Domestic cats (*Felis catus*) in Denmark have increased significantly in size since the Viking Age

Julie Bitz-Thorsen[a] and Anne Birgitte Gotfredsen[b].

Zoological Museum, Natural History Museum of Denmark, University of Copenhagen, Denmark

Corresponding author:

Julie Bitz-Thorsen, Email: julie.bitz-thorsen@uit.no, Norwegian College of Fishery Science, UiT – The Arctic University of Norway, Tromsø.

ORCiD

Julie Bitz-Thorsen, https://orcid.org/0000-0002-0815-5432

Word count abstract: 205

Word count main text: 6421

Number of references: 61

Number of tables: 3

Number of figures: 5

[a] The present affiliation of Julie Bitz-Thorsen is provided in the corresponding author information. The work was carried out at the given affiliation of the Zoological Museum, Natural History Museum of Denmark, University of Copenhagen, Denmark.
[b] Both authors contributed equally to the work on this article.

Domestic cats (*Felis catus*) in Denmark have increased significantly in size since the Viking Age

The earliest finds of domestic cat in Denmark date back to the Roman Iron Age (c. 1-375 AD). Initially, cats occurred sparsely and only from the Viking Age (c. 850-1050 AD) did they become more frequent in numbers, though primarily in urban contexts and in connection with fur production. In medieval times, cats became beasts of pest control in rural settlements, manorial estates as well as in the expanding towns, where large and numerous refuse heaps attracted various rodents. To investigate size trends over time of the domestic cat (*Felis catus*) in Denmark, bone measurements and statistical analyses were performed on archaeological and modern material. Domestic cats were found to increase significantly in size over time since the Viking Age. Limb bones and mandibles exhibited the most significant change in increase (up to 16%), as compared to modern female cats, and tooth size the least (c. 5.5%). The most plausible explanations for such a size increase were improved living conditions caused by increased food availability and a possible shift in human usage of the cats, from a rat and mice captor to a well-fed and well-cared pet. Despite the observed increase in size, domestic cats have kept many osteological features indistinguishable from their wild progenitor.

Keywords: *Felis catus*, domestic cat, size increase, Middle Age, Viking Age

Introduction

Domestication of cats

All domestic cats (*Felis catus)* descent from the wildcat (*Felis silvestris*) populations widely distributed over Europe, Africa and Southwest Asia (Kitchener 1991, Clutton-Brock 1999). The domestic cat we know today stems from the Middle East subspecies *Felis silvestris lybica* (Clutton-Brock 1999, Driscoll et al. 2007). One of the earliest probable finds of a domestic cat has been documented from Cyprus dated to approx. 7,500 BC (Vigne et al. 2004). Since there are no fossil records of wildcats from Cyprus, the cat must have been brought to the island intentionally by people (Clutton-Brock 2012, Vigne et al. 2004). It was a young cat buried together with a human, indicating a special bond or relation between humans and cats during the early Neolithic (Vigne et al. 2004, Driscoll et al. 2007). Furthermore, in ancient Egypt, around 3,700 BC, we find archaeological records of mummified cats suggesting a close cat-human relationship (Van Neer et al. 2014). Zooarchaeological evidence points to a commensal relationship between humans and cats lasting thousands of years before humans exerted substantial influence on their breeding (Clutton-Brock 1999, Vigne et al. 2004, Van Neer et al. 2014). This prolonged human animal relationship without leaving domestication traits on the cats was termed “commensalisation” (e.g. Vigne 2015), explained as the mutual benefits for the cats having increased food availability as formed by the many mice attracted by stored cereals and on the other hand people benefitting from this new pest control, eventually leading to domestication (Clutton-Brock 1999, Vigne et al. 2004, Vigne 2015, Van Neer et al. 2014).

The spread of domestic cat to Europe followed ancient land and maritime trading routes and Ottoni et al. (2017) showed that cats started to spread across the

Mediterranean as early as 1,700 BC and the spread was suggested to be due to their increasing popularity and usefulness on ships infested with rodents (Faure & Kitchener 2009). Between 400 and 1,200 AD, ancient Egyptian cats became substantially more frequent in the rest of Europe (Ottoni et al. 2017) and depictions of cats in domestic contexts are found on Greek artefacts from as early as the end of the sixth century BC (Faure & Kitchener 2009). In medieval times it was compulsory for seafarers to have cats on-board their ships (Johansson & Hüster 1987), leading to their dispersal across trading and warfare routes. Spread of the black rat (*Rattus rattus*) and house mouse (*Mus musculus*) by sea routes (O'Connor 2008, Engels 2001, Jones et al. 2013) encouraged cat dispersal for the control of these new pests (Engels 2001, Jones et al. 2013). Besides using cats as pest controls, the expansion of the domestic cat may also have been for cultural usage, which in Medieval Europe included trade of domestic cat pelts to be used as clothing (Ewing 1981).

Domestic cats in Denmark

During the Roman Iron Age (c. 1-375 AD) new pets were introduced to Denmark. Among these, and although rare, was the domestic cat (Hatting 1990, 2004, Damm 2000, Faure & Kitchener, 2009), which easily found its place near the farms and in the open country. The oldest genuine find of a domestic cat derives from a cremation grave in Kastrup, Southern Jutland (ZMK 153/1971) dated to the Late Roman Iron Age c. 200 AD (Aaris-Sørensen 1998). The find consists of a single astragalus with visible cut marks together with burned bones from an adult person. Together with the cat bone a sheep astragalus with a drilled perforation was found – both astragali have undoubtedly been used as amulets (Aaris-Sørensen 1998). At this point, the wildcat populations were barely present in Denmark anymore (Aaris-Sørensen 1998). The latest occurrence of a wildcat in Denmark was from the site Næsbyholm Storskov (ZMK 106/1965) near Sorø, Zealand dated to the Early Roman Iron Age (c. 1-100 AD) (Damm 2000, Hatting 2004, Møhl 2010).

Through the Roman Iron Age and early part of the Viking Age the domestic cat was a sparsely distributed animal, represented by very few bones among a vast amount of animal bones, usually also by bone fragments in too poor conditions to measure. However, there are some sites with cat remains (besides those used in the study). Lundeborg, Svendborg (ZMK 78/1986, Hatting 1994) and Seden Syd, Odense (ZMK 238/2005, Kveiborg 2007b) dated to the Late Roman Iron Age c. 200-375 AD, Dankirke, Ribe (ZMK 125/1968) dated to c. 500 AD (Hatting 1991), Ribe (ZMK 120/1974, Hatting 1991) dated to c. 700 AD, and finally Posthuset, Ribe (ZMK 6/1992, Enghoff 2006) dated to c. 725-760 AD (see Table 1). Dental measurements on the Dankirke and Ribe specimens documented that the cats were the domesticated form (Hatting 1991).

During the Viking Age, it was common to trade domestic cat pelts for use in clothing throughout Europe (Ewing 1981) and they were highly priced (Damm 2000, Faure & Kitchener 2009). In Denmark, we find examples of what could possibly be cat fur production sites. For instance, in a pit from Overgade, Odense, Denmark, a large number (N=1783) of cat bones comprising 83.5% of the mammal bones of the pit, providing a MNI of nearly 70 based on calvaria, exhibited clear signs of having been killed for their pelts (Hatting 1990, 2004). Hatting's conclusions were due to i) clear cut marks around the snout (upper jaw, *maxillare* and nose, *nasale* and lower jaws, *mandibula*) on the majority of skull bones and ii) evidence on the cats' neck bones indicating that the cats were killed by a powerful jerk when the head was pulled from the body (Hatting, 1990, p. 184). All skeletal elements of the cats were present in the Odense pit but in varying numbers with skulls being the predominant element; some bones were disarticulated and some formed complete skeletons. Furthermore, the age and size distribution with most of the cats having been killed at an age just less than one year and the remainder (adults) presumed female cats led Hatting to suggest that the adult females were part of a breeding stock (Hatting, 1990, p. 192). Although, the relative abundance of cat bones found at Viborg Søndersø was smaller than at Odense these cats exhibited skinning traces like those of the Odense cats (Hatting 1998). Likewise, during the Middle Ages recently excavated finds further support to the possible existence of skin production farms and evidence of specialized pelt production. A pit from Læderstæde, Roskilde dated to c. 1200-1400 AD revealed a large number of cat bones (N=434), comprising c. 19% of the domesticates of the find, showing that the cats had age patterns, skeletal element representation and skinning traces very similar to those of cats from the Odense pit (Hansen 2017).

