild progenitor, at least in the early stages of domestication (Hemmer, 1975). It is therefore clear that there is more work to be done on the origins of the Ancient Egyptian cats and the present authors are continuing with this study.

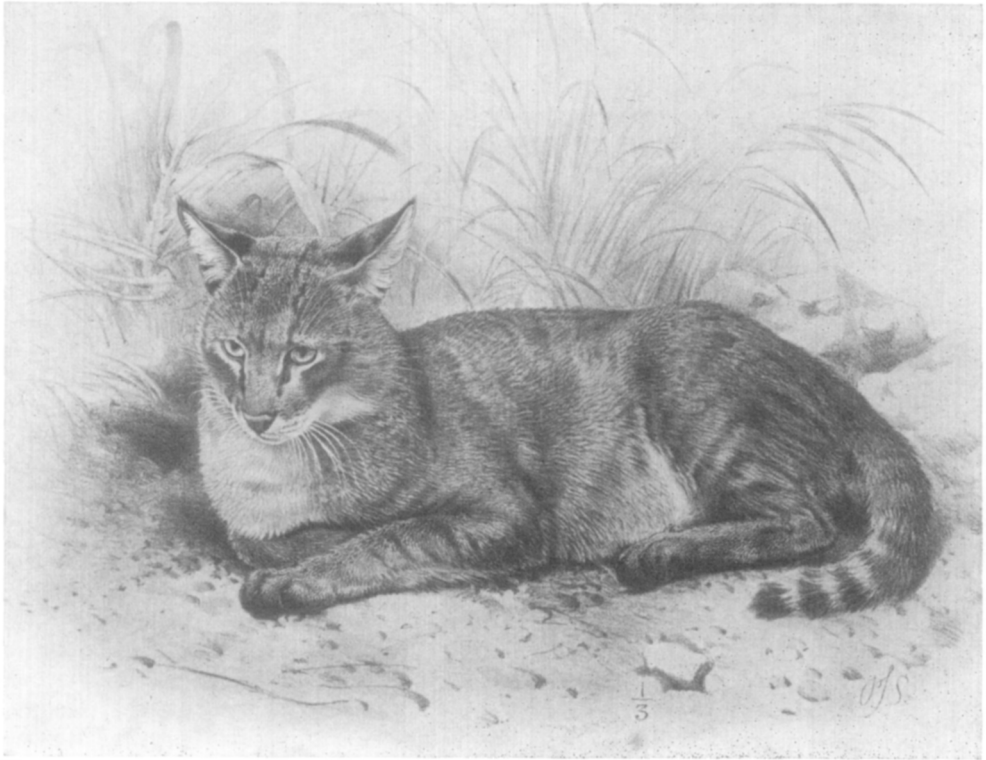


Figure 2. *Felis chaus*, from Anderson (1902).

