

## Chapter 6

### Microfaunal Remains from the East Granary, Roman Vindolanda:

Evidence for Human - Animal Interactions

by Deb Bennett and Robert M. Timm

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#### Introduction and methods

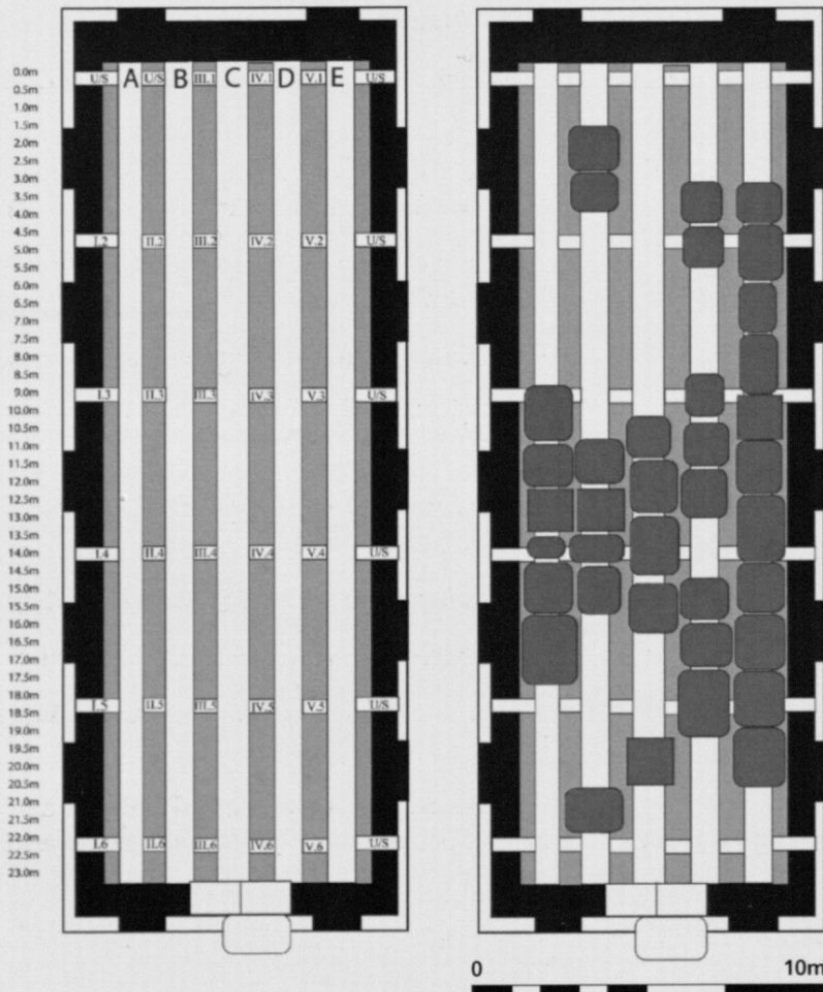
The East Granary situated within the Roman fort-village complex at Vindolanda was in active use from the early third through the late fourth centuries A.D. The architectural layout of the foundation of this building consists of five parallel channels cut by cross-flues at regular intervals (Figs. 1-3), and naturally lends itself to fine-resolution spatial sampling. A quadrat survey comprising 258 1-liter samples taken at half-meter intervals along the channels

and from most of the cross-flues was carried out at two levels, yielding some 526 samples in total.

Each sample was carefully screen-washed to 1 mm by Vindolanda Trust volunteers for the recovery of faunal remains, yielding a total of approximately 4,000 complete or fragmentary bones. This report documents the species identity, distribution, and significance of these remains (Figs. 9 - 14 and Tables 1 - 49).

Herein, we also consider 23 contexts -- including paved surfaces, ditches, trenches, and drains -- peripheral to the East Granary and within 2 meters of it. These contexts were sampled by standard troweling and hand-collection methods, and are variously dated from the early third to the late fourth century, that is, the whole of the time period represented by the granary. The species identity and distribution of these remains are compared to those from the East Granary itself (Fig. 4 and Tables 50 - 60).

Bones were identified by comparison with previously identified material from Vindolanda, and with modern reference material housed in the collections of the University of Kansas Natural History Museum, Division of Mammals and Division of Birds, and of the Department of Archaeology, Durham University. Reference manuals for bone identification were consulted also (Cohen and Serjeantson, 1996; Tomek and Bochénski, 2009; Gilbert et al., 1981; Olsen, 1979a, 1979b; Schmid, 1972; Sisson and Grossmann, 1974). Owl pellets were identified by comparison with those produced by modern barn owls and other owls and raptors (Figs. 5 - 8; Bunn et al., 1982; Johnsgard, 1988; Mikkola, 1983; Morris, 1969; Serjeantson, 2009; Sparks, 1989; Yalden, 2009).



**Figures 1 & 2** Layout of channels and flues in the East Granary. Arrow indicates north. The "front" of the granary is considered to be the north end; the "back" or "loading dock" is at the south end. Positions of surviving flagstones which formed the working floor of the East Granary. Samples processed by wet sieving came from earth between the channels, beneath the floor level.



## Results

### Number of bones recovered

Ditches, drains, trenches, and paved surfaces peripheral to the East Granary produced 1,610 bones or bone fragments identifiable to species, each of which was assigned a unique catalog number. Of the material recovered from the East Granary itself, 1,254 bones proved to be identifiable to species or nearest comparable species, and these specimens also were assigned catalog numbers. Two bones pertaining to fish, not identified beyond family, were assigned catalog numbers, along with a few bones belonging to the common toad, *Bufo bufo*. In addition, approximately 3,000 small fragments of bone from the quadrat samples were identifiable only to genus if at all. This material was examined but not assigned catalog numbers.

In addition to the normal bony evidence for the existence of various vertebrate taxa, three partial pellets of the barn owl, *Tyto alba*, were recovered intact (Figs. 5–8).

### Species identifications

The faunal list for all contexts herein reported comprises 41 species, only two of which were present in peripheral contexts but absent from samples taken from beneath the East Granary. The combined faunal list from both East Granary sampling levels - Level 1 (dated A.D. 300–400) and Level 2 (dated A.D. 218–280) - comprises 39 species, 71% of which were found to occur in both excavated levels.