During the Middle Age, cat remains were more commonly found in refuse layers, and in greater numbers (Møhl 1971), together with bones of other medieval domestic livestock (Hatting 1990, 1998, 2004). The earliest known find of black rat in Denmark is from the Viking Age (Rantzau 2015). The fact that subfossil occurrences of black rats in Denmark were from locations near the coast suggests that seafaring vessels were the dispersal vectors of rats (Rantzau 2015) and domestic cats probably followed the same dispersal pattern. The expanding towns resulted in great amounts of consumption waste deposited, which may very likely have been an important food source for the cats, directly as well as indirectly by attracting rodents especially mice and rats.

[Table 1 near here]

Measurable implications of domestication

The domestic cat is one of the world's most numerous pets (Driscoll et al. 2009), yet it is probably the least domesticated. The cat still has its hunting instinct, is territorial and generally solitary and it also lacks so-called neotenous characteristics (i.e., retention of a juvenile characters seen in other domesticated animals) (Clutton-Brock 1999). There are some modern cat breeds that exhibit phenotypic variation, but overall it is nowhere near the variation seen in dogs. It has been argued, and is also well accepted, that mammals subject to domestication, although not uniformly present in all species, undergo a decrease in body size (Tchernov 1984, Meadow 1984, Grigson 1989, Tchernov and Horwitz 1991), reduction in cranial capacity, shortening of the facial region of the skull, including jaws and sometimes associated with reduction in size of cheek teeth, and reduced sexual dimorphism (Tchernov and Horwitz 1991, Clutton-Brock 1999). These morphological changes appear to hold true for most mammals, e.g. sheep and goat (Zohary, Tchernov and Horwitz 1998), cattle (Grigson 1969, Tchernov and Horwitz 1991), pigs and dogs (Davis and Valla 1978, Tchernov and Horwitz 1991, Clutton-Brock 1999) and finally cats (Kratochvíl 1973, 1976, 1977, French et al. 1988, Clutton-Brock 1999). The domestic cat of northern Europe was from the very beginning reported to be small sized because its wild progenitor the subspecies *F. s. lybica* had a smaller body size than the *F. s. silvestris* (Johansson and Hüster 1987, p. 24). In present-day Denmark the zoogeography and size trends of the wildcat was studied by Damm (2000), whereas the domestic cat has never been subjected to systematic biometric studies. In this study we aim at exploring the phenotypic variation and possible size changes by conducting biometric analyses on remains of domestic cat from its first appearance in Denmark through the Middle Ages to present-day.

Materials and Methods

Archaeological material

The archaeological bone material available from the collections of the Zoological Museum, Natural History Museum of Denmark (NHMD) covers a wide range of time periods and localities in Denmark (Table 2, Figure 1). The material was sub-divided into six groups according to chronological period, although temporal overlaps could not be avoided. Group 1) Late Bronze Age, Group 2) Iron Age, Group 3) Viking Age, Group 4) Viking Age/Early Middle Age, Group 5) Middle Age and Group 6) Post Medieval Time.

The excavated material from Kongens Nytorv (ZMK 19/2011), Copenhagen, was temporally split into two: Kongens Nytorv Early (1050-1550 AD) and Kongens Nytorv Late (1550-1660 AD), and assigned to groups 5 and 6, respectively. Three assemblages, Odense (142/1970), Læderstræde (ZMK 61/2015) and Svendborg (ZMK 154/1977) originate from structures that may be characterized as fur production sites. In order to include medieval material from other contexts, we included two contemporaneous collections, Ørkild (ZMK 127/1988) and Næsholm (ZMK 104/1941), deriving from high-status settlements where cats served different purposes. The sample sizes of Ørkild and Næsholm were too small to allow for a pooling of high-status sites in a separate group. For groups 1 and 2, the museum collections consisted of very few specimens: Almosen (ZMK 48/1992) of one tibia only, Gyngstruplund Nordøst (ZMK 136/2005) also of one tibia, Strøby Toftegård (ZMK 53/1996) of one radius and the bog find "Jernkatten" (ZMK 81/000) of a single individual comprising of both calvarium and postcranial bones.

There is not much information about sexual dimorphism in domestic cats. Previous studies have focused on the wildcat, finding few measurements of the calvarium to differ significantly between sexes, although with some overlap (Kratochvil 1976, Knospe 1988, Petrov 1992). Sex identification of the domestic cat, however, is limited to only a few morphometric characteristics on pelvis and mandible (Pitakarnnop et al. 2017). Pitakarnnop et al. (2017) generated an equation for parameters on pelves applicable with 97.3% accuracy. However, this analysis used measurements on complete pelves (left and right pelvic bones fused at the pelvic symphysis) which in archaeological material only on very rare occasions have been found. Pitakarnnop et al. (2017) also generated an equation from mandible measurements, but with only 64.9% accuracy. We therefore chose to omit assessing a sex ratio of the archaeological material and instead assumed both sexes to be represented in the material.

[Figure 1 near here]

Modern reference material

To investigate the size trends of domestic cat through time, the archaeological material was compared to modern material of domestic cats (1870 – present). To account for sexual dimorphism in cats, the modern material had to be divided into three groups: Group 7) Females, Group 8) Unknown sex and Group 9) Males. None of the modern cats represent modern special breeds such as Angora or Siamese because selective breeding has caused these particular breeds to have different proportions of the calvarium and possibly also post cranial discrepancies compared to modern common breeds (e.g. Hatting 1990). Table 2 provides an overview of the nine groups of all the material.

[Table 2 near here]

Selection and measurements

To avoid duplicate measurements of the same individual, only the bones from the right side of the animal were used. For the Kongens Nytorv material bones from the left side were measured when no corresponding right-side bones had been found from the context in question. Further, only adult cats were used – or rather, immature or juvenile individuals with unfused epiphyses and/or a porous rough bone surface were omitted. For the limb bones, the individual is defined as adult when both epiphyses are fused to the diaphysis but still included if the fusion lines are visible (O'Connor 2008). For the mandible, it is difficult to distinguish the adult cats. An individual was included when the permanent dentition was present (see Hatting 1990, Damm 2000), and additionally for the modern individuals, only included when the limb bones belonging to the specimen in question were determined as adults. Measurements of the bones were performed according to the standards proposed by Angela von Driesch (1976). An electronic slide calliper with 0.01 mm accuracy was used. The bone measurements on cat remains of Odense and Svendborg (Matr. nr. 607a) were extracted from Hatting (1990). The bone measurements selected for this study for the limb bones were: greatest length (GL) and smallest breadth of the diaphysis (SD), and for the mandible: total length of mandible from the condyle process – infradentale (TL), height of mandible between P_4 and M_1 (HM (P4)), length of the cheek tooth row (CTR) P3-M1 and length of M_1 (M1).

Statistical analyses

A Kolmogorov-Smirnov Test was used to test the data for normal distribution and further a Tukey's outlier test was performed. None of the datasets of the measurements contained outliers that needed to be removed. For the statistical analysis, one-way ANOVAs were performed on eight bone and tooth measurements. See Table 3 for further details. Finally, post hoc Tukey-Kramer Multiple Comparison Tests were performed for pairwise analyses of the groups.

A linear model of the data used to calculate percentage of increase between groups was created from a selection of the data: groups 3-9. Groups 1 and 2 were excluded due to small sample size ($N \leq 2$). Hatting (1990) suggested that the adult individuals of the Odense material might solely be females. As this possibility could not be ruled out and since we did not assess the sex ratio of the archaeological material, we took the conservative approach to use only females of the modern material for comparison (Table 3). This means, that observed increases constitute the smallest possible differences between archaeological groups and modern material.