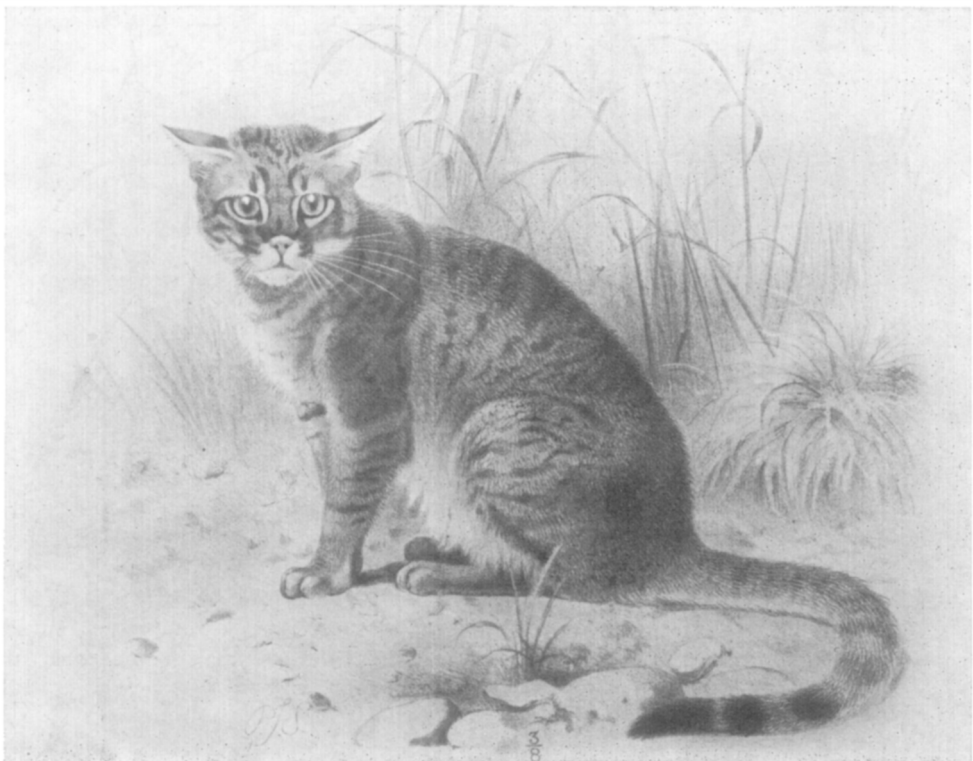


Figure 3. *Felis silvestris libyca*, from Anderson (1902).

In addition to the one skull of unknown provenance and the 190 skulls from Gizeh there is in the British Museum (Natural History) a collection of 53 mummified cats that are still wrapped and which are mostly complete. It was the examination of this collection that prompted this paper.

The mummies were presented by Sir Flinders Petrie, probably all at one time in about 1900 but unfortunately, as with much of the biological material that was collected and distributed by Petrie, there is almost no information on their locality or period. There is no mention of the collection in any of the correspondence or distribution lists, drawn up by Petrie, that were available to us, and we can only surmise that at least some of the cats came from Abūdos and a note from Petrie about other animal remains from this site indicates that he believed them to belong to the Twenty-fifth to Thirtieth Dynasties (*c.* 747–343 BC). The mummified cats were packed together and the collection has the appearance of having come all from one site, but this may not be so, and it is possible that some of the cats came from Denderah.

Dating of the Mummies

Historical evidence suggests that the collection of mummified cats dates to the end of the Late Period (Twenty-sixth to Thirtieth Dynasties, *c.* 664–343 BC) but to verify this, samples of the linen wrappings taken from two of the cats were subjected to radiocarbon dating (as part of a long term project on the radiocarbon dating of animal remains from Ancient Egypt). Full details of the measurements are described by Burleigh (1980) and the results of the tests only are presented here with the comment that the date obtained for specimen 79.5372 falls within the expected period whilst that for cat 79.5420 is somewhat later and falls within the Ptolemaic Period (*c.* 332–30 BC).

Table 1. Radiocarbon dates for linen wrappings from the mummified cats

Lab. No.	BM(NH) No.	Radiocarbon date (5570 yr half-life)	Calibrated date, <i>c.</i>
BM-1547	79.5372	2220 ± 40 bp (270 bc)*	380 BC‡
BM-1548	79.5420	2110 ± 45 bp (160 bc)*	170 BC‡

*bp=Radiocarbon years before present. bc=Radiocarbon years before Christ.

‡BC=The date after calibration to calendar years before Christ. The apparent discrepancy between these dates when compared with the uncalibrated radiocarbon dates is due to wiggles in the calibration curve (Clark, 1975; Burleigh, pers. com.).

Techniques of Mummification

Radiological examination of the mummified cats showed that the bodies had all been packaged in the same manner by the embalmers. In order to produce a compact cylindrical mummy the head had been set at right angles to the neck which was fully extended. The forelimbs were stretched down along the front of the body, whilst the hind limbs were tucked up against the pelvis with the tail curled up between the feet. In the young cats the pressure of the binding had usually caused the rib cage to collapse (Figure 4) but with adult animals it remained fully expanded with the ribs in place.

Eight of the mummies were elaborately bound with a geometric pattern of light and dark bandages (Figure 5). This bandaging is similar in pattern to that of human mummies of the Ptolemaic period (Carol Andrews, pers. comm.), and it accords well with the radiocarbon date that was obtained for cat 79.5420 (Table 1). The remaining cats were all wrapped in plain uncoloured bandages with only one of the mummies having a painted head (Figure 6).

