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**Published paper**
A zooarchaeological study of biometric variation in the cat *Felis silvestris Schreber*

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A zooarchaeological study of biometric variation in the cat *Felis silvestris* Schreber

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Abstract

Investigation of modern biometric data indicates that it may be possible to distinguish wildcats from house cats in many instances. Applying the log-ratio (log-difference) technique to archaeological samples from medieval northern Europe, and to mixed samples of wildcats and house cats shows that the differentiation may not always be clear, and the possibility that some samples include hybrids is discussed. The technique is applied to samples from the Orkney islands to demonstrate that single wildcat specimens can be identified in small samples.

Keywords

Cat  *Felis silvestris*  size-index scaling  York  Haithabu  Orkney
Cats are one of the most widespread and familiar animals of the domestic realm, and their association with people extends at least into the Neolithic period (Vigne et al 2004; Davis 1989). Opinions regarding the original domestication of cats range from the view that they were deliberately domesticated by people as useful predators of household vermin (e.g. Zeuner 1963; Kratochvil and Kratochvil 1976; Clutton-Brock 1999) to the behavioural model proposed by Todd (1978), which has cats adopting people as a useful source of food, and being first tolerated then encouraged and fed by people. Serpell (1988; 1996) has made the point that people seem to find benefit in the companionship of other species, quite apart from any resource value those animals may have, and the furry, purry amiability of cats fits them particularly well to the role of companion animal. That being the case, it is remarkable how little research has tackled the archaeology of the relationship between people and cats, compared to, for example, the copious literature on caprines or dogs.

One factor in this relative neglect is that any systematic study would have to differentiate between the bones of wild and domestic cats. The latter term itself may be problematic. For the purposes of this paper, the term ‘house cat’ (c.f. German Hauskatze) is used in preference to ‘domestic cat’, as it is purely descriptive and makes no assumptions about the phylogenetic relationship between synanthropic and free-living cat populations. A ‘speciation’ model of animal domestication, such as underlies the attribution of Linnaean binomials to domestic forms (Gentry et al 2004), requires separation of the breeding populations of the domestic animals and their wild precursors; indeed, this is one of the defining aspects of animal domestication. However, house cats are conspecific and sympatric with a particularly widespread and polytypic species, Felis silvestris, the modern range of which extends throughout Europe into western Asia and through the entire length of Africa (Sunquist and Sunquist 2002). Breeding between house cats and wildcats is a major conservation problem today in parts of Europe (Daniels et al. 2001; Peripaoli et al 2003; Yamaguchi et al. 2004; Kitchener et al 2005; Lecis et al. 2006). It is a reasonable presumption that the genetic boundary between the two ecomorphs has always been as blurred as the behavioural boundary. The first point to make about the zooarchaeological data, therefore, is that it may be unrealistic to expect a clear
distinction between wildcat and house cat bones because of the probability that hybrid forms existed wherever and whenever the two ecomorphs were sympatric.

The investigation reported here forms part of a larger study of the archaeology of cats. The attribution of cat bones to house cat or wildcat is at the heart of investigating their zooarchaeology, and this paper limits itself to investigating the feasibility of making such attributions with confidence by the use of conventional biometrical techniques, and to investigating inter- and intra-sample variability in ancient and modern samples of cat post-cranial bones. Within European zooarchaeology, it has been the convention to attempt differentiation of wild- and house cats by demonstrating the smaller size of the latter ecomorph (e.g. Harcourt 1979, 154; Johansson and Hüster 1987, 44-7). Whether this apparent size difference derives from a marked difference in selection pressures in synanthropic populations, or reflects the origin of house cats in the more lightly-built African form of *Felis silvestris* (formerly *F. lybica*; see Clutton-Brock 1999), or a combination of both founder effect and several millennia of drift, is a debatable point. For the present purposes, it serves as a starting point for investigation.