[Table 3 near here]

[Figure 2 near here]

Results

For the statistical analyses, groups 1 and 2 could not be included in all analyses due to paucity of material. The statistical results are displayed in Table 3. The one-way ANOVA values for all measurements are significantly different between groups, (P<0.001). From the linear model of GL of femur (GL) measurements, we estimate the percentage increase in size over time. We find an average increase of the limb bones of 16% between the Odense cats (group 3) and the modern females (group 7), and an increase of 4% between Post Medieval Time (group 6) and the modern females (group 7). For the mandible measurements, the average increase between the Odense Cats (group 3) and modern females (group 7) was also 16% and between Post Medieval Time (group 6) and modern females (group 7) 4%. The measurements to show the least increase are those of the teeth, CTR and M1. For M1, the increase between the Odense cats (group 3) and the modern females (group 7) is c. 5.5% and between Post Medieval Time (group 6) and the modern females (7) only 1.5%. Percentage increase for the other measurements can be found in Table 3 (see also Figure 2).

The multiple comparisons of femur length between groups are displayed in Figure 3 show that the size of domestic cats increased with time. The Viking Age and Middle Age groups together (a) and the Post Medieval Time and Females group together (b), which also groups with Unknown Sex and Roman Iron Age (c). Males group with "Unknown sex" and Roman Iron Age (d). Group 4 is also included in group (b) but this could very likely reflect the small sample size (N = 3). The same trend is seen for the mandible measurements and teeth measurements but not as evident (Figure 4).

Figure 5 shows a plot of the breadth and length of tibia with all groups included. This plot also shows the natural overlap in size between groups that overlap in chronological time periods. The one measurement of group 1 Bronze Age falls between the Middle Age and Post Medieval period, and the two measurements of Group 2 Iron Age, falls within the range of the modern material.

[Figure 3 near here]

[Figure 4 near here]

[Figure 5 near here]

Discussion

We find clear evidence of an increase in body size of the domestic cat from the Viking Age till today. Some of the groups, especially those from the Viking Age and Middle Age (groups 3-6), have broad and overlapping time periods hence some of the groups overlap chronologically. The Viking Age and Middle Age cats also overlap in their measurements. However, if we look at the pairwise comparison graph of femur length (Figure 3) we still see a gradual increase from the Viking age through the Middle Age. As previously stated it was not possible to divide the archaeological material according to sex. It was, however, evident from the size variation of cats from the Viking Age and medieval materials that both sexes were present. This means that the observed size increase is an absolute minimum increase and that the size increase was in effect larger.

An early medieval assemblage of domestic cats (N=1030) from Haithabu, present-day Northern Germany, dated between the ninth and eleventh centuries was examined by Johansson and Hüster (1987). The Haithabu domestic cats were shown to comprise both sexes and further to be significantly smaller than modern domestic cats (Johansson & Hüster 1987), and comparable in size to the Viking Age and medieval cats of the present analysis. O'Connor (2007) too found Viking Age / medieval cats to be smaller than modern domestic cats.

As for the modern material, Group 8 Unknown sex will naturally also overlap with both Group 7 Females and Group 9 Males since we expect to have both sexes in this group. Despite some overlaps of the chronological groups, we do find a clear tendency for an increase in size of the species from the Viking Age through all groups compared with the modern material, for the mandibles as well as limb bones.

Furthermore, in Figure 3, Group 4 (Viking Age/Early Middle Age) overlaps with the Post Medieval Time and modern females. This could possibly reflect the small sample size of this group (N=3). The earliest groups (1 and 2) comprise very few specimens but are remarkably large in comparison to the Viking Age/Early Middle Age individuals (Figure 5). A hypothesis to this observation could be that the earliest and indeed rare occurrences of the domestic cats in Denmark may represent high prestige gifts or goods imported for trade. At the early stage present-day Denmark did not have a domestic cat population. The Kastrup urn find of a domestic cat astragalus, which could unfortunately not be measured due to burning, was from a high-status burial site (see Jensen 2006). Further, the Almosen, Tyvelse, as well as the "Jernkatten" finds were recovered from ritual bog deposits (U. Møhl in litt., Jørgensen 1992). The early domestic cats were special and valued creatures, which is very much in accordance with the status of early domestic chicken (*Gallus domesticus*) which were found as whole skeletons in ritual contexts or in graves (e.g. Gotfredsen 2017).

We do not find the same increase in size for the teeth as seen for limb bones and mandible measurements, especially regarding length of M1. Although we see significant statistical differences between groups, the length of cheek tooth row (CTR) and M1 do not have as steep an increase over time as the limbs and mandibles (Table 3), which is also in accordance with the findings of both Hatting (1990) from Odense and Johansson & Hüster (1987) from Haithabu. Altogether, this means that the body of domestic cats has increased over time, but the teeth did not follow the same rate of size increase. Perhaps teeth evolve more conservatively or slowly than other skeletal elements. Teeth may have withstood reduction during the domestication process as proposed by Clutton-Brock (1999), Damm (2000) and Kratochvíl (1976) before body size started to increase again.

General changes in size are well documented for other carnivores (Clutton-Brock 1999, Davis and Valla 1978, Tchernov and Horwitz 1991). Most studies find an increase in body size. These studies primarily concern changes taken place within the last century and seen in relation to global warming. A typical case is Bergmann's rule, which states that the same species is larger in cold areas (i.e. further to north) and smaller in warm areas (Bergmann 1847). This applies to the stone marten, *Martes foina*, in Denmark, which became smaller with rising temperatures (Tom-Tov et al. 2008) but also due to changes in dietary access. Size change in relation to food availability was found for the Eurasian lynx, *Lynx lynx*, in Sweden (Tom-Tov et al. 2009) with dwindling food availability resulting in smaller body sizes. In contrast, also an increase in body size may be due to changes in the environment, expanding agriculture and altered land use. This in turn could have led to an increase in food availability as in the case of the red fox, *Vulpes vulpes* and badger, *Meles meles*, in Denmark (Tom-Tov 2003, Tom-Tov et al. 2003). The amounts of waste and garbage produced by an increasing human population and urbanisation allow for certain species to fully rely on human waste as their primary food source (Tom-Tov 2003).

Plausible explanations for the observed increase in size of the domestic cat could be increased food availability, most likely from human waste, and/or perhaps intentional selection by humans as also suggested by Hatting (1990). Further, it has been shown that food availability during growth has a major effect on body size of animals (Tom-Tov et al., 2009). The cat underwent a change from a fur providing and rodent catching animal (Johansson & Hüster 1987, Hatting 1990, Engels 2001, O'Connor 2008) to the present-day pet invited indoor, fed and cared for. The implication is that cats would have had to use less energy to find food thereby enabling them to spend energy on body growth instead. Domestic cats in medieval Schleswig c. eleventh to fourteenth centuries exhibited a larger size and a larger size variability than the aforementioned early medieval Haithabu cats (Benecke 1994). Although, no differentiation into cat breeds were observed, Benecke (1994, p. 353) still considered this to be a result of a more intensified cat household. A paleogenetic study by Ottoni et al. (2017) found no signs of selective breeding induced by humans prior to 1300 AD in Europe. Instead they document a new type of coat pattern to emerge which, however, did not become common until 1700 AD (Ottoni et al. 2017). The first appearance of more "fancy breeds", such as Persian or Siamese, was around 1800 AD (Driscoll et al. 2009).

Despite how far back in time we can trace the first occurrence of the domestic cat, this proves how remarkably little domestic cats have changed in appearance over time. The most familiar trait of pet domestication is the shorting of the snout, which gives the animals a more juvenile look the so-called neotenous traits and this is of course present for some cat races. However, most domestic cats still resemble their wild progenitor very much in the skeletal structure, in size and regarding specific muscle attachments on single skeletal elements. The domestic cat also displays a very independent nature like the wildcats – even though they are being fed they still go on successful hunts for birds and mice.

French et al. (1988) conducted a study of the Scottish wildcat, *Felis silvestris grampia*, domestic cat, and their hybrids. They found the wildcat material from the first half of the twentieth century (1901-1941) were genetically purer, whereas more recent individuals (1953-1978) had a significant hybrid proportion due to interbreeding between the two species. Hybridization may have been caused by the decreasing numbers of wildcats from around the 1940s and the destruction and division of suitable habitats (French 1988 et al., Damm 2000). Simultaneously, the encounter of domestic cats had steadily risen (French et al. 1988).