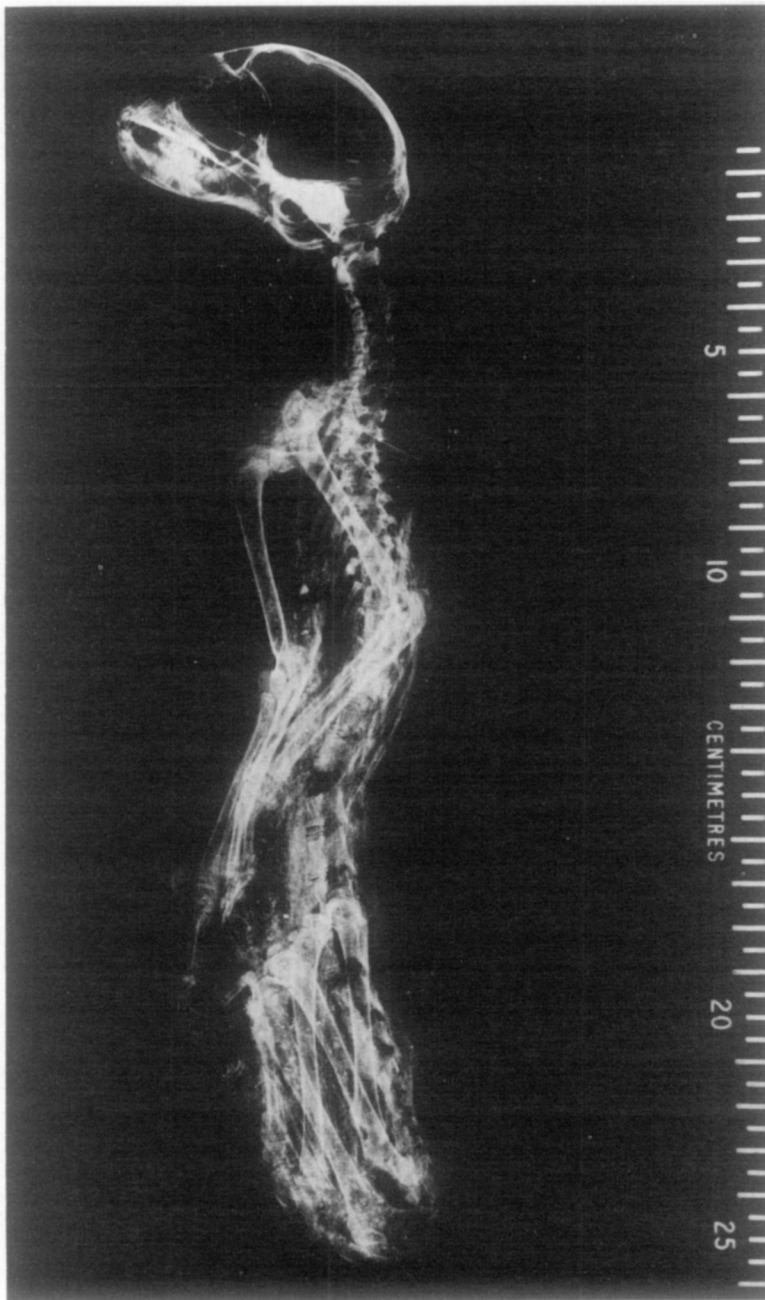


Figure 4. Radiograph of a mummified cat to show the arrangement of the body (No. 79.5366).

In order to try to find out how the mummies had been prepared by the embalmers attempts were made by Mr R. Harris to reconstitute the skin tissue from four of the cats (A–D), using the technique devised by Sandison (1971). The heads of cats A (79.5372) and B (79.5421) were immersed in 1% aqueous sodium orthophosphate for several hours which completely destroyed the tissue, showing that no efforts had been made by the Ancient Egyptians to embalm or preserve the corpses of these cats by direct immersion in natron (sodium carbonate). If a preservative such as natron had been used directly on the freshly dead corpses it should have been possible to restore the skin to more or less its original condition with sodium orthophosphate.

Because of the failure to reconstitute the skin from cats A and B it was decided to pretreat the heads of cats C (79.5406) and D (79.5407) with Steedman's fixative (a formaldehyde – phenoxetol – propylene glycol – water formula). This prevented the breakdown of the tissues and the reconstitution of these specimens was moderately successful.