## Species list from quadrat samples taken from east granary sub-floor channels

## Lower Vertebrates

Fish, sp. indet. of the family Salmonidae - Level 1 only

*Bufo bufo*, Common Toad - Levels 1 and 2

## Birds

*Anas querquedula*, Garganey - Level 2 only (with scrappy material less certainly assignable from Level 1)

*Columba oenas*, Stock Dove - Level 2 only

*Corvus corax*, Raven - Level 1 only

*Corvus corone*, Carrion Crow - Level 1 only

*Coturnix coturnix*, Quail - Level 2 only

*Emberiza citrinella*, Yellowhammer - Levels 1 and 2

*Emberiza (Miliaria) cf. calandra*, Corn Bunting - Levels 1 and 2

*Emberiza cf. schoeniculus*, Reed Bunting - Level 1 only

*Gallus gallus*, Domestic chicken - Levels 1 and 2

*Grus grus*, Common Crane - Levels 1 and 2

*Hirundo rustica*, European Swallow (Barn Swallow) - Level 2 only

*Passer domesticus*, House sparrow - Levels 1 and 2

*Passer cf. montanus*, Mountain sparrow - Level 2 only

*Riparia riparia*, Sand Martin - Level 1 only

*Sturnus vulgaris*, Starling - Levels 1 and 2

*Tetrao tetrix*, Black Grouse - Levels 1 and 2

*Turdus philomelos*, Song Thrush - Levels 1 and 2

Cf. *Tyto alba*, Barn Owl (pellets) - Level 2 only (but likely from both levels; see Discussion)

## Mammals

*Apodemus sylvaticus*, Wood Mouse - Levels 1 and 2

*Apodemus cf. flavicollis*, Yellow-necked Field Mouse - Levels 1 and 2

*Arvicola terrestris*, European Water Vole - Levels 1 and 2

*Bos taurus*, Domestic Cattle - Levels 1 and 2

*Canis familiaris*, Domestic Dog - Levels 1 and 2

*Capra hircus*, Domestic Goat - Level 1 ("Ovicaprine" from both levels)

*Capreolus capreolus*, Roe Deer - Level 1 and 2

*Cervus elaphus*, Red Deer - Level 1 and 2

*Equus* sp., Domestic Horse, Ass, and Mule - Levels 1 and 2

*Felis catus*, Semi-wild Cat - Levels 1 and 2 (note this species has previously been termed *Felis sylvestris*).

*Lepus capensis*, European Hare - Levels 1 and 2

*Microtus agrestis*, Field Vole - Level 1 only

*Mus musculus*, Commensal Mouse - Levels 1 and 2

*Mustela cf. erminea*, Stoat - Levels 1 and 2

*Myodes glareolus*, Bank Vole - Level 1 only (note that this species has until recently been known as *Clethrionomys glareolus*).

"Ovicaprine" - Domestic Sheep or Domestic Goat - Levels 1 and 2

*Ovis ammon*, Domestic Sheep - Level 1 ("Ovicaprine" from both levels)

*Sus scrofa*, Domestic Hog - Levels 1 and 2

*Talpa europaea*, European Mole - Levels 1 and 2

### Species lists from peripheral contexts

Two types of context occurring in the immediate vicinity of the East Granary were sampled: paved corridors and roadways, and ditches, trenches, and drains.

**Faunal list from paved corridors and roadways:** Comprising Contexts V08-07A, V08-09A, V08-12A, V08-13A, V08-16A, V08-17A, V08-18A, V08-22A, V08-64A. Sheep (*Ovis ammon*) or Goat (*Capra hircus*) are identified to species only where skull or horn core material was recovered; otherwise their remains are grouped as "ovicaprines".

#### Birds

*Gallus gallus*, Domestic Chicken

#### Mammals

*Arvicola terrestris*, Water Vole

*Bos taurus*, Domestic Cattle

*Canis familiaris*, Domestic Dog (several different breeds, adults and juveniles)

*Capra hircus*, Domestic Goat

*Cervus elaphus*, Red Deer

*Equus* sp., (Horse, Ass, or Mule)

*Felis catus*, Semi-wild Cat

*Meles meles*, European Badger

"Ovicaprines" - Undifferentiable Domestic Sheep or Goat

*Sus scrofa*, Domestic Hog

**Faunal list from ditches, drains, and trenches:** Comprising contexts V08-15A, V08-23A, V08-25A, V08-27A, V08-28A, V08-32A, V08-33A, V08-39A, V08-40A, V08-45A, V08-46A, V08-66A, V08-67A, V08-69A. Sheep (*Ovis ammon*) or Goat (*Capra hircus*) are identified to species only where skull or horn core material was recovered; otherwise their remains are grouped as "ovicaprines".

### Birds

*Cygnus cygnus*, Whooper Swan

*Gallus gallus*, Domestic Chicken

*Grus grus*, Common Crane

### Mammals

*Bos taurus*, Domestic Cattle

*Canis familiaris*, Domestic Dog; several different breeds

*Capreolus capreolus*, Roe Deer

*Cervus elaphus*, Red Deer

*Equus* sp., (Horse, Ass, or Mule)

*Equus* cf. *asinus*, Domestic Ass

*Felis catus*, Semi-wild Cat

*Meles meles*, European Badger

*Ovis ammon*, Domestic Sheep

"Ovicaprines" - undifferentiable Domestic Sheep or Goat

*Sus scrofa*, Domestic Hog

### Species frequency

By far the commonest species from the East Granary (as in all localities at Vindolanda) is *Bos taurus*, domestic cattle. By contrast, frequent from beneath the granary but almost unknown from elsewhere at Vindolanda are the remains of the commensal house mouse, *Mus musculus*, and of wild mice and voles of the genera *Apodemus*, *Arvicola*, and *Microtus*. The most frequent bird species from the East Granary (as from other Vindolanda localities) is *Gallus gallus*, the introduced domestic chicken. Again by contrast, very frequent from the East Granary but unknown from elsewhere at Vindolanda is the house sparrow, *Passer domesticus*.

That we can discern these differences is due to the employment of wet screening as a recovery technique in the East Granary. We here record

the presence of 21 species of small mammals and birds that have never before been reported from Vindolanda: *Anas querquedula*, *Coturnix coturnix*, *Columba oenas*, *Emberiza citrinella*, *Emberiza (Miliaria) cf. calandra*, *Emberiza cf. schoeniclus*, *Hirundo rustica*, *Passer domesticus*, *Passer cf. montanus*, *Riparia riparia*, *Sturnus vulgaris*, *Turdus philomelos*, *Talpa europaea*, *Mustela cf. erminea*, *Apodemus sylvaticus*, *Apodemus cf. flavicollis*, *Arvicola terrestris*, *Microtus agrestis*, *Mus musculus*, *Myodes glareolus*, and also *Tyto alba* by indirect evidence (pellets).

Remains from paved roads or walkways and from ditches and drains peripheral to the East Granary exceed the number of those recovered from below the building. This is true despite the employment of hand-troweling as the sole method of recovery from these contexts. Only one small mammal - a jaw ramus pertaining to the water vole *Arvicola terrestris* - was recovered from a roadway between the East Granary and the Headquarters Building to the south. This is one of only three specimens of rodent ever recovered by hand-troweling from Vindolanda (Hodgson, 1976, 1977). Rodent remains could be recovered by hand-troweling because Trust volunteers are well-trained, dedicated, thorough, and observant. For the same reasons, three particularly well-indurated pellets pertaining to the barn owl (*Tyto alba*) were recovered intact from the wet-sieving operation, the most complete of which is compared in Figs. 5 - 8 to the pellet of a living barn owl.