According to Hatting (2004) and Møhl (2010) there were no longer wildcats in Denmark by the Early Roman Iron Age (c. 1 - 100 AD). In addition to the aforementioned Kastrup cat dated to the Late Roman Iron Age (Aaris Sørensen 1998) there are a few other occurrences of cat from the Late Roman Iron Age, for instance, Lundeborg, Svendborg (Hatting 1994) and Seden Syd, Odense (Kveiborg 2007b). Further, a recently excavated Iron Age site Postgården VI, Aalborg dated to c. 250 BC – 100 AD, provided a cat bone (Østergaard 2016) which was directly radio carbon dated (S. Østergaard pers. comm. 2016). However, it could not be ascertained that these cat remains were in fact from domestic cats. In addition, there are a few sites with possibly older specimens of the domestic cat but with very broad dates: Almosen (ZMK 48/1992) dating to the Late Bronze Age (1100-500 BC) and the bog find “Jernkatten” (“the Iron Cat”) (ZMK 81/0000) that dates to the Iron Age (500 BC – 375 AD).

One cat in our dataset, the “Jernkatten” (Group 2), stands out. Its’ measurements of postcranial bones fall within the range of the modern males of domestic cat - however, the measurements of the calvarium fall within the wildcat category according to measurements of Kratochvíl (1973, 1976) on Czechoslovakian wildcats. We find the mean value for wildcat length of M1 to be 8.5 mm (min = 7.4, max = 9.8) and for the domestic cat 7.00 mm (min = 5.7, max = 8.0) (Kratochvíl 1973, 1976). The length of the “Jernkatten” M1 is 8.64 mm, falling within the wildcat range. According to Damm (2000, appendix F) the length of M1 of wildcats (N=18) from the Ertebølle period to the late Neolithic/Early Bronze Age in Zealand had a mean value of 8.60 (min = 7.6 mm, max = 9.1 mm). Also, for the CTR, where the wildcat range is in average 21.70 mm (min = 19.4, max = 24.0) and for the domestic cat 18.41 mm (min = 16.6, max = 20.5) (Kratochvíl 1973, 1976). For the Danish wildcats on Zealand this measurement varied between 19.8 mm and 22.8 mm with a mean of 21.8 mm (N=11) (Damm 2000, appendix F). Again, “Jernkatten” falls within the wildcat range with its 21.35 mm of the CTR. Consequently, we suspect the “Jernkatten” specimen might be a hybrid of the wildcat and the domestic cat. Petrov et al. (1992) also performed measurements on calvaria of Bulgarian wildcats. If we compare the measurements (both mandibles and teeth) then “Jernkatten” falls within the range of a male wildcat. Thus, “Jernkatten” has limb bone measurements falling within the range of our modern domestic male cats but skull and teeth having the size as those of wildcats.

If we assume that the Almosen cat is from the very late phase of the Late Bronze Age (500 BC) and that last appearance of the wildcat was in fact from around 100 AD, then there should have been at least 5-600 years of overlap between wildcat and domestic cat in Denmark and hence an opportunity for hybridization. However, it should be noted that the wildcat at this point was decreasing in number (Degerbøl 1933, Damm 2000) and that the domestic cat was still very rare (Hatting 1990, 2004). The late find of wildcat at Næsbyholm Storskov dated to the Early Roman Iron Age led Møhl (2010) to suggest a possible refugium for wildcats to have existed on central Zealand, Denmark, since another late wildcat from the Late Bronze Age locality Kornerup near Roskilde (Degerbøl 1933) have been found in the vicinity. Such a refugium in central Zealand would have made such an overlap in time plausible, at least in eastern Denmark. According to Damm (2000) there are no hybrids documented from Danish excavations so far. Considering the striking resemblance between the domestic and the wild form is it may never have been considered to investigate this aspect.

Conclusion

Present-day domestic cats of Denmark have increased significantly in size since the Late Viking Age. Archeological material found in the NHMD, Zoological Museum collections indicate that the earliest finds of domestic cats were from the Bronze Age / Iron Age. They were large in size, comparable to present day cats, and possibly represented rare and perhaps precious gifts or goods imported for trade. In contrast, the domestic cats of the Viking Age and Middle Age were much smaller, although gradually increasing in size, than the early Iron Age cats and today's domestic cats.

This may be due to the influx of small type domestic cats to the urban centres developing during that period.

For future studies, we would like to further investigate the early domestic cats including “Jernkatten” and the possibility of hybridization. We would need more direct radio carbon dates on the last wildcats and the earliest domestic cats in order to fully shed light on the first occurrence of this late coming domesticate in Denmark and in combination with genomic studies to investigate whether hybridization really happened.

Acknowledgements

Inge Bødker Enghoff, who was the BSc supervisor of Julie Bitz-Thorsen, is thanked for her help, guidance, and interest in this project. Carl Chr. Kinze is thanked for his much-appreciated comments and linguistic corrections of the manuscript. Further, Morten Steineke and the Museum of Copenhagen are thanked for help with dating the cat material of the Kongens Nytorv excavations. From the NHMD we thank Kristian Gregersen for helping us find the necessary material from the collections and Knud Rosenlund for always having his door open for questions. Finally the two reviewers are thanked for their suggestions on improiving the manuscript.

Funding

The work was carried out at the Zoological Museum, Natural History Museum of Copenhagen, Denmark.

References

Aaris-Sørensen, K., 1998. *Danmarks Forhistoriske Dyreverden*. København: Gyldendal.

Benecke, N., 1994. *Der Mensch und seine Haustiere*. Stuttgart: Konrad Theiss Verlag, GmbH & Co.

Bergmann, C., 1847. Über die Verhältnisse der Wärmeökonomie der Thiere zu ihrer Grösse. *Göttinger Studien*, 3 (1), 595–708.

Clutton-Brock, J., 1999. *A Natural History of Domesticated Mammals*. 2nd ed. Cambridge: Cambridge University Press.

Clutton-Brock, J., 2012. *Animals as Domesticates: a world view through history*. East Lansing, Michigan: Michigan State University Press.

Damm, J.G., 2000. *Vildkatten, Felis silvestris silvestris, og dens historie og udbredelse i Skandinavien i den postglaciale tid*. Unpublished thesis. University of Copenhagen.

Davis, S.J.M. and Valla, F., 1978. Evidence for domestication of the dog 12,000 years ago in the Natufian of Israel. *Nature,* 276, 608-610. doi:10.1038/276608a0

Degerbøl, M., 1933. Danmarks Pattedyr i Fortiden. *Videnskabelige Meddelelser fra dansk naturhistorisk Forening*, 96. Festskrift II. København.

Driscoll, C.A., Menotti-Raymond, M., Roca, A.L., Hupe, K., Johnson, W.E., Geffen, E., Harley, E.H., Delibes, M., Pontier, D., Kitchener, A.C., Yamaguchi, N., O'Brien, S.J. and Macdonald, D.W., 2007. The Near Eastern Origin of Cat Domestication. *Science*, 317 (5837), 519–523. doi:10.1126/science.1139518

Driscoll, C.A., Clutton-Brock, J., Kitchener, A.C. and O'Brien, S.J., 2009. The taming of the cat. Genetic and archaeological findings hint that wildcats became housecats earlier—and in a different place—than previously thought. *Scientific American*, 300 (6)**,** 68–75.

Engels, D.W., 2001. *Classical Cats: The Rise and Fall of the Sacred Cat.* 1st ed. London: Routledge.

Enghoff, I.B., 2006. Pattedyr og fugle fra markedspladsen i Ribe, ASR 9 Posthuset. *In:* C. Feveile, ed. *Ribe Studier. Det ældste Ribe: Udgravninger på nordsiden af Ribe Å 1984-2000.* Aarhus: Aarhus Universitetsforlag. Jysk Arkæologisk Selskabs Skrifter Bind 1.1, 167-187.

Enghoff, I.B., 2015. *Kgs. Nytorv Z.M.K. 19/2011; KBM 3829 – The Animal Bones*. Report in ArchaeoScience 10. Copenhagen: University of Copenhagen, Natural History Museum of Denmark.

Ewing, E., 1981. *Fur in dress*. London: Batsford.