**Materials and methods**

Cat bones typically occur at rather low frequencies in zooarchaeological assemblages: it is unusual for them to constitute more than 1% of an assemblage. Accordingly, it is exceptional for any one element of the cat skeleton to yield a useful biometric sample, making it necessary to combine data from as many elements as is practicable. A technique that allows just such a combination of data is the use of log-ratio or log-difference values (Meadow 1999). Bond and O’Connor (1999) used just such an approach to investigate size variation in cat bones from medieval York, using a single cat skeleton as the ‘standard’ measure against which to rescale the archaeological data. It is generally better practice to use mean values from a number of skeletons as the standard than to use a single individual that may be atypically proportioned. The largest readily-accessible samples of biometric data pertinent to this paper are those published by Kratochvil (1973, 1976a). The former study investigated size and morphological variation within and between samples of 51 wildcat and 60 house cat
skulls, whilst the latter studied the postcranial skeletons of 31 wildcats and 76 house cats. In both studies, the wildcats were from populations in the western Carpathians and the house cats from the Brno region. Kratochvil’s aim was to describe and quantify consistent differences between the wildcat and house cat samples, testing and validating criteria proposed by previous authors such as Röhrs (1955) and Schauenberg (1969), and to measure the degree of intra-population variability of different characters. This latter point is important in a zooarchaeological context as Kratochvil’s data on variability may help to resolve whether a given archaeological sample represents a rather variable sample of one or other ecomorph or a mixture of the two. The data also show that sexual dimorphism is negligible in the postcranial skeleton and in the cranial skeleton of house cats, but measurable in the cranial skeleton of wildcats (Kratochvil 1976b). Again, this is a valuable observation when trying to explain variation in zooarchaeological samples. Given the lack of sexual dimorphism in postcranial elements, this present study uses Kratochvil’s male and female house cat data combined to constitute a ‘standard’ dataset against which to compare archaeological data using the log-ratio (log-difference) technique (Meadow 1999).

Log-ratio values were calculated using the algorithm

\[ \text{Log-ratio} = \log_{10}(\text{observed/standard}) \]

The house cat data were used as a standard, in preference to the wildcat data, because the sample size is appreciably larger for Kratochvil’s house cat sample, and because a preliminary scan of archaeological data indicated that the great majority of specimens were closer in size to the house cat size range than to the wildcat range. The modern data are summarised in Table 01, which is derived from Kratochvil (1976a). Some of Kratochvil’s measurements are not used here, either because they are only rarely available or recorded in zooarchaeological material or because of ambiguity in equating his measurements with those defined and illustrated by von den Driesch (1976) and used by most zooarchaeologists.

Further modern data were acquired from house cats and wildcats in the collections of the author and the University of York (Table 02). The house cats are fully documented as to sex and age at death. The wildcats are not fully documented, but were stated on acquisition to have originated as ‘road-kill’ specimens in highland
Scotland, and to have pelage characteristics of ‘wild’ \textit{F. silvestris}. Given the uncertainty that surrounds the diagnosis of wild- and house cats in regions of close sympatry (Kitchener \textit{et al.} 2005), it is possible that one or more of these cats is a hybrid (see discussion of the data below). None the less, these data comprise a sample of modern cats from mainland Britain that includes \textit{behaviourally} wild and domestic individuals. All measurements were taken using sliding callipers to a precision of 0.1mm, following conventional zooarchaeological procedures.