Almost all bones recovered from peripheral contexts belong to mammals; less than 1% pertain to birds, and of these only common crane (*Grus grus*) and whooper swan (*Cygnus cygnus*) - both quite large species - have been recovered. The situation changes greatly with regard to East Granary samples: while 91% of bones recovered from Level 1 are mammals, only 74% of bones recovered from Level 2 pertain to mammals. Bones of lower vertebrates are present at very low

frequency (less than 1%) in both levels. Relative frequencies of mammal, bird, and lower vertebrate species are shown in Figs. 4A, 4B and Tables 54 - 60.

## DISCUSSION

### Comparison with species previously reported from Romano - British Sites

The most common animal species reported from almost all Romano - British sites are domestic cattle, hogs, sheep, goats, and chickens (see Huntley and Stallibrass, 1995, for a useful bibliography to the extensive literature). Previous reports on Vindolanda mammals have shown that domestic cattle represent about 40 - 60% of all bone recovered, whether this is calculated as a percentage of minimum individual count (Bennett, 2007b) or whether as a straight percentage of cataloged bones (Bennett, 2005). However, cattle bones occur at a much higher relative frequency - some 74% - from paved surfaces here reported. Ditches, trenches, and drains produced cattle bone at a more normal frequency of 40% (Fig. 4A, Table 54).

The large number of bones of small mammals recovered through screen-washing techniques for this study greatly increases our knowledge of the wild fauna which lived in meadow, field, streamside, and woodland habitats (Huntley, 2003 and this volume) that surrounded Roman Vindolanda. The number of small mammal species from Vindolanda is now comparable to that from nearby Birdoswald (Izard, 1997), though with some differences: from Vindolanda we identify *Apodemus cf. flavicollis* in addition to *A. sylvaticus*; the latter has not yet been found at Birdoswald. Izard (1997) reports the common shrew (*Sorex araneus*), while we report the European mole (*Talpa europaea*). Izard reports "stoat" without specific identification probably because in the absence of a large sample containing complete bones and teeth, identification can be problematic (Holmes, 1987); we identify *Mustela cf. erminea* on the

basis of a distal humerus and a partial jaw ramus containing a partial carnassial and the canine tooth. Significantly, while both of these northern localities produced the commensal or house mouse (*Mus musculus*), there is no evidence to date from either locality for the occurrence of either the brown rat (*Rattus norvegicus*) nor the black rat (*Rattus rattus*).

The Vindolanda bird list has expanded even more than that for the mammals. Bennett (2007a) reported ten species of birds from Vindolanda that had been recovered over many seasons of excavation by careful hand troweling. By far the commonest bird recovered from Vindolanda (counting all years of excavation and over all contexts) is the domestic chicken, *Gallus gallus*. Among birds likely to have been used by people as food, we may now add the garganey (*Anas querquedula*) and common quail (*Coturnix coturnix*) to the black grouse (*Tetrao tetrix*), mallard (*Anas platyrhynchos*), common shelduck (*Tadorna tadorna*), whooper swan (*Cygnus cygnus*), common crane (*Grus grus*), and golden plover (*Pluvialis apricaria*) previously reported. While Izard (1997) reports no geese from Birdoswald, Bennett (2007a) reports the barnacle goose (*Branta leucopsis*) from Vindolanda while O'Connor (1993) reports several species of geese and a teal (*Anas crecca*), as well as the ern (*Haliaeetus albicilla*) and two species of seagull from Roman Segontium located on the Severn Estuary, a site which overall has a much more maritime character than does Vindolanda. From Birdoswald Izard (1997) reports woodcock (*Scolopax rusticola*), which has not so far been seen at Vindolanda.

It is not surprising to find the remains of pigeons, which are seed-loving birds, in the context of a Romano-British granary, and *Columba* spp. are reported both here and by Izard (1997). Likewise both the scavenger species - raven (*Corax corax*) and carrion crow (*Corax corone*) - are reported from both localities. The list of small songbirds at Vindolanda vs. Birdoswald differs more: while Izard reports greenfinch (*Carduelis chloris*), a

prunellid (likely a dunnoek, *P. modularis*), and a motacillid (a wagtail or pipit), we report barn swallow (*Hirundo rustica*), house martin (*Riparia riparia*), song thrush (*Turdus philomelos*), mountain sparrow (*Passer cf. montanus*), yellowhammer (*Emberiza citrinella*), reed bunting (*Emberiza cf. schoeniclus*), and corn bunting (*Emberiza cf. calandaria*). Both localities produce the starling (*Sturnus vulgaris*). Most of these birds remain common throughout northern England and southern Scotland, and, given the short distance between Birdoswald and Vindolanda and the vagility of the birds, it is likely that all of them actually occurred in both places.

The bones of raptors and owls occur at much lower frequency in Romano - British sites than do the bones of the birds listed above (Serjeantson, 2009; Parker, 1988). The red kite (*Milvus milvus*) has been reported from Ribchester, southwest of Vindolanda (Stallibrass and Nicholson, 2000). Apart from pellets attributable to the barn owl (*Tyto alba*), no bones of predatory birds have so far been recovered from Vindolanda.

### Dogs and large mammal remains from beneath the east granary

In some Vindolanda contexts excavated in previous years, we found large amounts of cattle bone broken into cobble-sized pieces, and it is thought that this material represents "rubble" brought in as fill and to help level up the ground surface for the construction of buildings, roads and pathways. However, in this case the material usually also shows damage from impact and erosion which is not the case with bones from the present study.

Cattle bone is just as frequent from beneath the East Granary floor as it is from the ditches, drains, and trenches that surround the building. Cattle specimens from beneath the East Granary are generally more fragmentary than material from peripheral contexts, but even so, to get beneath the granary, bones or fragments of bone must either have fallen through gaps in the floor or else have been

brought, swept or washed in either through the flues (Fig. 3) or through the north or south ends of the channels (Fig. 1), presumably at times when the foundation of the building was in disrepair. Since the remains of hoofed mammals are more common from samples taken below surviving flags than from any area where flags were removed (compare for example Figs. 9A and 9B with Fig. 2), the latter seems more probable. Although survey of mineral grains from subfloor samples indicates that material may have drifted in (Huntley, present volume), the association between floor flags and the bones of hoofed mammals suggests that the bones were brought in, probably by dogs. This seems more likely since many of the ungulate bones are gnawed.

Only about 5% of hoofed animal remains came from north of Flue 2 and south of Flue 5, with 90% coming from beneath central parts of the granary, most abundantly in areas roofed by surviving floor flags. Cats and dogs show the same pattern, with only 8% of remains at Level 2 and none at Level 1 being found near the ends of the building. This again suggests that most ungulate remains were carried under the granary, there to be gnawed at leisure by cats and dogs.

Although the remains of stoat are rare in the sample, their presence must mean that they either resided under the granary, visited it, or else were brought there as the prey of owls or dogs. Stoats probably visited the granary to steal the eggs and chicks of small birds and to hunt mice. They in turn sometimes fall prey to barn owls. Field observations by author Timm indicate, however, that dogs readily learn to specialize in hunting both stoats and moles.