Faure, E. and Kitchener, A.C., 2009. An Archaeological and Historical Review of the Relationships between Felids and People. *Athrozoös*, 22 (3), 221-238. doi:10.2752/175303709X457577

French, D.D., Corbett, L.K. and Easterbee, N., 1988. Morphological discriminants of Scottish wildcats (*Felis silvestris*), domestic cats (*F. catus*) and their hybrids. *Journal of Zoology*, 214 (2), 235-259.

Gotfredsen, A.B., 2017. Animal Sacrifices and Deposits in Inhumation Graves of the Roman Iron Age in Zealand and Funen, Eastern Denmark. *In*: L. Boye, P. Ethelberg, and U. Lund Hansen, ed. *Wealth and Prestige 2. Animal Sacrifices and Deposits in Inhumation Graves of the Roman Iron Age in Zealand and Funen, Eastern Denmark*. Taastrup: Kroppedal Museum, Studier i Astronomi, Nyere Tid, Arkæologi IV, 13-268.

Grigson, C. 1969. The uses and limitations of differences in absolute size in the distinction between the bones of aurochs (*Bos primigenius*) and domestic cattle (*Bos taurus*). *In:* P.J. Ucko and G.W. Dimbleby ed. *The domestication and exploitation of plants and animals*. London: Duckworth, 277-294.

Grigson, C., 1989. Size and sex: Evidence for the domestication of cattle in the Near East. *In:* A. Miller, D. Williams and N. Bardner ed. *The Beginnings of agriculture*. Oxford: British Archaeological Report International Series 496, 77-109.

Hansen, K.L., 2017. *Animal bones from medieval deposits in Læderstræde, Roskilde – a zooarchaeological analysis*. Unpublished thesis. University of Copenhagen.

Hatting, T., 1990. Cats from Viking Age Odense. *Journal of Danish Archaeology*, 9, 179-193.

Hatting, T., 1991. The Archaeozoology. *In:* M. Bencard, L, Bender Jørgensen and H.B. Madsen ed. *Ribe Excavations 1970-76 Volume 3*. Esbjerg: Sydjysk Universitetsforlag, 43-57.

Hatting, T., 1994. The Animal Bones from the refuse Layer at Lundeborg. *In:* P.O. Nielsen, K. Randsborg and H. Thrane ed. *The Archaeology of Gudme and Lundeborg*, October 1991 Svendborg. København: Akademisk Forlag, 94-97.

Hatting, T., 1998. Dyreknogler. *In:* J. Hjermind, M. Iversen and H.K. Kristensen ed. *Viborg Søndersø 1000-1300. Byarkæologiske undersøgelser*. Aarhus: Aarhus Universitetsforlag. Jysk Arkæologisk Selskabs Skrifter Bind 34.

Hatting, T., 2004. Husdyrene. *In*: E. Roesdahl, ed. *Dagligliv i Danmarks middelalder. En arkæologisk kulturhistorie*. Aarhus: Aarhus Universitetsforlag, 110-122.

Jansen, H.M., Hatting, T. and Sørensen, I., 1988. Svendborg in the Middle Ages – an Interdisciplinary Investigation. *Journal of Danish Archaeology*, 6 (1), 198-219.

Jensen, M.L., 2006. Kastrup-fundet ved Gram i Sønderjylland – en fyrstelig grav fra ældre romersk jernalder? *Arkæologi i Slesvig*, 11, 45-58.

Johansson, F. and Hüster, H., 1987. *Untersuchungen an Skelettresten von Katzen aus Haithabu (Ausgrabung 1966-1996)*. Berichte über die Ausgrabungen in Haithabu 24. Karl Wachholtz Verlag: Neumünster.

Jones, E.P., Eager, H.M., Gabriel, S.I., Johannesdottir, F. and Searle J.B., 2013. Genetic tracking of mice and other bioproxies to infer human history. *Trends in Genetics*. 29 (5)**,** 298–308. doi:10.1016/j.tig.2012.11.011

Jørgensen A.B., 1992. *NÆM j.1992:200 - Almosen ved Tyvelse. Beretning vedr. indledende undersøgelse af offerplads og formodet vejanlæg fra yngre stenalder – bronzealder – ældre jernalder*. Næstved Museum.

Kitchener, A., 1991. *The Natural History of the Wild Cats*. Ithaca, N.Y.: Comstock Pub. Associates, Cornell University Press.

Knospe, C., 1988. Sex dimorphism in the skull of the cat. *Anatomischer Anzeiger*, 167, 199-204.

Kratochvíl, Z., 1973. Schädelkritieren der Wild- und Hauskatze (*Felis silvestris silvestris* Schreb. 1777 und *F. s. f. catus* L. 1758). *Acta Scientiarium Naturalium Brno.* 7 (10), 1–50.

Kratochvíl, Z., 1976. Das Postkranialskelett der Wild- und Hauskatze (*Felis silvestris* und *F. lybica F. catus*). *Acta Scientiarium Naturalium*. 10 (6), 1-43.

Kratochvíl, Z., 1977. Die Unterscheidung Postkranialer Merkmalspaare Bei *Felis s. silvestris* und *F. lybica F. catus* (Mammalia). *Folia Zoologica*, 26 (2), 115-128.

Kveiborg, J., 2007a. *Zooarkæologisk gennemgang af knoglemateriale fra OBM 4399, Gyngstruplund, NØ (FHM 4296/372)*. Rapport fra Konserverings- og naturvidenskabelig afdeling. Moesgård Museum.

Kveiborg, J., 2007b. *Knogler af pattedyr og fugl fra Seden Syd (OBM 9882). En zooarkæologisk gennemgang af udvalgte dyreknogler fra OBM 9882 Seden syd indsamlet i årene 2001-2004*. Konserverings- og naturvidenskabelig afdeling. Rapport Nr. 2, Moesgård Museum. Available from: https://www.moesgaardmuseum.dk/media/1408/moes0702.pdf

Meadow, R.H., 1989. Osteological evidence for the process of animal domestication. *In:* Clutton-Brock, J. ed. *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*. London: Unwin Hyman, 80 –90.

Møhl, U., 1961. Oversigt over dyreknogler fra Næsholm. *In*: V. La Cour, ed. *Næsholm*. København: Nationalmuseet, 364-429.

Møhl, U., 1971: Et knoglemateriale fra Vikingetid og Middelalder i Århus. Husdyrene og den vilde fauna. *In:* H. H. Andersen, P. J. Crabb & H. J. Madsen ed. *Århus Søndervold. En byarkæologisk undersøgelse*. Aarhus: Aarhus Universitetsforlag. Jysk Arkæologisk Selskabs Skrifter 9, 321-329.

Møhl, U., 2010. Dyreknogler fra Næsbyholm Storskov. En plads fra ældre romersk Jernalder. *In:* V. Nielsen ed. *Oldtidsagre i Danmark - Sjælland, Møn og Lolland-Falster*. Aarhus: Aarhus Universitetsforlag. *Jysk Arkæologisk Selskabs Skrifter* 71, 259-273.

Nyegaard, G., 1998. *Faunalevn fra bronzealder. En Zooarkæologisk undersøgelse af sydskandinaviske bopladsfund*. Unpublished PhD thesis. Zoologisk Museums Kvartærzoologiske Undersøgelser, University of Copenhagen.

O'Connor, T.P., 2007. Wild or Domestic? Biometric Variation in the *Cat Felis silvestris. Schreber*. *International Journal of Osteoarchaeology*, 17 (6), 581-595.

O'Connor, T.P., 2008. *The Archaeology of Animal Bones*. College Station, Texas: Texas A&M University Press.

Ottoni, C., Van Neer, W., De Cupere, B., Daligault, J., Guimaraes, S., Peters, J., Spassov, N., Prendergast, M.E., Boivin, N., Morales-Muñiz, A., Balasescu, A., Becker, C., Benecke, N., Boroneant, A. Buitenhuis, H., Chahoud, J., Crowther, A., Llorente, L., Manaseryan, N., Monchot, H., Onar, V., Osypinska, M., Putelat, O., Morales, E.M.Q., Studer, J., Wierer, U., Decorte, R. Grange T. and Geigl, E., 2017. The palaeogenetics of cat dispersal in the ancient world. *Nature Ecology & Evolution,* 1 (7)**,** 0139. doi:10.1038/s41559-017-0139

Petrov, I., Nikolov, H. and Gerasimov, S., 1992. Craniometrical sex determination of wild cat *Felis silvestris* in Bulgaria. *Acta Theriologica,* 37 (4), 381-396.