Samples of tissue previously removed from cat B were then analysed by Mr A. J. Easton using atomic absorption spectroscopy and this confirmed that no chemical salt had been applied directly to the skin of this cat. Only very low concentrations of sodium were detected and these were consistent with the traces of sodium found naturally in Egyptian soils. This cat was unlike the other three mummies used in these tests, however, because it had patches of a brownish-black substance coating the hair. This was examined under infra-red spectrophotometry but no definite conclusions were made about its identity; it is most likely to be the resin that was commonly used in the embalming process by the Ancient Egyptians on both animal and human corpses.

Although the reconstruction experiments indicate that no attempts had been made to preserve the body tissues of cats A and B with sodium salts such as natron, analysis of hairs from cat A showed that unlike the skin they were coated with mineral crystals. In 10.9 mg of hair the sodium concentration was 3.6% (BM(NH) lab. No. 3945), and scanning electron microscope examination showed that the surface of each hair was covered with minute needle-like crystals. Furthermore these crystals were in much higher concentrations at the tips of the hairs than towards the roots. This finding led us to make the following assumptions about the mummification of this cat. The animal had died or had been killed. Then it had been eviscerated and the head, limbs, and tail had been arranged in the prescribed manner whilst the corpse was still fresh. No embalming salts or resin had been used directly on cat A but it had been bound with bandages that were soaked in natron. This had spread through to the surface of the cat's fur but had not penetrated the skin.

Cat B, on the other hand, had been treated with resin but there was no evidence of natron on any of the hair. Thus it can be seen that there were two methods of mummification, one using natron-soaked bandages and the other using resin applied directly to the corpse.

After the cats were eviscerated it appears that the body cavities of some of the corpses had been filled with earth or sand; a practice that is known from examination of other animal and human mummies. This earthy material shows up on the radiographs as opaque granules and it may have been placed in the body as packing, and to absorb moisture.

Microscopy of the Hairs of the Mummified Cats and Comparative Material

We were interested to find out what the mummified cats would have looked like as living animals and how their pelage compared with that of present day cats, both wild and domestic. For this purpose we selected hairs from six of the mummies (BM(NH) Nos.

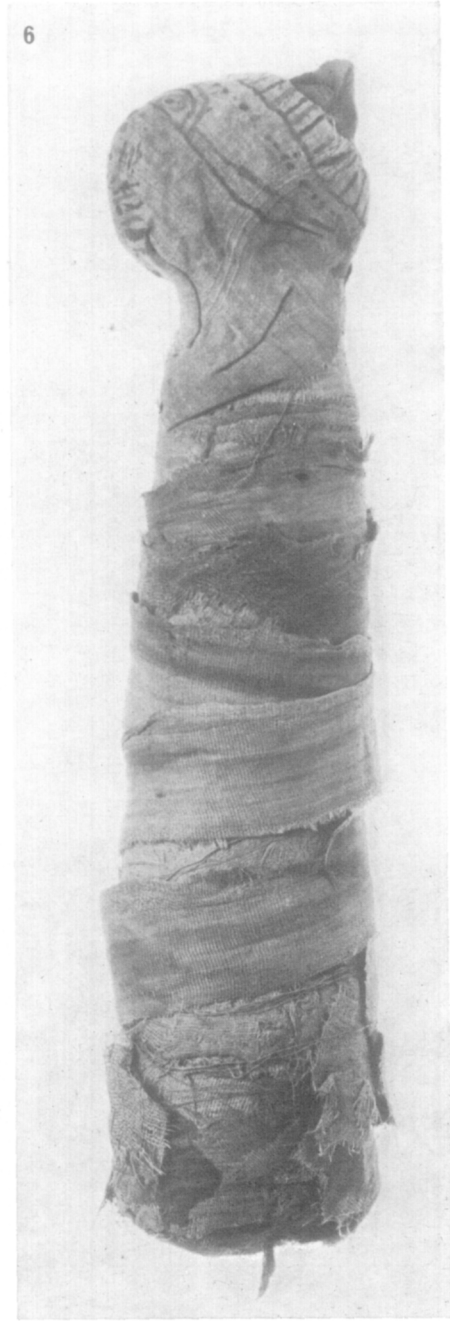


Figure 5. Elaborate bandaging of one of the cats, of which the head is missing (No. 79.5361). Figure 6. Simple bandaging of the only mummy with a painted head (No. 79.5351).