Archaeological datasets were acquired from the author’s own records and from published data. Data from sites in York and Lincoln, recorded by the author between 1979 and 1999, have been used to assemble three substantial post-Roman samples:

- YorkVik – York Viking Age (or Anglo-Scandinavian), 10\textsuperscript{th} to early 11\textsuperscript{th} century AD. Specimens from 16-22 Coppergate, assemblages published in O’Connor (O’Connor 1989)
- YorkMed – York High Medieval, 12-13\textsuperscript{th} century. Specimens from 16-22 Coppergate and The Bedern (Bond & O’Connor 1999)
- LincVik – Lincoln Anglo-Scandinavian, 10\textsuperscript{th} to early 11\textsuperscript{th} century. Specimens from Flaxengate timber building phases (O’Connor 1982)

As comparanda for these English samples, further data were acquired from the broadly ‘Viking Age’ assemblage from Haithabu (modern Hedeby; Johansson and Hüster 1987) and from the medieval assemblage from Schleswig (Spahn 1986). These two examples were chosen as the exceptionally large size of the assemblages allows investigation of intra-sample variation.

Further data were acquired from a post-medieval assemblage from Kilton Castle, in the north of England. These cats were part of a mixed assemblage of cats and rodents recovered from the lowest deposits in a well, and apparently derived from 17\textsuperscript{th} century ‘clearing up’ of the castle. The cats are included here as examination of the morphology of cat crania in this assemblage indicates the presence of wildcats and house cats, making the size range and variability of the post-cranial bones particularly relevant to this paper.
Results

To start with an internal comparison, Kratochvil’s wildcat sample means were re-expressed as log-ratio values against the house cat standard (Table 01). Unremarkably, all values were positive, indicating the wildcats to be larger on all measured parameters. The log-ratio values were generally lowest for measurements taken on the atlas, axis, pelvis and tarsals; i.e. the difference is most marked in bones of the limbs, ranging from 0.062 (femur SD) to 0.107 (scapula spinus length). From the limb bones, length measurements generally gave larger log-ratio values than breadth measurements. Lengths range from 0.091 (humerus GLC) to 0.102 (fibula GL). Disregarding the length measurements, the forelimb generally gave higher values than the hindlimb: forelimb breadth values range from 0.080 (radius SD) to 0.101 (radius Bp), and hindlimb values from 0.062 (femur SD) to 0.078 (femur Bp, tibia Bp). To summarise, comparisons of length and breadth measurements should be made separately. We may expect limb bones, especially length measurements, to show the clearest differentiation of wild and house cats, and hindlimb breadth measurements to show the least differentiation, though even these measurements show the wildcat sample to be significantly larger than the house cats (t-test analyses on untransformed data are given in full in Kratochvil 1976a).

In order to compare the scale of those log-ratio values with the degree of variability of the house cat sample, four measured variables were investigated in more detail: tibia GL, radius GL, humerus Bd and femur Bd. These four were chosen to give a mix of fore- and hindlimb elements, and of lengths and breadths. The minimum and maximum values given by Kratochvil for each of the four variables were converted to log-ratio values based on the house cat mean values, thus showing the highest and lowest log-ratio values that the house cat sample would have given had the specimens been plotted individually. The results are shown in Table 03. The values for range show that the largest individual house cat specimen would typically have fallen into the wildcat range, though somewhat below the mean. The particularly high maximum values for humerus and femur Bd reflect exceptionally large values for one male house cat. The much narrower confidence limits show that the house cat sample typically has quite tightly-clustered data with a few outliers reflected by the values for
the range. Apart from the humerus and femur Bd values, the data would lead us to expect a zooarchaeological sample of house cats to include the odd one or two giving values up to ±0.06, with the great majority well inside this limit. Given that differences in sample means range from 0.062 to 0.107, this internal comparison of Kratochvíl’s data indicates that it should be possible to differentiate most wildcats from most house cats on log-ratio scaled size alone, but with some overlap between exceptionally large house cats and likewise small wildcats. The same calculations were performed on the numerically smaller wildcat sample (Table 03). The lower values for the range show that there were fewer outliers in the wildcat sample, whereas the slightly higher values for the 95% confidence limits reflect the smaller sample size (hence higher values for the standard error of the mean, hence larger confidence limits). None the less, the wildcat results confirm a generally clear separation of the two samples, if anything indicating that it is more likely that an outlying large house cat would be mistaken for a wildcat than that an exceptionally small wildcat would be grouped with the house cats.