The remains of two suckling piglets, both very complete as to vertebrae and limb elements but missing their heads and most of their ribs, come from beneath flags at the very center of the granary (Fig. 9B). These might represent smoked pork that, becoming rotten, was thrown out and then picked up by dogs which carried them to a den beneath the granary. Only

4.5 meters away from the pile of piglet bones and in the same channel at the same stratigraphic level lay the remains of two puppies, further indication that dogs could gain entry to the space beneath the granary floor.

### **Distribution of remains relative to human, owl and cat activity**

The distribution of animal remains in and around the East Granary reveals patterns of human activity. Both the north and the south ends of the East Granary building appear to have been busy places - the front end functioning as a market stall, while the rear of the building was a loading dock for receipt of bulk shipments of grain (Andrew Birley, present volume). The remains of most but not all animal species recovered from beneath the East Granary cluster away from the north and south ends of the building. Only 20% of all animal bones excavated from Level 2 come from either north of Flue 2 or south of Flue 5. If chickens and small bird species other than the house sparrow are not counted, the percentage drops to 3%.

Some of the larger birds, particularly fowls from Level 2, show an opposite pattern; they are clustered at the ends rather than toward the middle of the building. At Level 1, however, these species too are found more toward the center than at either end of the granary. 95% of fowl bones are carpometacarpi, humeri, femora, or tibiotarsi, i.e. they represent the meatier parts of the wings or legs of these birds. The Level 2 distribution likely thus reflects another human activity - soldiers enjoying a bite of fowl as part of their midday meal.

The remains of large hoofed mammals are found no more frequently in flues at either Level 1 or Level 2 than from anywhere else under the granary. The remains of cats, dogs, fowls, toads, fish, and songbirds other than the house sparrow likewise show little affinity for the flues. By contrast, almost all remains of the house sparrow and of most small mammal species are concentrated in or near flues, especially the mouths of flues 4 and 5

where intact owl pellets were also recovered. The exception to this is the house mouse, *Mus musculus*, which might be found anywhere under the building and is usually found away from flues. The difference in distribution between the commensal house mouse and wild species such as field mice, field voles, or water voles suggests that although house mice might occasionally have been caught by an owl, of all rodents mice alone were actually nesting under the granary floor. Undoubtedly the granary was infested with house mice - as granaries worldwide continue to be today. Other species of mice and voles were not living under the granary or anywhere within the bounds of the fort, but likely were brought there after having been captured afield by an owl. They were dismembered and eaten as the owl sat upon its favorite perch under the eaves on the west side of the granary between flues 4 and 5, and we have recovered their bones from pellets ejected by the owl, most of which subsequently became disaggregated.

"Housecleaning" was apparently regularly ordered in the vicinity of the granary and warehouse. It has already been noted that cattle bones were deposited on paved surfaces near the East Granary with unusually high frequency. It is possible that the bones were deposited on the pavement at a time when these buildings were being cleaned out, perhaps in anticipation of an important visitor or before departure for battle. Interestingly, remains of Red Deer - mostly antler fragments - also occur at unusually high frequencies in paved contexts peripheral to the East Granary, lending support to the idea that scrap material from a nearby workshop had also been swept out onto roadways.

The remains of two wild carnivores - the European badger (*Meles meles*) and the stoat (*Mustela cf. erminea*) - are represented in this study but at very low frequency. A single stoat bone was recovered from each of the two granary levels, while two badger bones come from peripheral contexts. The position of the stoat bones is not near or in the flues but

rather toward the center of the building, suggesting that it may have been a regular visitor to the sub-floor space. With nests of barn swallows, martens, and house sparrows almost certainly present in or near the granary, stoats probably raided nests for eggs or chicks and ate house mice. Badgers, by contrast, were probably not permitted to den within the fort at any period of its occupation; their remains were instead brought in by fur trappers.

Apart from the house sparrow, small birds are rare in the East Granary samples, and these species are not concentrated at flues. Probably they were the prey of the semi-wild cat (*Felis catus*) (Woods, 2003), whose remains also occur under the flagged portion of the East Granary floor.

### Vindolanda owls and their prey

No skeletal remains of owls were recovered from East Granary samples. However, direct evidence for the presence of owls comes from three intact pellets, two from the west side of the building between the mouths of flues 4 and 5, and one from the east side near the mouth of flue 3 (Fig. 14A). The gustatory habits of owls, especially the barn owl (*Tyto alba*), are a true boon to the zooarchaeologist, for these birds do not prefer to dine in the field but rather bring captured prey back to a favored roost. There, the owl tears its meal into chunks and eats it completely, bones and all. Later, the owl regurgitates the indigestible parts in a pellet, so that large numbers of pellets may accumulate below an owl's roost. When freshly regurgitated, barn owl pellets are bound together with digestive mucus and are coated with a "varnished" grey crust formed mostly of the fur of the prey species ingested (Figs. 7, 8). Pellets become indurated as they dry out and tend not to disaggregate unless crushed or submerged in water (Serjeantson, 2009; Yalden, 2009).

At both stratigraphic levels investigated, the bones of toads, wild species of mice, and of house sparrows are concentrated near pellet recovery sites on the west side of the granary



(Figs. 11A,B and 13A, B). The pellet locality on the more exposed east side of the building could represent a roost that was less often used, or used for only a short period of time, but it is more likely that a concentration of pellets and bones similar to that from the west side is present but has not been documented because the eastern mouths of the flues were not sampled (Fig. 1). No owl pellets were recovered intact from Level 1, but we surmise from the generally whole, uneroded condition of the bones, from the abundance of bones and their concentration about the western mouth of flue 4, and from the species list itself, that most if not all remains of wild mice and house sparrows recovered from either excavated level actually came from barn owl pellets which became disaggregated over time or during the screen washing process.

Pellets accumulated near the mouth of flue 4 because the owl roosted somewhere above. The superstructure of the East Granary is absent and models showing its form must, although extensively researched, nonetheless be partly conjectural (Connolly, 1991; Morris, 1979; Rickman, 1971; Birley, present volume; Fig. 3). To avoid undesirable outward stress upon supporting walls, the tie-beams for the simple roof trusses used by the Romans in granary construction were allowed to rest entirely atop them, and the ends of the tie-beams thus extended the full width of the eaves (see reconstructions in Connolly, 1991, p. 16; note that this is not the construction shown in the East Granary model, Fig. 3). A triangular space formed by the exposed junctures of the tie-beams with the rafters would have created exactly the type of sheltered roost preferred by the barn owl. Barn owls commonly nest in barns and other farm outbuildings; there were probably spaces for the birds to get in between the tops of the walls and the rafters, or the Roman architect might even have provided "eulenlochen" or owl-holes in the pediments to encourage this rodent-hungry bird to nest in the granary's attic.