79.5369, 79.5372, 79.5375, 79.5390, 79.5397, 79.5421) and compared them with hairs from skins in the collection of the British Museum (Natural History) belonging to *Felis silvestris libyca*, *Felis chaus* and North African domestic cats. Like those of all *F. s. libyca* and *F. chaus* it could be seen under the light microscope that the outer guard hairs of the mummified cats were speckled and banded in a characteristic way that is common to many wild mammals and is known as "agouti" after the South American rodent of that name. This banding indicates that the cats probably looked very like the living *F. s. libyca* with fur that was tawny-yellow-grey in colour and had markings that were similar to those of a striped tabby or "Abyssinian" domestic cat.

The hairs of the mummified cats and comparative specimens were measured and further examined by use of the scanning electron microscope (Stereoscan 180). The information obtained from this detailed examination is given below.

The size of the hairs

Fifteen guard hairs from the skins of four cats were measured using an automatic measuring device (Stogate sensor micrometer linked to an automatic data recorder), the measurement being taken at the widest point below the tip, and the results are given in Table 2.

We were aware from the descriptions given by Wildman (1954), Brunner and Coman (1974) and other workers, that size and form of hair varies over the body. In order to eliminate as far as possible this disparity and so compare directly the different cats, the sample of 15 guard hairs from each of the modern animals and the one mummified cat were all removed from one location only, around the neck region of the pelage.

Table 2. Measurements of the guard hairs of a mummified cat to compare with those of present day wild and domestic cats. The maximum diameter was taken in the shield region and is given in μm

Species	BM(NH) Reg. No.	Sex	Age	Diameter (μm)				
				<i>n</i>	<i>m</i>	Range	s.d.	s.e.
<i>Felis chaus</i>	98.6.5.4	♀	adult	15	126.8	93-156	21.1	5.4
<i>Felis silvestris libyca</i>	70.678	♀	adult	15	104.6	74-135	17.7	4.6
Domestic cat	44.27	♂	adult	15	109.7	86-143	15.8	4.1
Mummified cat	79.5375	?	adult	15	90.1	69-117	15.0	3.9

n = Number of fibres. *m* = Mean (estimated by average value of the observations on the variate). Range = Observed size range (lowest and highest values of variate). s.d. = Standard deviation. s.e. = Standard error of the mean.

It can be seen from this table that the guard hairs of *Felis chaus* have a greater diameter than those of either the mummified cat, *F. s. libyca*, or the modern domestic cat, all of which are rather similar in size as would be expected since they are assumed to represent only one species.

Cuticular scale patterns

It has often been suggested, as for example by Brunner & Coman (1974), that the microscopic patterns of cuticular scales can be used to help with the identification of species from hairs. We therefore used the scanning electron microscope (Stereoscan 180) to study the size, shape, and arrangement of the cuticular scales on the guard hairs of the mummified cats and of the modern comparative specimens (*Felis chaus*, *F. s. libyca*, and domestic cats). As shown in Table 3 and Figure 7, however, we were not able to discern any differences between *F. chaus* and the other cats in respect of these characters. Only in one of the two specimens of *F. s. libyca* (70.678) was a variation observed. In this pelt the scales on the tip of each hair fibre formed what can be described as a chevron pattern.

Table 3. Cuticular scale patterns on guard hairs from ancient and modern cats

Species	BM(NH) Reg. No.	Sex	Age	Description of hair*		
				Tip	Mid-shaft	Base
1. <i>Felis chaus</i>	98.6.5.4	♀	adult	1	1	1 & 2
	19.7.7.3495	♂	adult	1	1	2
2. <i>Felis silvestris libyca</i>	70.678	♀	adult	2	1	2
	40.176	♀	adult	1	1	2
3. Domestic cat	44.27	♂	adult	1	1	2
	1.5.5.14	♂	kitten	1	1	2
4. Mummified cat	79.5369	?	adult	}	1	1
	79.5372	?	kitten			
	79.5375	?	adult			
	79.5390	?	adult			
	79.5397	?	kitten			
	79.5421	?	adult			1 & 2

*Descriptions are based on two guard fibres from each animal, both fibres taken from the neck region of the pelage. Classification of the arrangement of scales, form of scale margin and distance between scale margins follows the system of Wildman (1954) with the modifications proposed by Brunner & Coman (1974):—

Tip	1—Irregular waved, crenate, close-margins
	2—Single chevron, crenate, close-margins
Mid-shaft (shield)	1—Flattened irregular mosaic, smooth, near-margins
Base	1—Diamond petal/broad petal, smooth, distant-margins
	2—Broad petal, smooth, distant-margins.