Table 02 lists length data from the additional house cats and wildcats. The three wildcats have separated from the house cats, and specimens from each of the wildcats have grouped together. EAU776 is the largest of the three by some way, and gives values that would place it around mid-range of Kratochvíl’s wildcat sample. EAU777 and EAU783 are appreciably smaller, particularly the latter. There is no substantial ‘break’ in the data between the smallest of the wildcats and the largest of the house cats. Given the difficulty of differentiating ‘pure’ wildcats in modern Scottish populations from pelage characters alone, it is at least possible that EAU783 is actually a hybrid. None the less, this sample usefully shows the range and variance that may be expected of a sample that contains both wild and house cats.

The archaeological sample from Kilton Castle was thought to contain both ecomorphs. Table 04 lists the length data for comparison with Tables 01 and 02. The first point to note is that the largest of the Kilton cats are very large, approaching the maximum values for Kratochvíl’s wildcat sample given in Table 01. At the other end of the range, the smallest are below the house cat standard values. As with the mixed modern sample in Table 02, there is no discernible ‘break’ in the data that could be taken to mark the boundary between wild and domestic forms. Fig 01 shows quite
clearly the continuity of the Kilton data between the largest and smallest specimens. The Kilton data seem to confirm that the sample contains both wildcats and house cats but the continuity indicates a considerable size overlap, and thus perhaps a degree of hybridisation, between the two ecomorphs.

The medieval archaeological samples were chosen in part as substantial datasets, and in part on the expectation that samples from medieval towns would represent populations predominantly of house cats, with maybe an occasional specimen of wildcat deriving from animals hunted for their fur. Figs 02 and 03 show the log-ratio size distribution of the two York samples, and show a distinct difference in size distribution between two medieval phases in the same city. The Viking age sample, though small in number, shows a size variation either side of the standard, with perhaps two particularly large cats standing out on the breadth measurements (Fig 02). The two specimens exceeding 0.060 in Fig 02 are both ulnae. This value is close to the value discussed above as likely to differentiate most house cats from wildcats, and these two specimens do stand out from the general trend of the distribution in fig 02. The third largest specimen is a radius at 0.048, within the range seen in the reference collection wildcats (Table 02). Pending further discussion below, the two largest specimens can be described as ‘probably wildcat’, with the large radius possibly representing a hybrid or an exceptionally large house cat.

Comparing the York Viking age sample with the medieval sample, the difference is quite striking. On the medieval length measurements, just three specimens are within ±0.01 of the standard, and the remaining 45 are all below. On breadth measurements, just eight are within ±0.01 of the standard and the remaining 58 are all below. The medieval sample is clearly of cats that were substantially smaller than the standard sample: indeed, around 20 of the breadth sample are as far below the house cat standard as we might expect wildcat breadth measurements to be above the standard. These figures indicate a distinct decrease in the size of cats in York between the Anglo-Scandinavian and High Medieval periods; i.e. either side of the Norman Conquest. Fig 04 shows length and breadth results for the Lincoln sample, and a size distribution more akin to the York medieval sample than to the contemporary 10th-early 11th century sample. One cat stands out in the Lincoln breadth data, a radius at 0.044. This is not a particularly high value, though the specimen is distinctly larger.
than the remainder of the distribution. Given that, this specimen could be another ‘probable wildcat’. More to the point, the Lincoln data suggest that the size distribution of the York 10th century cats is distinctive to the city, not to the period of time.