Owl pellets recovered from the East Granary are rounded in shape and packed with intact or nearly-intact, uneroded bones of toads, mammals, and birds (Figs. 5, 6). The pellets

are identified as those of barn owl from overall size and shape (Fig. 7), and by the fact that bones regurgitated by barn owls are generally recovered intact like those from Vindolanda, in contrast to bones from similar-sized pellets of the tawny owl (*Strix aluco*), which are usually crushed (Fig. 8; Yalden, 2009; Baxter, 1993; Morris, 1969). Pellets from raptors (buzzards, *Buteo buteo* or kestrels, *Falco tinnunculus*) are elongated rather than round in shape and the bones they contain are typically eroded by digestive juices (Yalden, 2009). Of all the owls, buzzards, and raptors that occur in Britain, barn owls are the most likely to choose a building for a roosting or nesting site (Bunn, et al. 1982; Johnsgard, 1988; Sparks and Soper, 1989). Barn owl roosts with associated "pellet microfaunas" have been recovered from four other Romano-British sites (O'Connor, the Caerleon frigidarium, 1986; Baxter, Drayton II Villa, 1993; West, the London basilica, 1993; and Baxter, Love's Farm St. Neots, in press).

Becoming active at sunset, barn owls scout for prey by flying silently, low and slowly, along the forest edge. They may hover or alight upon a fencepost or stump before pouncing on prey. In the British Isles murid and cricetid rodents, or other species that superficially resemble them including shrews and moles, are the commonest species taken, but barn owls also consume stoats, toads, baby hares, songbirds, bats, snakes, and insects (Johnsgard, 1988; Sparks and Soper, 1989; Mikkola, 1983).

Diet as evinced by pellet contents has been used to differentiate owls, but there can be large overlaps in the diets of barn owls and tawny owls (Chamberlain et al., 2000; Herrera, 1974). The diet of the tawny owl living in an urban environment is likely to contain a much greater fraction of small birds than does that of a barn owl living in mixed forest - field habitat (Fig. 15A; Glue, 1974; Love, et al., 2001). However, the barn owl is a highly opportunistic hunter that will take almost any prey small enough for it to kill (Sparks and Soper, 1989), and it responds

quickly to local population increases in potential prey (Johnsgard, 1988). Thus house sparrows, if locally or temporarily abundant, are just as likely to form the mainstay of a barn owl's diet as of a tawny owl (Fig. 15B).

More problematic is the complete absence of shrews of the genera *Neomys* and *Sorex* from the Vindolanda sample, especially given that Baxter (1993) reports them from Drayton II Villa in Leicestershire and Izard (1997) reports *Sorex* from nearby Birdoswald. While tawny owls generally avoid shrews as prey, *S. araneus* and *S. minutus* formed nearly one-third of the diet of barn owls living in mixed grassland-forest habitat (Glue, 1974; Love et al., 2000; Yalden, 2009). A barn owl might, however, abandon the hunting of shrews which weigh only 5 - 12g. per individual when presented with an abundance of bulkier field voles or, especially, water voles – the latter evidently available from the nearby Chineley Burn at Vindolanda.

Vindolanda's setting in open grassland, fields and pasturage bordered by riparian woodland habitat would have provided ideal hunting grounds for barn owls. Increase in agricultural activity - clearing of forest, mowing and plowing of fields, cattle and horses being let to graze in fields and meadows - changes the number and kind of owl prey species. Population numbers of a favorite barn owl prey, the field vole (*Microtus agrestis*) have been shown to decline in response to mowing and grazing of fields, as do those of field mice (*Apodemus* spp.) (Chamberlain et al., 2000; Derting and Cranford, 1989; Dickman et al., 1991; Glue, 1974; Love et al., 2001). In East Granary samples, both field voles and field mice decline by almost half from the earlier Level 2 to the later Level 1, suggesting in harmony with paleobotanical results (Huntley, this volume) that over time the Romans converted increasing acreage to grazing land. House mice (*Mus musculus*) also decline over time, while the water vole (*Arvicola terrestris*) greatly increases. Although it is a favored prey item, the field vole weighs only about 40-55g. Hunting efficiency is increased when owls turn to the plump water vole, which tips the scales

at between 150 - 350g. As water voles became more available over time, house mice weighing only 10-25g. (Nowak, 1999), may, like shrews, have become less worth the effort to hunt.

In recent years, the consumption of water voles by barn owls in Britain has declined in proportion to the decline of the water vole itself, suggesting that this species is indeed high on the owl's list of favored menu items (Serjeantson, 2009). Barn owls have a high metabolic rate and consequently a considerable appetite; a nesting pair and their young may consume more than 1,000 rodents per year (Sparks and Soper, 1989). In areas such as ancient Vindolanda where both barn owls and field voles occur, the owls and voles act as symbionts whose population numbers rise and fall in synchrony (Johnsgard, 1988).

While barn owls evince the small species in their diet by the composition of their regurgitated pellets, if they capture something larger than a water vole they are likely to dismember it, discarding inedible parts after tearing off the softer portions (Sparks and Soper, 1989). These larger bones also tend to accumulate below the owl's roost, and such deposits may include remains of animals as large as hares, chickens, kittens, piglets, or puppies. While the distribution of small mammals and house sparrows in East Granary samples suggests that they were captured and eaten by barn owls, piglet and puppy remains occur only under the flagged floor near the center of the granary and thus probably do not represent owl prey.