Pitakarnnop, T., Buddhachat, K., Euppayo, T., Kriangwanich, W., and Nganvongpanit, K., 2017. Feline (*Felis catus*) Skull and Pelvic Morphology and Morphometry: Gender-Related Difference? *Anatomia Histologia Embryologia*, 46 (3), 294-303.

Rantzau, D., 2015. *Migration, morphology and archaeological history of the black rat (Rattus rattus) and brown rat (Rattus norvegicus) in Denmark*. Unpublished thesis. University of Copenhagen.

Steineke, M. and Jensen, J.J. 2017: *Kongens Nytorv Metro Cityring Project, KBM 3829, Øster Kvarter, Københavns Sogn, Sokkelund Herred, Københavns Amt*. København: Københavns Museum, Museum of Copenhagen, Slots- og Kulturstyrelsen, j.nr.: 2010-7.24.02/KBM-0017.

Tchernov, E., 1984. Commensal animals and human sedentism in the Middle East. *In:* J. Clutton-Brock and C. Grigson ed. *Animals and archaeology: Early herders and their flocks*. Oxford: British Archaeological Reports International Series 202, 911-115.

Tchernov, E. and Horwitz, L.K., 1991. Body size diminution under domestication: Unconscious selection in primeval domesticates. *Journal of Anthropological Archaeology*, 10, 54-75.

Tom-Tov, Y., 2003. Body sizes of carnivores commensal with humans have increased over the past 50 years. *Functional Ecology*, 17 (3), 323-327. doi:10.1046/j.1365-2435.2003.00735.x

Tom-Tov, Y., Tom-Tov, S. and Baagøe, H.J., 2003. Increase of skull size in the red fox (*Vulpes vulpes*) and Eurasian badger (*Meles meles*) in Denmark during the twentieth century: an effect of improved diet? *Evolutionary Ecology Research*, 5 (7), 1037-1048.

Tom-Tov, Y., Leader, N., Tom-Tov, S. and Baagøe, H.J., 2008. Temperature trends and recent decline in body size of the stone marten, *Martes foina*, in Denmark. *Mammalian Biology*, 75, 146-150.

Tom-Tov, Y., Kjellander, P., Tom-Tov, S., Mortensen, P. and Andrén, H., 2009. Body size in Eurasian lynx in Sweden: dependence on prey availability. *Polar Biology*, 33 (4), 505-513. doi: 10.1007/s00300-009-0728-9

Van Neer, W., Linseele, V., Friedman, R. and De Cupere, B., 2014. More evidence for cat taming at the Predynastic elite cemetery of Hierakonpolis (Upper Egypt). *Journal of Archaeological Science,* 45**,** 103–111. doi:10.1016/j.jas.2014.02.014

Vigne, J.-D., Guilaine, J., Debue, K., Haye, L. and Gerárd, P., 2004. Early taming of the cat in Cyprus. *Science*, 304 (5668), 259.

Vigne, J.-D., 2015. Early domestication and farming: what should we know or do for a better understanding? *Anthropozoologica*, 50 (2), 123-150.

von den Driesch, A., 1976. *A Guide to the Measurement of Animal Bones from Archaeological Sites*. Cambridge, Massachusetts: Harvard University Press, Peabody Museum Bulletins.

Zohary, D., Tchernov, E. and Horwitz, L.K., 1991. The role of unconscious selection in the domestication of sheep and goats. *Journal of Zoology*, 245, 129-135

Østergaard, S., 2016. *ÅHM 6023, Postgården VI (FHM 4296/1324). Analyse af knoglemateriale fra jernalderbebyggelse*. Konserverings- og naturvidenskabelig afdeling. Rapport Nr. 29, Moesgaard Museum. Available from: https://www.moesgaardmuseum.dk/media/3612/moes_1629.pdf

Table Captions

Table 1: An overview of samples used in the present study compared to a selection of contemporaneous Danish sites. The number (NISP = number of Identified Specimens) of domesticates (dog, cat, pig, cattle, sheep/goat, and horse), the number of cats and the relative frequency of cat remains are given. The sites and contexts are chronologically arranged.

Table 2: An overview of archaeological collections and modern material of domestic cats from Denmark dating from 1100 BC to the present time. Groups designate the grouping for the statistical analyses.

Table 3: Statistical analyses and calculations on bone measurements of Danish domestic cats: Kolmogorov-Smirnov Test for normal distribution, One-Way ANOVA and linear regression for eight bone measurements, and calculations of size increase between groups 3, 6 and 7.

Table 1

SITE	DATING	NISP (DOMESTICATES)	NISP (CATS)	% CAT BONES	COLLECTION NO.	REFERENCE
10. Almosen, Tyvelse[A]	1100-500 BC	380	1	<0.1	Z.M.K. 48/1992	*det.* G. Nyegaard 1992
"Jernkatten"[A]	500 BC – 375 AD	NI	6	-	Z.M.K. 81/0000	*det.* U. Møhl
2. Gyngstruplund Nordøst	0-200 AD	244	1	<1	Z.M.K. 136/2005	Kveiborg 2007a
Lundeborg, Svendborg	200-375 AD	7,210	4	<0.1	Z.M.K. 78/1986	Hatting 1994
Seden Syd, Odense	200-375 AD	3,624	3	<0.1	Z.M.K. 238/2005	Kveiborg 2007b
Dankirke, Ribe[B]	c. 500 AD	NI	2	-	Z.M.K. 125/1968	Hatting 1991
Ribe, Ribe Excavations 1970-76	c. 700 AD	5,995	7	<1	Z.M.K. 120/1974	Hatting 1991
Posthuset, Ribe	725-760 AD	1,078	5	<1	Z.M.K. 6/1992	Enghoff 2006
11. Strøby Toftegård	650-1075 AD	3,074	1	<1	Z.M.K. 53/1996	*det.* A.B. Gotfredsen
3. Overgade, Odense[C]	1070 ± 100 AD	2136	1783	83.5	Z.M.K. 142/1970	Hatting 1990
1. Viborg Søndersø	1000-1300 AD	10,992	166	1.5	Z.M.K. 14/1998	Hatting 1998
12. Vejleby, Lolland[D]	1000 – 1300 AD	928	6	0.65	Z.M.K. 109/1971	*det.* U. Møhl
8. Kongens Nytorv Early	1050-1550 AD	9,487	247	2.6	Z.M.K. 19/2011	Steineke & Jensen 2017, Enghoff 2015
6. Næsholm Slot[E]	1240 -1340 AD	2,494	23	0.9	Z.M.K. 140/1941	Møhl 1961
7. Læderstræde, Roskilde[C]	1200-1400 AD	2251	434	19.3	Z.M.K. 61/2015	Hansen 2017
4. Svendborg, Matr. nr. 607a	1200-1500 AD	16,264	251	1.5	Z.M.K. 154/1977	*det.* Tove Hatting
5. Ørkild Borg	1200 -1534 AD	5,288	109	2.1	Z.M.K. 127/1978	Jansen et al. 1988
9. Kongens Nytorv Late	1550-1660 AD	7,481	466	6.2	Z.M.K. 19/2011	Steineke & Jensen 2017, Enghoff 2015

[A]Designates that the find is a sacrificial bog deposit.

[B]The Dankirke bone material was not quantified, only the cat bones were counted and presented in Hatting 1991.

[C]Designates that the assemblage derives from one single context a pit.

[D]The measured bones of Z.M.K. 113/1962 derived from a cemetery, therefore the NISP counts were taken from a contemporaneous settlement at Vejleby Z.M.K. 109/1971.

[E]The number of domesticates were estimated from Møhl (1961) who did not publish the exact NISP counts for the most abundant species.