Figs 05 and 06 show the distribution of length data from the very large assemblages at Haithabu and Schleswig. The range and distribution of the Haithabu sample is unexceptional, being quite similar to the contemporaneous samples from York and Lincoln. The Schleswig sample, in contrast, shows a remarkable range, from 0.105 to –0.138. The largest specimens overlap with Kratochvil’s wildcat data, with the reference collection wildcats, and with the largest specimens in the Kilton Castle sample. It seems feasible, therefore, that the largest five specimens, at least, in the Schleswig distribution derive from wildcats. Indeed, a graph of humerus GL in the original report shows a distinct ‘shoulder’ of larger cats, though this interpretation is not offered (Spahn 1986, fig 24). However, that does not explain the remarkably small specimens in the sample, and the question of intra-sample variability merits further discussion.

Discussion

What becomes clear from a consideration of the modern data, and of the archaeological samples, is that it would be unrealistic to expect a clear differentiation in biometric data between wildcats and their house cat contemporaries. Furthermore, the size distribution of house cat populations varied distinctly from time to time and from place to place. Table 05 summarises the variation observed in length measurements, using the mean log-ratio values for each sample, and the standard deviation of that mean. Although this manipulation of log-ratio values is unconventional, it serves a useful purpose here in summarising both the overall size difference between samples in this investigation, and giving us a measure of the degree of intra-sample variation. The mean values show that the largest average size occurs, not surprisingly, in the reference collection sample known to contain both wildcats and house cats, and in the Kilton Castle sample inferred to contain both. That result, at least, tends to support the interpretation of the Kilton sample. Apart from
Schleswig, the other archaeological samples show a consistency in their standard deviation values, those values being lower than in the two ‘mixed’ samples. With more conventional data, the standard deviation values could be converted to a coefficient of variation ($V = 100 \times \text{std dev/mean}$). However, as the mean values from these data range either side of zero, such calculation would be meaningless (i.e. for the reference collection sample, $V = 100 \times 0.038/0.000 = \infty$). Indeed, the absolute numerical value of the calculated standard deviations are of little significance, but the results at least confirm that ‘mixed’ samples tend to show a higher intra-sample size variation than do archaeological samples arguably predominantly composed of house cats. Schleswig is therefore highly anomalous, with a mean value in the same range as the other Viking and medieval archaeological samples, and a size distribution consistent with the other archaeological samples (Fig 06), but a far higher standard deviation than even the ‘mixed’ reference sample.

It has been argued above that the largest few cats in the Schleswig sample may have been wildcats, but that does not explain the high overall variance. The Schleswig sample spans an appreciable period of time, from the later 11\textsuperscript{th} century into the 14\textsuperscript{th} century. Although some distinction is made in the published report between ‘young’ and ‘old’ phases within that period, the biometrical data are not subdivided. It is clear that cat bones were about equally distributed between the two phases, and that there was no substantial change in the spatial distribution of cat bones between the phases (Spahn 1986, 15-17). What we have for Schleswig, therefore, is a pooled sample spanning several centuries. It is quite possible that some size change occurred in house cats during this period of time, greatly increasing the intra-sample variability. The very small size of some of the cats is notable, suggesting quite strong selection pressures acting on adult body size (e.g. see Spahn 1986, fig 25, which illustrates two skulls at either end of the size range). Whether those pressures favoured smaller body size, or whether we are seeing a relaxation of pressures that would normally favour a larger body size, is not apparent. With a medium-sized animal such as the cat, it is difficult to predict the direction in which body size would tend to move given a relaxation of the selection pressures associated with a ‘wild’ lifestyle.