## Woodworms, house sparrows and owls

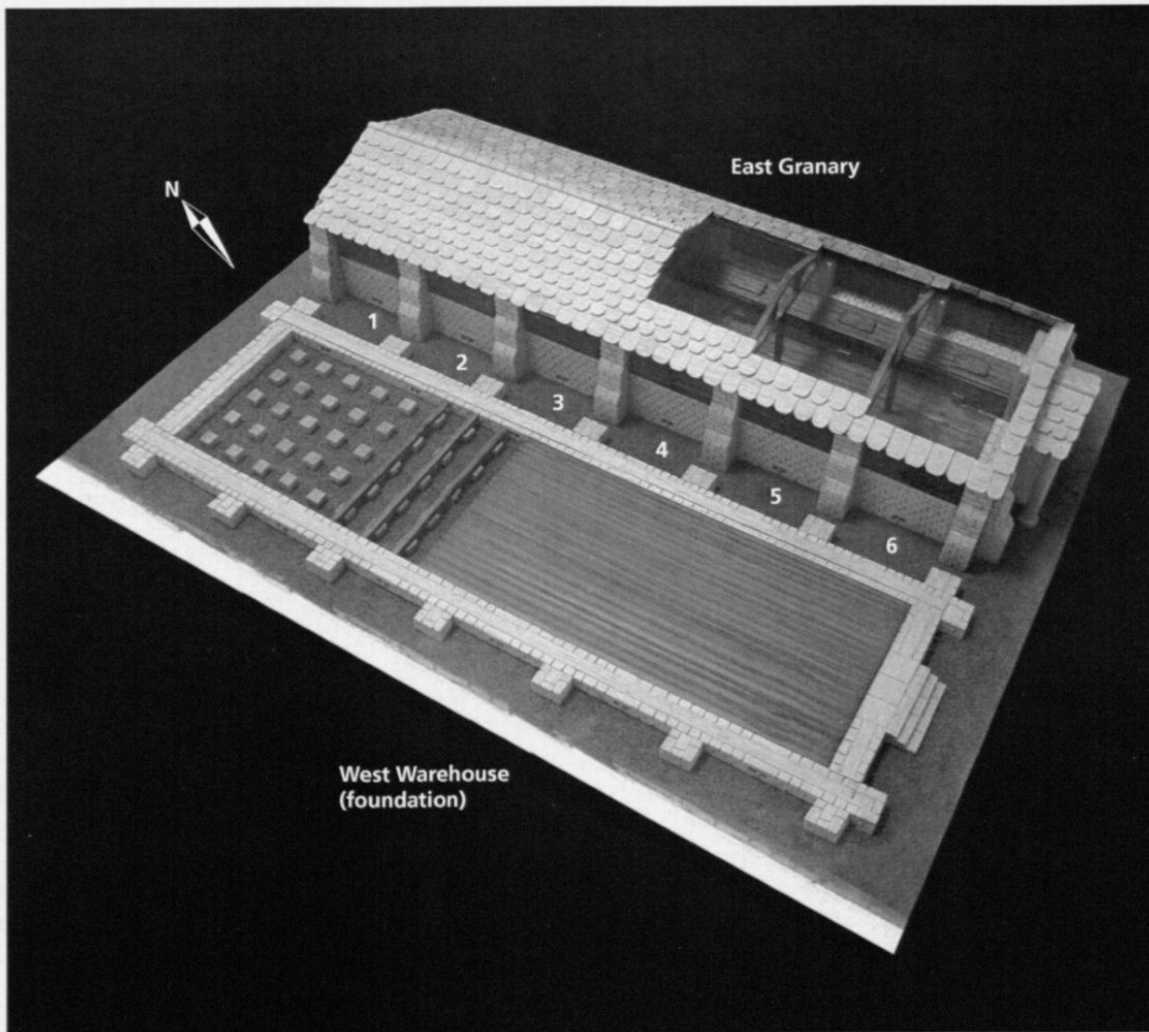
During examination of the floor level of the East Granary, traces of a wooden wall were discovered which seems to have partitioned the interior about 8 - 10m from its northern end. From the same area comes an abundance of coins and other small finds; these have been interpreted as perhaps representing a market in the front of the granary, separated from the main storage area behind (Andrew Birley, this volume).

Paleobotanical examination of East Granary flot samples brought to light the “completely unexpected” presence of hundreds of bits of wood - probably representing the disintegrated remains of the same interior partition - bearing holes made by woodworms (Huntley, this volume). “Woodworm” is the term applied to the larval or grub stage of certain beetles of the order Coleoptera. Woodworms infest trees as well as furniture and other objects made of wood. Beetle eggs laid in a hole in the wood hatch into larvae which tunnel into the grain as they feed on the sapwood (the outer portion of the tree trunk, or planks or timbers made from this part, which are often rich in starch). After living in the wood for about three years, the larvae quickly develop into adults. They bore their way out of the wood and then take wing to feed and to mate (Duff, 2008; Hickin, 1967, 1985).

The most common British “woodworm” species include the furniture beetle (*Anobium punctatum*), the powder post beetle (*Lyctus brunneus*), the hardwood borer (*Ptilinus pectinicornis*), and the boring weevil (*Euophyrum confine*) (Duff, 2008; Hickin, 1967). They attack sycamore, maple, ash, beech, birch and willow, and they are especially likely to attack wood that has already started to rot from fungal attack. Humid climate, or humid areas in buildings, favor them. Oak was a common building material at Vindolanda, and interestingly, it becomes susceptible to attack by the furniture beetle only after some sixty years have elapsed since the felling of the timber. For walnut and beech, the period of immunity is a little less. For soft woods, however, it is short - less than 20 years (Hickin, 1967).

Since the East Granary was in use for much longer than sixty years, and since softer woods as well as hardwoods were used in its construction, it is reasonable to surmise that in the humid climate of Northumberland there was an abundance of woodworms - and thus seasonally of emerging adult beetles, which are a favorite prey of the house sparrow, *Passer domesticus* (Anderson, 1977, 2006; Gavett and Wakeley, 1986; Groschupf, 2001; Summers-Smith, 1963, 2009). The large numbers of house sparrow bones that have been recovered from owl-roost flues of the East Granary may reflect communal roosting by house sparrows (Beissinger and Osborne, 1982; Brown, 1978; McGillivray, 1980, 1983; Peach et al., 2008). When these birds nest away from urban areas, they space their nests at least several meters apart. However, the above-cited studies have shown that house sparrow nest density increases in urban environments, and anywhere that food supply is abundant. House sparrows often parasitize or co-opt the nests of swallows (Stoner, 1939). Like swallows, they prefer to raise their broods in buildings, constructing their untidy-looking nests in holes or voids in timbers or in nooks in sheltered parts of the architecture (Groschupf, 2001).

The sheer abundance of house sparrow bones, and their concentration at the mouth of Flue 4, suggests that barn owls found house sparrows, especially unmated “helpers” and subadults which populate crowded nesting communities (Veiga and Boto, 2000), to be easy prey. Sparrow abundance was in turn upheld by the very woodworms of which our paleobotanist has found surprising but incontrovertible evidence (Huntley, this volume). Bones of *Passer domesticus* neither increase nor decrease over the time period studied, because although they are birds associated with human agricultural activity (Serjeantson, 2009; Pinowski and Summers-Smith, 1990), they were East Granary residents that relied, just as much as did the human residents of Vindolanda, upon a continuous supply of grain.



**Fig. 3** A scale model of the East Granary and the foundations of the West Warehouse building immediately to the west. The south end of the granary is cut away to enable a view of the interior. Openings for the ventilation flues are numbered. Note the louvered upper portions of walls, which would provide easy entrance for house sparrows (*Passer domesticus*) and other small granivorous birds. Attic space could have provided nesting sites for barn owls (*Tyto alba*). The woodworm-infested partition is inferred to have been placed across the width of the building interior somewhere between Flues 1 and 2.

## CONCLUSIONS

The wet-screening technique used for recovery of bone from East Granary samples has been extremely valuable, bringing many previously undiscovered species to light. As a result of this study, 24 species of mammal are now known from Vindolanda: *Apodemus* cf. *flavicollis*, *Apodemus sylvaticus*, *Arvicola terrestris*, *Bos taurus*, *Canis familiaris*, *Capra hircus*, *Capreolus capreolus*, *Cervus elaphus*, *Equus asinus*, *Equus caballus*, *Equus caballus* X *Equus asinus*, *Felis catus*, *Homo sapiens*, *Lepus capensis*, *Martes* cf. *martes*, *Meles meles*, *Microtus agrestis*, *Mus musculus*, *Mustela* cf. *erminea*, *Myodes*

*glareolus*, *Ovis aries*, *Sus scrofa*, *Talpa europaea* and *Vulpes vulpes* (previously identified as *V. fulva*; Hodgson, 1976, 1977; Bennett, 2005, 2007b).