NI = No Information

Table 2

Site no.	Site	Time Period	Dating	Collection no.	Reference	Group
10	Almosen*, Tyvelse	Late Bronze Age	1100-500 BC	Z.M.K. 48/1992	*det.* G. Nyegaard 1992	1
-	“Jernkatten”[Δ], Bog find	Pre Roman - Roman Iron Age	500 BC - 375 AD	Z.M.K. 81/0000	*det.* U. Møhl	2
2	Gyngstruplund Nordøst	Early Roman Iron Age	1-150 AD	Z.M.K. 136/2005	Kveiborg 2007 a	
11	Strøby Toftegård	Germanic Iron Age/Viking Age	650-1050 AD	Z.M.K. 53/1996	*det.* A.B. Gotfredsen	
3	Overgade, Odense	Viking Age	1070 ± 100 AD	Z.M.K. 142/1970	Hatting 1990	3
1	Viborg Søndersø	Viking Age/Early Middle Age	1000-1300 AD	Z.M.K. 14/1988	Hatting 1998	4
12	Vejleby, Lolland	Viking Age/Early Middle Age	1000-1300 AD	Z.M.K. 113/1962	*det.* U. Møhl	
7	Læderstræde 4, Roskilde	Middle Age	1200-1400 AD	Z.M.K. 61/2015	Hansen 2017	5
4	Svendborg	Middle Age	1200-1500 AD	Z.M.K. 154/1977	*det.* T. Hatting	
5	Ørkild Borg	Middle Age	1200 - 1534 AD	Z.M.K. 127/1978	Jansen et al. 1988	
6	Næsholm Slot	Middle Age	1240 - 1340 AD	Z.M.K. 104/1941	Møhl 1961	
8	Kongens Nytorv early	Middle Age	1050 - 1550 AD	Z.M.K. 19/2011	Steineke and Jensen 2017	
9	Kongens Nytorv late	Post Medieval Time	1550-1660 AD	Z.M.K. 19/2011	Steineke and Jensen 2017	6
	Modern females	Present	1870 – present			7
	Modern unknown sex	Present	1870 – present			8
	Modern males	Present	1870 – present			9

* Nyegaard (1998) noted that the cat bone was of a slightly different coloration than the remaining bones of the find hence there is a risk that the bone may be an intrusion.

[Δ] There is little information on the ”Jernkatten” bog find regarding provenance and exact dating within the Iron Age.

Table 3

MEASUREMENT	N	KOLMOGOROV-SMIRNOV	ONE-WAY ANOVA	a	b	R^2	y(3)	y(6)	y(7)	%INCREASE (group 3 vs. 7)	%INCREASE (group 6 vs. 7)
HUMERUS (GL)	50	D=0.0731, *P*=0.9340	$F_{7,42}$=18.509, *P*=0.001	3.8863	69.820	0.7065	81.479	93.138	97.024	16.02%	4.00%
RADIUS (GL)	53	D=0.0739, *P*=0.9138	$F_{7,45}$=20.356, *P*=0.001	3.5932	69.087	0.7039	79.867	90.646	94.239	15.25%	3.81%
FEMUR (GL)	64	D=0.0881, *P*=0.7030	$F_{7,56}$=22.225, *P*=0.001	4.3319	76.129	0.7024	89.125	102.12	106.45	16.27%	4.06%
TIBIA (GL)	65	D=0.0725, *P*=0.8596	$F_{8,56}$=18.579, *P*=0.001	4.7457	78.248	0.6647	92.485	106.72	111.47	17.03%	4.26%
MANDIBLE (TL)	94	D=0.0971, *P*=0.3377	$F_{7,86}$=43.738, *P*=0.001	2.2866	45.932	0.7681	52.792	59.652	61.938	14.77%	3.69%
MANDIBLE (HM(P4))	148	D=0.0913, *P*=0.1697	$F_{7,140}$=35.828, *P*=0.001	0.4666	7.5117	0.5264	8.9115	10.311	10.778	17.32%	4.33%
CHEEK TOOTH ROW (CTR)	126	D=0.0725, *P*=0.5211	$F_{7,118}$=16.514, *P*=0.001	0.3376	16.596	0.4379	17.609	18.622	18.960	7.13%	1.78%
M1	141	D=0.0580, *P*=0.7306	$F_{7,133}$=9.1503, *P*=0.001	0.0740	6.6816	0.0860	6.9036	7.1256	7.1996	4.11%	1.03%
Average Increase Limbs										**16.14%**	**4.03%**
Average Increase Mandible										**16.05%**	**4.01%**
Average Increase Teeth										**5.62%**	**1.41%**

Abbreviations: GL = Greatest length. TL = Total length of mandible from the condyle process - infradentale. HM(P4) = Height of mandible between P_4 and M_1. CTR = Length of the cheek tooth row. M1 = Length of M_1.

Group 3 = Odense (Viking Age), Group 6 = Post Medieval Time (1550-1660 AD) and Group 7 = Modern material (1870 – present), females.

Figure Captions

Figure 1: Map showing the locations of sites providing cat remains for the biometric analysis. Numbers are referring to numbers in Table 2. Drawing: Julie Bitz-Thorsen modified from Knud Rosenlund.

Figure 2: A selection of cat calvaria from the examined groups of this study. From the left to the right upper row: modern wildcat, MK689, Hungary, male; “Jernkatten” (Group 2); Overgade, Odense (Group 3); Læderstræde 4, Roskilde (Group 5). From the left to the right lower row: Svendborg (Group 5); Næsholm (Group 5); female modern cat, K330 (Group 7); male modern cat, K362 (Group 9).

Figure 3: Plot showing the differences in femur length between groups of domestic cats. This was done by multiple comparisons using Tukey’s HSD. Boxes indicate the mean for each group and error bars indicate the 95% confidence interval. Means sharing a letter are not significantly different. Group 1: Late Bronze Age (N=0), Group 2: Roman Iron Age (N=1), Group 3: Viking Age (N=9), Group 4: Viking Age/Early Middle Age (N=3), Group 5: Middle Age (N=15), Group 6: Post Medieval Time (N=13), Group 7: Modern females (N=5), Group 8: Modern unknown sex (N=6) and Group 9: Modern males (N=12).

Figure 4: Plot showing the differences in M1 length between groups of domestic cats. This was done by multiple comparisons using Tukey’s HSD. Boxes indicate the mean for each group and error bars indicate the 95% confidence interval. Means sharing a

letter are not significantly different. Group 1: Late Bronze Age (N=0), Group 2: Roman Iron Age (N=1), Group 3: Viking Age (N=35), Group 4: Viking Age/Early Middle Age (N=20), Group 5: Middle Age (N=32), Group 6: Post Medieval Time (N=13), Group 7: Modern females (N=6), Group 8: Modern unknown sex (N=15) and Group 9: Modern males (N=19).

Figure 5: Plot showing the measurements of tibia, greatest length and smallest breadth of diaphysis, for the groups of domestic cats. Group 1: Late Bronze Age (N=1), Group 2: Roman Iron Age (N=2), Group 3: Viking Age (N=5), Group 4: Viking Age/Early Middle Age (N=1), Group 5: Middle Age (N=23), Group 6: Post Medieval Time (N=8), Group 7: Modern females (N=5), Group 8: Modern unknown sex (N=5) and Group 9: Modern males (N=13).