It remains to ask whether the results of this investigation have any practical application in the diagnosis of cat bones from archaeological samples, given that these
generally occur in small numbers, precluding the analysis of intra-sample variation that has been possible here. Table 06 lists measurements of cat limb bones from Late Iron Age structures overlying the broch at Howe, Orkney (Smith 1994). One radius stands out from the remainder, sufficiently so to suggest that this could perhaps be a small wildcat, the remaining specimens deriving from house cats. The log-ratio values for length and breadth measurements on the large radius are not clearly in the modern wildcat range, but do approach the range of values seen in larger samples in which the presence of wildcat is either known (e.g. Table 02) or suspected (Table 04). This specimen lies just outside the $2\sigma$ range of the York Viking sample. Perhaps of more significance is the apparent confirmation that the majority of specimens are from house cats. Orkney is well beyond the sphere of Roman influence and therefore, even given the ‘post-Roman’ 4th to 8th century AD date of the Orcadian Late Iron Age, the Howe specimens are inconsistent with the oft-repeated assertion that house cats ‘came to Britain with the Romans’, at the northern end of a distribution that began with domestication in Middle or New Kingdom Egypt (e.g. see Kratochvil and Kratochvil 1976; Teichert 1977; Serpell 1988; Malek 1993). A second example is given in Table 07, which lists measurements of cat bones from the high-status late Viking Age site at Earl’s Bu, Orkney (Batey et al. 1993). Again, one specimen, a humerus, stands out as being well within the range to be expected of wildcat, with the remaining specimens all being typical of rather small house cats in the range seen at York and Haithabu.

Finally, limb bone measurements from a cat recovered from the Roman site at Quseir el-Qadim, Egypt, have been tested against the house cat standard. This cat was reported by von den Driesch and Boessneck (1983), who draw particular attention to its size; “extremely large for a house cat” (ibid., 208). By adding this egregious cat to the analysis, the aim was to test the limitations of the procedure. Conversion of limb bone lengths and breadths to log ratio values against the house cat standard gave a range of strongly positive values, from 0.043 (radius Bd, though note 0.026 for calcaneum GL) to 0.079 (femur GLC). On the face of it, this is a wildcat-sized cat, though calculations of log-ratio values against Kratochvil’s wildcat sample means (Table 01) gave consistently negative values (-0.013 tibia Bp to –0.047 radius Bd). Von den Driesch and Boessneck are quite confident that this is a house cat, citing morphological traits of the cranium and mandible, and the photographs that accompany their paper clearly show a shortened angular process on the mandible,
typical of house cats. Furthermore, the context of the burial, wrapped in linen and lain on woollen textile (appropriately of tabby weave) in a niche within a major building, strongly suggests ‘domestic’ status, whatever the morphology. The same authors have drawn attention to the often large size and ‘wild’ proportions of house cats in ancient Egypt (Boessneck and von den Driesch 1982). Evidently, any investigation of house cats from Roman or earlier Egyptian sites would need to play close attention to context as well as to biometry.

Conclusions
This investigation has demonstrated that differentiation of wildcat and house cats may be feasible using a conventional and relatively unsophisticated biometric technique. However, examination of intra-sample range and variation within large zooarchaeological samples shows that it maybe unrealistic to expect a clear size distribution break between the two ecomorphs, a result that is consistent with modern observations that sympatric wildcats and house cats interbreed freely to produce a continuum of hybrid forms. None the less, application of the results to two typically small samples has shown that specimens of wildcat may be identified in samples consisting largely of house cats, albeit with differing degrees of confidence. The Quseir el-Qadim cat was an exceptional beast, and serves as a warning that the context of the finds should be taken into consideration. The next step is to attempt the converse, namely to identify scarce house cats among samples that largely consist of wildcats (O’Connor, in prep.). Acquiring the data for such an analysis is more difficult than accessing the substantial medieval samples used in this paper, but further investigation is essential if our knowledge of the domestication and adoption of this most familiar of companion animals is to proceed on a more sound evidential basis.

Acknowledgements
I am grateful to Jennifer Harland for permission to use her data from Earl’s Bu.