Ageing of the Cats and Cause of Death

It was possible to age all the mummified cats in the collection on the stages of eruption of the teeth and on the fusion of the epiphyses of the limb bones. The ages of tooth eruption were deduced from data collected by Berman (1974) whilst the ages of epiphyseal fusion were based on the work of Smith (1969). Where possible each cat's age was determined on a number of centres rather than the state of fusion of individual epiphyses or eruption of single teeth. In addition comparisons were made with radiographs of modern domestic cats of known age collected by Dr Christine Gibbs and Dr S. Orr at the Veterinary School, University of Bristol.

Table 4 shows the age at death of the 53 mummified cats. As there is known to be variation in times of fusion in limb bones and eruption of teeth between individuals, we chose wide limits to each class in order to compensate for this disparity.

From Table 4, it can be seen that there are two peaks in the death assemblage, one with 20 cats between one and four months and the second with 17 cats between nine and twelve months. Only two cats survived to live more than two years. This distribution is very unlikely to reflect natural mortality and we are inclined to believe that the cats were deliberately slaughtered at two optimum ages for mummification. The first, at about four months, when the animal had reached a suitable body size for mummification. and the second, between nine and twelve months, when all those cats not required for the purpose of breeding were culled. This second group probably included a high proportion of unwanted males who were killed off before they became sexually aggressive. We were not, however, able to determine the sex of the mummified cats because in no

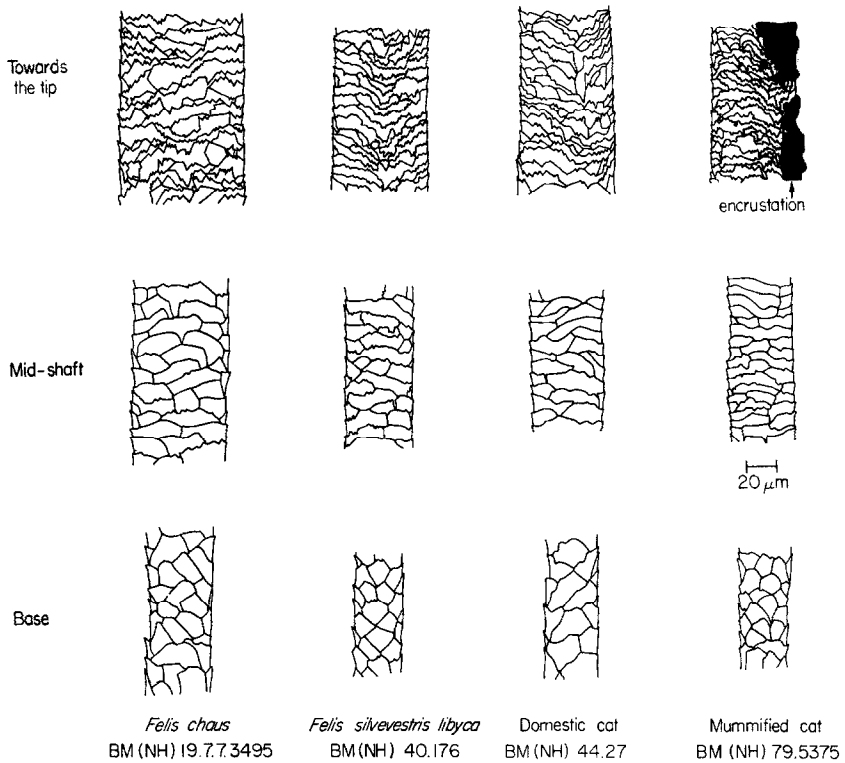


Figure 7. Cuticular scale patterns of guard hairs from ancient and modern cats.

Table 4. The estimated age at death of the Ancient Egyptian mummified cats in the British Museum (Natural History)

	Age Class (months)					
	Under 1	1-4	5-8	9-12	13-24	Over 24
Number of cats	2	20	5	17	7	2

case could we distinguish a penis bone (baculum) in the radiograph. Apart from the difficulty of separating the different bones in the pelvic region of the tightly packed mummies there could be two other explanations for the absence of these bones, either the animals were all female or the penis bones in males were removed when the cats were eviscerated.