This study has also more than doubled the list of Vindolanda bird species from 10 to 23: *Anas platyrhynchos*, *Anas querquedula*, *Branta* cf. *leucopsis*, *Columba oenas*, *Corvus corax*, *Corvus corone*, *Coturnix coturnix*, *Cygnus cygnus*, *Emberiza* cf. *calandra*, *Emberiza citrinella*, *Emberiza* cf. *schoeniclus*, *Gallus gallus*, *Grus grus*, *Hirundo rustica*, *Passer domesticus*, *Passer* cf. *montanus*, *Pluvialis apricaria*, *Riparia riparia*, *Sturnus vulgaris*, *Tadorna tadorna*, *Tetrao tetrix*, *Turdus philomelos*, *Tyto alba* (pellets only) (Bennett, 2007a). In addition, one species of fish (family Salmonidae, sp. indet.), and the common toad *Bufo bufo* round out the total number of 49 vertebrate species known from Vindolanda.

One of the central questions that this study has sought to answer is whether the East Granary was used exclusively for the purpose of storing grain. Paleobotanical evidence (Huntley, this volume) indicates that the building was, indeed, used primarily to store grain, but our analysis of vertebrate bone shows that the building was the focus of many activities, both human and animal. The north end of the granary was sufficiently well trafficked that animal species including dogs, cats, house mice, toads, and stoats living or pursuing prey under the floor avoided that end of the building. They also avoided the south end of the building, which appears to have been used as a loading dock.

Generations of barn owls (*Tyto alba*) roosted along the sheltered west side of the granary building, and they may also have roosted on the east side. Barn owls live, on average, less than three years; if there was a barn owl roost continuously present throughout the life of the East Granary building, it served as a perch for more than sixty generations of barn owls. A barn owl ejects one or two pellets per day, so that even if this bird was not always present

at the East Granary, and even if workers periodically cleaned around the base of the building, over nearly two centuries hundreds or even thousands of pellets would have accumulated below the roost above the mouth of flue 4, certainly enough to account for the abundance of bones of small mammals and birds recovered from these samples.

The species composition of possible owl prey from East Granary samples resembles that of modern tawny owls (*Strix aluco*) living in urban environments more than it resembles that of barn owls living in mixed grassland-forest habitat, but because recovered pellets contain bone that is largely intact and uneroded, and because the owl appears to have been roosting in the building over a long period of time, we consider that the bird that produced the pellets was almost certainly a barn owl (*Tyto alba*). Thanks to the barn owl's habit of bringing captured prey back to favored roosts to be eaten, we are able to obtain a glimpse of the wild microfauna which existed 1,800-1,600 years ago outside the Vindolanda fort-village complex. Most small mammal species recovered from East Granary samples were not living beneath the granary or even within the fort, but rather were brought there after having been captured afield by barn owls. Species which probably did call the sub-floor of the East Granary home include toads (*Bufo bufo*), house mice (*Mus musculus*), and moles (*Talpa europaea*). The stoat, *Mustela* cf. *erminea*, was a sub-floor visitor which itself probably sometimes became owl prey.

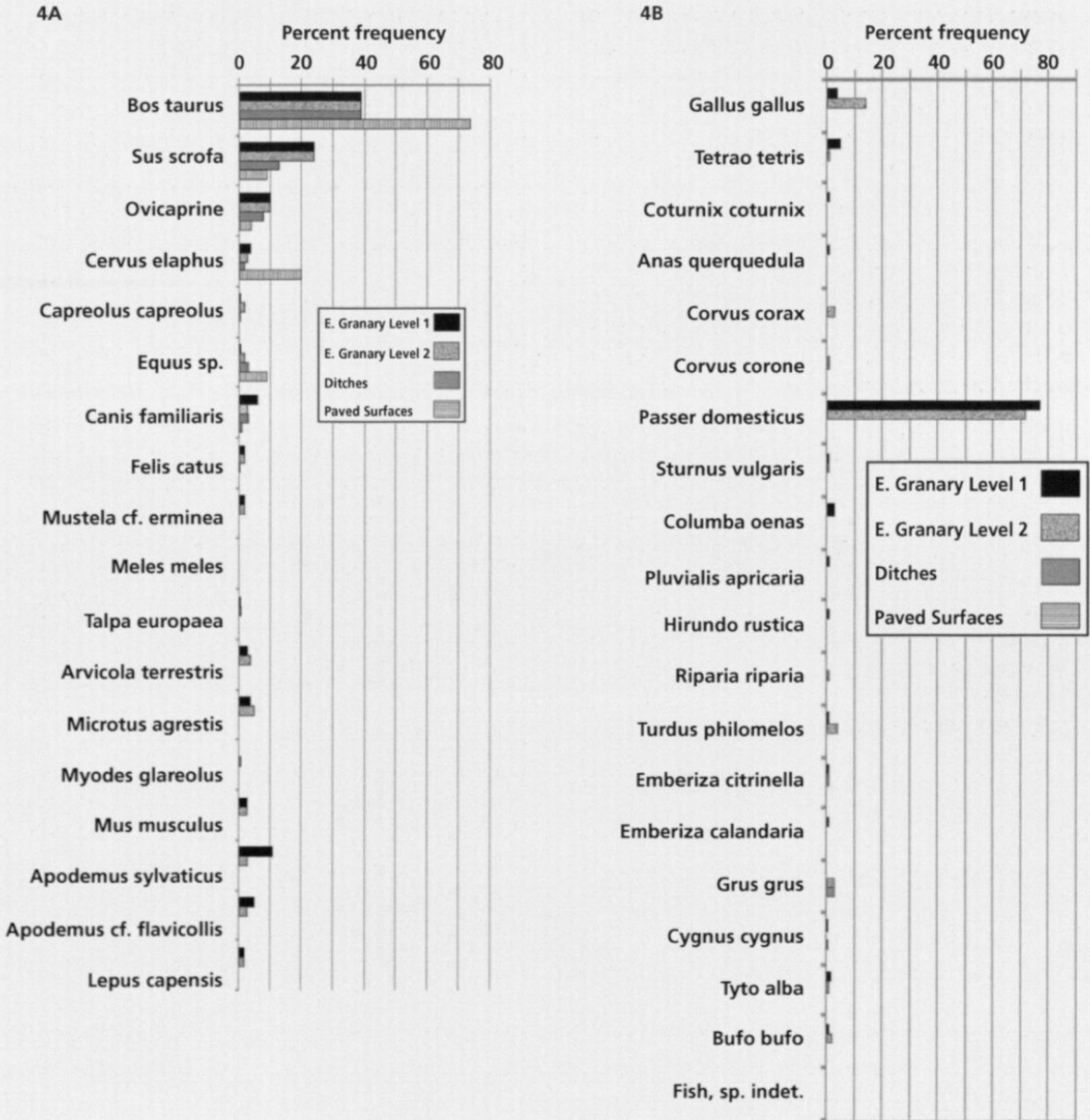
The proportion of species eaten by Vindolanda barn owls changed over time. In the earlier (218-280 A.D.) Level 2 deposits, *Microtus agrestis* forms 12% and *Apodemus* (*A. sylvaticus* and *A.* cf. *flavicollis* together) form 15% of the putative diet, while *Arvicola* contributes only 9%. In Level 1 samples (dated A.D. 300 - 400), *Microtus* declines to 7% and *Apodemus* to 6%, while *Arvicola* more than doubles to 20%. This dietary shift greatly increased the owls' hunting efficiency because of the much greater individual weight

of water voles as compared to field voles or mice. By contrast, house sparrow percentages change very little over the time periods sampled, probably because the continual availability of grain supported a large population in the vicinity of the East Granary.