References


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Table 01. Sample means, standard deviation and number of cases for house cat and wildcat samples derived from Kratochvil (1976) with codes following von den Driesch (1976)
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<th>GL(log)</th>
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Table 02. Length measurements and corresponding log-ratio values for wild- and house cat specimens from University of York (EAU numbers) and author’s reference collections. Specimens designated ‘wild’ were attributed on pelage characters. The specimens have been sorted by size. Note that ‘wild’ specimens have separated entirely from the remainder and that specimens from the same individual mostly cluster together. Of the house cats, Hobbit was an intact male; the others were all female.
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<th>Bone</th>
<th>Range</th>
<th>95% CI</th>
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<td>Radius GL</td>
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<tr>
<td>Humerus Bd</td>
<td>-0.054 to 0.095</td>
<td>±0.007</td>
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<tr>
<td>Femur Bd</td>
<td>-0.050 to 0.091</td>
<td>±0.007</td>
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Range and 95% Confidence Intervals for four house cat sample parameters converted to log-ratio values with respect to the house cat sample mean.

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<th>95% CI</th>
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<td>Radius GL</td>
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<tr>
<td>Humerus Bd</td>
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<td>±0.015</td>
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<tr>
<td>Femur Bd</td>
<td>-0.054 to 0.035</td>
<td>±0.013</td>
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Range and 95% Confidence Intervals for four wildcat sample parameters converted to log-ratio values with respect to the wildcat sample mean.

Table 0.3: Log-ratio values for maximum minimum and 95% Confidence Interval values for house and wildcat data from Kratochvil (1976a).
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Table 04. Length measurements and corresponding log-ratio values for cat bones from post-medieval deposits at Kilton Castle, Yorkshire, sorted by size.
Table 05. Sample mean values of log-ratio length measurements and standard deviations of those mean values.

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<td>Bd</td>
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<tr>
<td>--------</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Howe</td>
<td>Radius</td>
<td>102</td>
<td>9</td>
</tr>
<tr>
<td>Howe</td>
<td>Radius</td>
<td>95</td>
<td>8</td>
</tr>
<tr>
<td>Howe</td>
<td>Radius</td>
<td>93</td>
<td>8</td>
</tr>
<tr>
<td>Howe</td>
<td>Femur</td>
<td>104</td>
<td>20</td>
</tr>
<tr>
<td>Howe</td>
<td>Femur</td>
<td>104</td>
<td>19</td>
</tr>
<tr>
<td>Howe</td>
<td>Tibia</td>
<td>109</td>
<td>19</td>
</tr>
</tbody>
</table>

Table 06. Howe Orkney. Measurements of cat bones from Late Iron Age Phase 8 as given in Smith (1994) with log-ratio values relative to the house cat standard.

<table>
<thead>
<tr>
<th>log-ratio value</th>
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<tbody>
<tr>
<td>EB humerus BD=17.7 -0.005</td>
</tr>
<tr>
<td>EB humerus BD=21.5 0.079</td>
</tr>
<tr>
<td>EB radius Bp=7.6 -0.025</td>
</tr>
<tr>
<td>EB tibia Bp=17.9 -0.034</td>
</tr>
<tr>
<td>EB astragalus GH=14.2 -0.046</td>
</tr>
<tr>
<td>EB astragalus GH=15.5 -0.008</td>
</tr>
<tr>
<td>EB calcaneum GL=27.8 -0.022</td>
</tr>
<tr>
<td>EB calcaneum GL=27.7 -0.023</td>
</tr>
</tbody>
</table>

Table 07. Earls Bu Orkney. Measurements of cat bones from Viking Age deposits with log-ratio values relative to the house cat standard. Data courtesy of J.F. Harland.
Fig 01. Kilton Castle length and breadth measurements against house cat standard. Note the high log-ratio values for the largest specimens, and the lack of any clear break in the data between the largest and smallest specimens.
Fig 02. Log-ratio length and breadth distributions for York 10th to early 11th century cats.
Fig 03. Log-ratio length and breadth distributions for York 12th to 13th century cats.
Fig 04. Log-ratio length and breadth distributions for Lincoln 10th to early 11th century cats.
Fig 05. Haithabu cat lengths against house cat standard
Fig 06. Schleswig cat lengths against house cat standard. Note the exceptionally high and low values at the extremes of this range.