With the exception of one cat, all the animals appear from the radiographs to have been healthy at the time of their death. In kitten No. 79.5351 (Figure 6) the cortices of the limb bones were seen from the radiograph to be abnormally thin and the vertebrae unusually small. Both these features indicate according to Orr (pers. comm., 1979) that the animal suffered from juvenile osteoporosis (nutritional secondary hyperparathyroidism). This is a nutritional bone disease brought about by a diet that is deficient in calcium (Bennett, 1976). The presence of this condition does not mean, however, that the animal was neglected or ill-treated but rather the opposite for the disease is today most commonly associated with domestic animals that are fed only on meat and it is found in the most pampered of household cats.

Juvenile osteoporosis is, in itself, not fatal but the cause of death of this kitten was revealed by close examination of the radiograph which shows that the occipital bone is separated from the base of the skull and that both the atlas and axis vertebrae are displaced. Six other cats, both kittens and adults, show a similar condition of severe dislocation of one or more of the cervical vertebrae as shown in Figure 8, and we have made the assumption that these seven cats were deliberately killed by having their necks broken. An alternative explanation is that dislodgement of the cervical vertebrae occurred

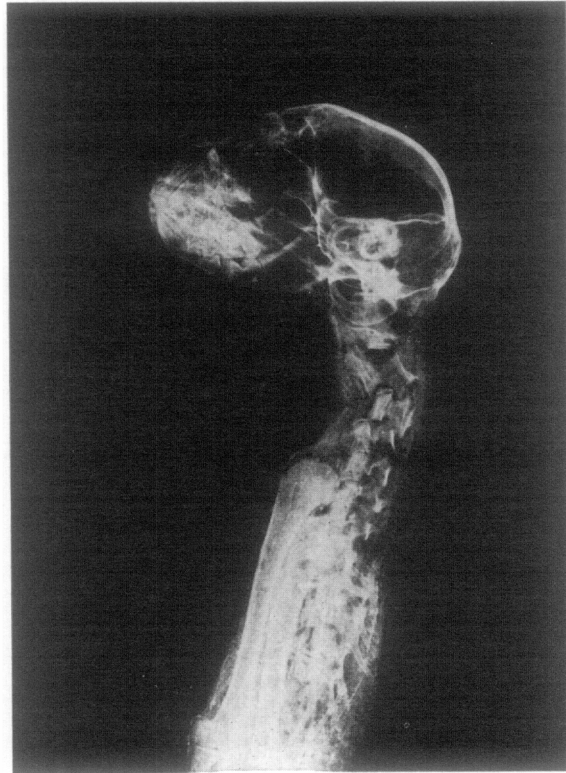


Figure 8. The head and neck of cat No. 79.5355 to show the displaced cervical vertebrae.

in these cats *post mortem* during re-arrangement of the head in preparation for wrapping the body, and that this operation took place some time after death when the body was locked by *rigor mortis* and therefore highly susceptible to this kind of damage. Examination of the rest of the skeleton of these cats does not, however, support this second interpretation. All of the bones of the fore and hind limbs, which were also re-arranged before wrapping the body, are intact and show no signs of being broken.

It was not possible to establish the cause of death in the remaining 46 cats, it may be that they were also strangled but because they struggled less violently there was no damage to the neck.

Discussion

Because Herodotus wrote at some length in *c.* 450 B.C. (Bk II, ch. 65–68) about the sacred burial places for animals and the deep affliction of the owners when their cats died,

it has become generally assumed that the Ancient Egyptians never killed cats (Rawlinson, 1970). Herodotus indeed wrote that when a cat died in a private house the owners shaved their eyebrows but it is probably a misconception that cats and other sacred animals were never killed. Although there is very little historical information on the mummification of sacred animals in the late period of Ancient Egypt it seems that both the cat and the ibis were kept in captivity in very large numbers by the priests for this purpose. It may be surmised that the cats were specially bred and reared until they were nearly full-grown. They were then killed, perhaps by strangling, and were made into mummies to be sold to the populace as votive offerings that were placed in sacred repositories. It is these votive offerings that have been excavated in such huge numbers by archaeologists over the last hundred years. Most of the mummies were simply made, with plain bandages wrapped around a barely-dried corpse, but some were much more elaborate. No doubt the price obtainable for a mummy depended on the degree of care that had gone into its preparation and the affluence of the purchaser.

Acknowledgements

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