Figure 1

Figure 2

Figure 3

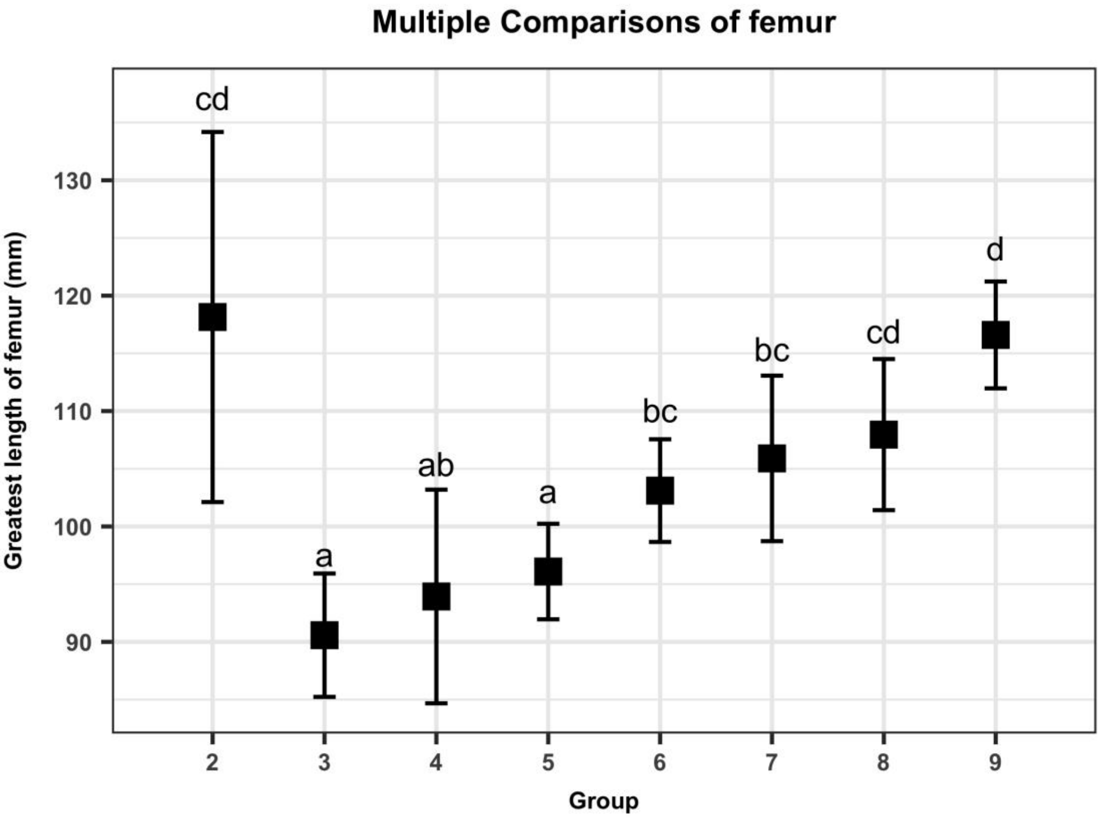

Multiple Comparisons of femur
Greatest length of femur (mm)
Group
90
100
110
120
130
2
3
4
5
6
7
8
9
cd
a
ab
a
bc
bc
cd
d

Figure 4

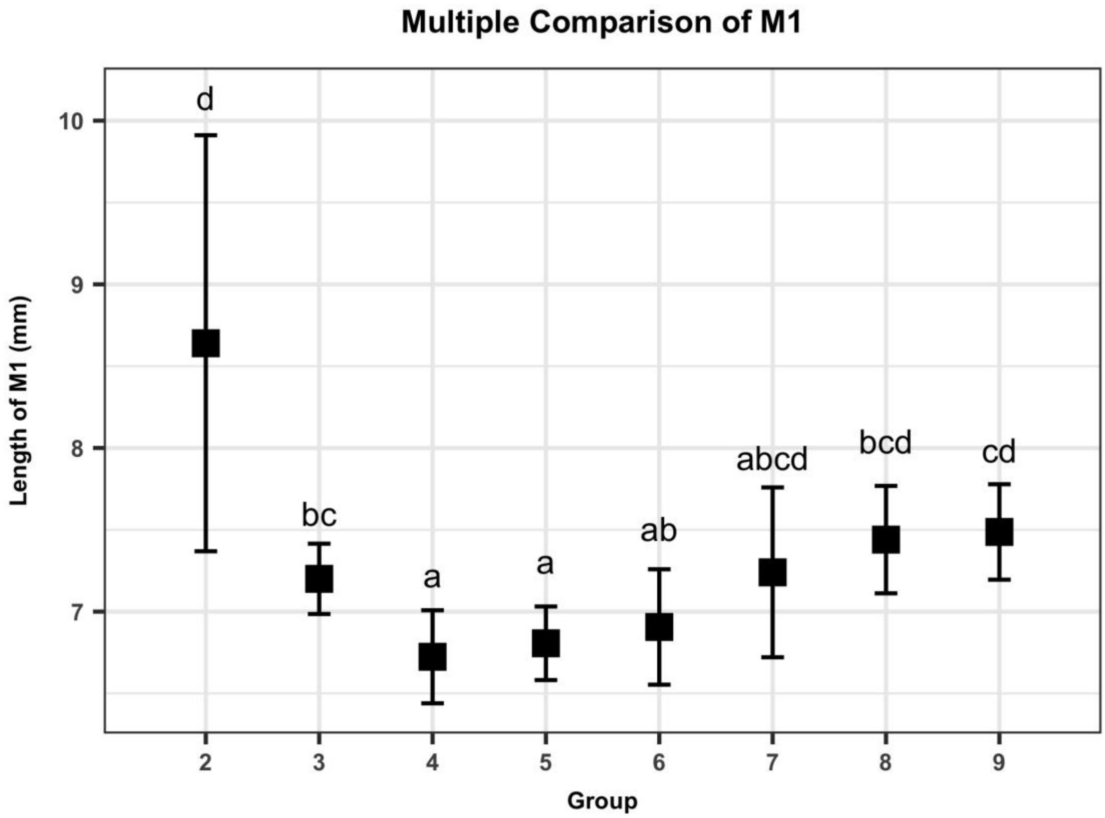
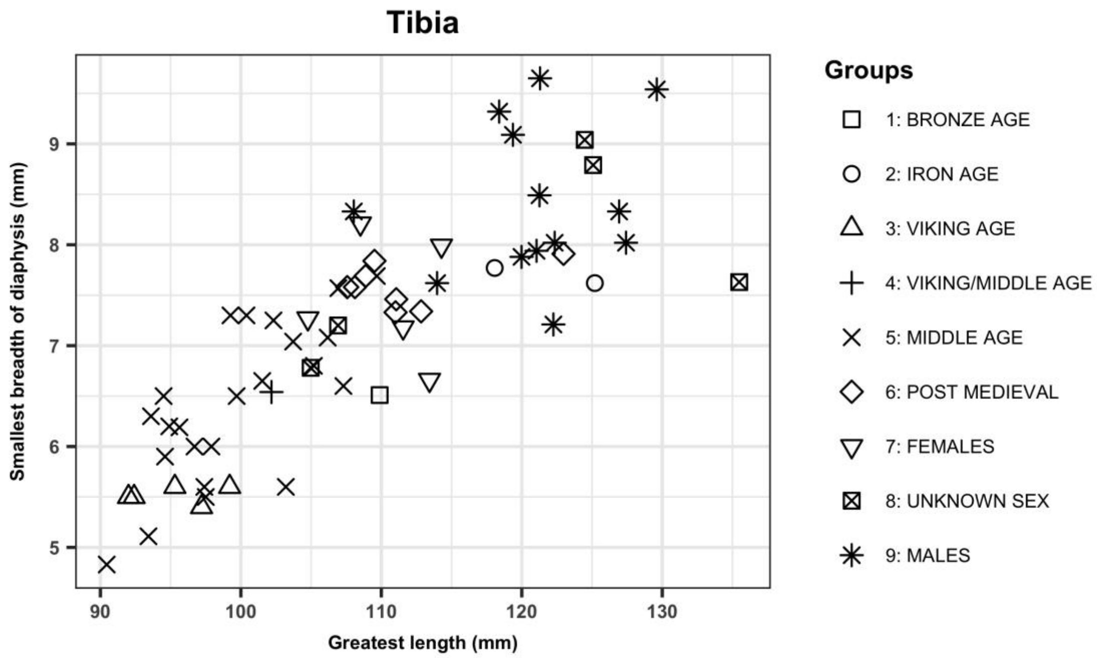

Multiple Comparison of M1
Length of M1 (mm)
10
9
8
7
d
bc
a
a
ab
abcd
bcd
cd
2
3
4
5
6
7
8
9
Group

Figure 5


Tibia
Smallest breadth of diaphysis (mm)
5
6
7
8
9
Greatest length (mm)
90
100
110
120
130
Groups
1: BRONZE AGE
2: IRON AGE
3: VIKING AGE
4: VIKING/MIDDLE AGE
5: MIDDLE AGE
6: POST MEDIEVAL
7: FEMALES
8: UNKNOWN SEX
9: MALES