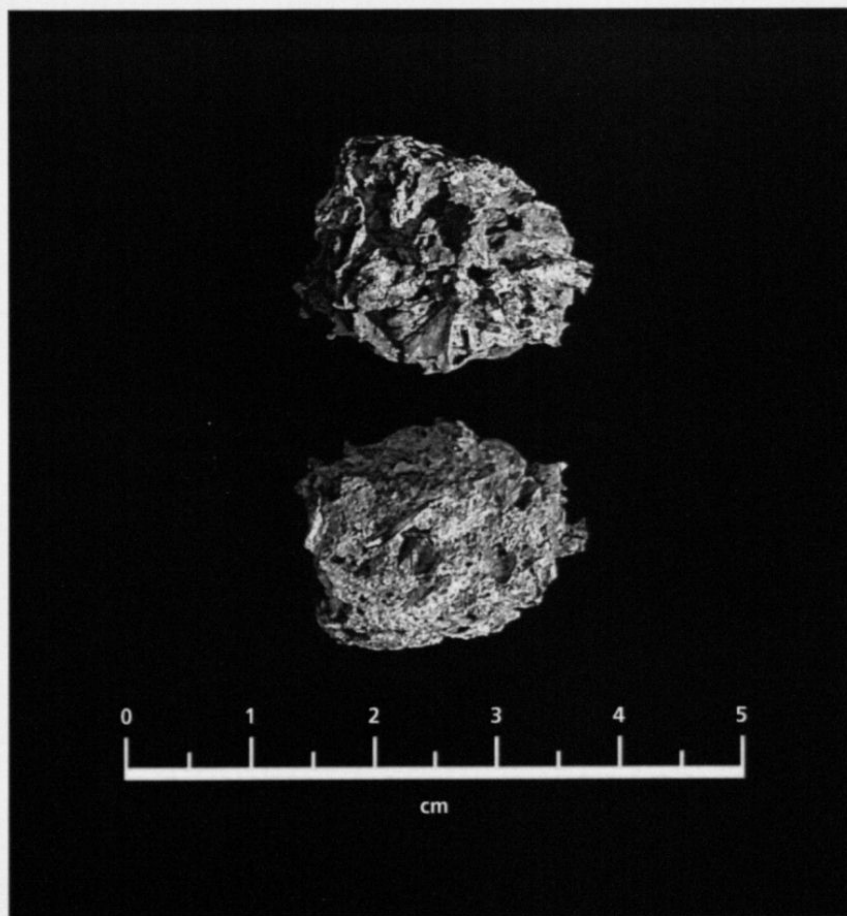
By contrast, crows, ravens, and songbirds are rare in the East Granary samples, nor are they concentrated under the owl roost. We conclude that they were most likely the prey of the semi-wild cat (*Felis catus*), whose remains also occur under the flagged portion of the East Granary floor.

Swallows (*Hirundo rustica*) probably built nests against the granary's walls, but their remains are rare from the East Granary sample. House sparrows by contrast are the most abundant species recovered from either granary sampling level, suggesting that they were nesting communally in or near the granary. House sparrow abundance was likely boosted at times by the mass emergence of "woodworms" as adult beetles, a preferred prey of the house sparrow.

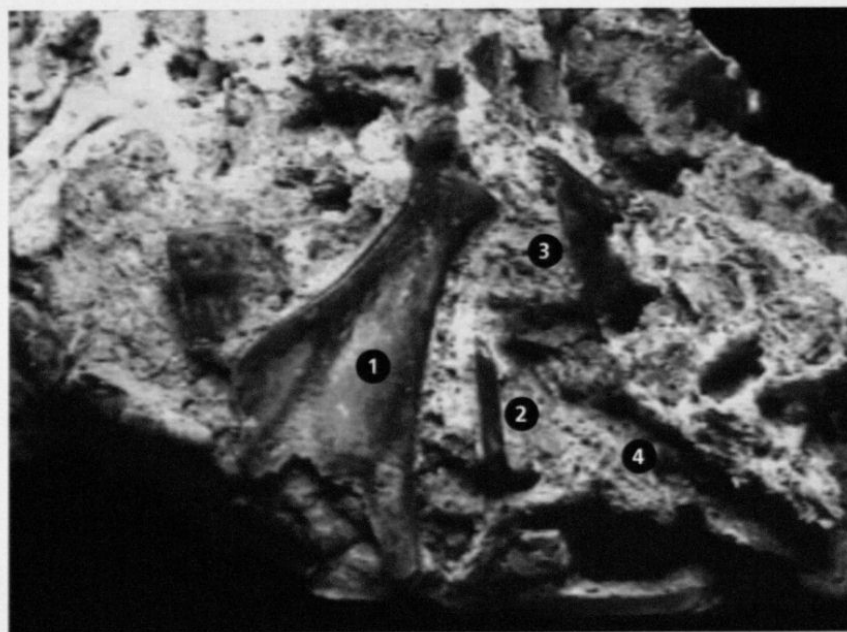
This study has shown that the East Granary lay at the heart of a number of linked species interactions. Human building activity leading to woodworm infestation invited a large population of house sparrows to nest communally on or near the granary. In addition, grain grown by farmers and stored in the granary by soldiers provided an abundant food supply for house mice and house sparrows, both of which eat grain. The house sparrow frequently, and the house mouse at least occasionally, were preyed upon by barn owls. Stoats patrolled the sub-floor space, raiding sparrow nests for eggs and chicks but sometimes themselves becoming prey to barn owls. Toads, moles, cats and domestic dogs appear to have used the granary for shelter; cats and dogs brought bones of large ungulates into the sub-floor space. Two puppies, perhaps the runts of a litter, apparently died there. Scraps of human food, including the bones of fowl, ducks, quail, plovers, and piglets (possibly smoked) were either dropped through openings in the floor or brought into the sub-floor space by cats or dogs. During the nearly two centuries of its existence, the East Granary was an important focus within the Vindolanda fort-village complex for both human and animal activity.



**Fig. 4** Relative species frequency from the four contexts studied; 4A depicts mammals, 4B birds and lower vertebrates. Cattle (*Bos taurus*) are by far the most frequent species here as everywhere at Vindolanda. Ungulate mammals far outnumber all other mammals. Among birds, the house sparrow (*Passer domesticus*) far outnumbers all others, but its remains were found only in the channels and flues of the granary. By contrast, large birds such as the common crane (*Grus grus*) and the whooper swan (*Cygnus cygnus*) were more often found in peripheral contexts.

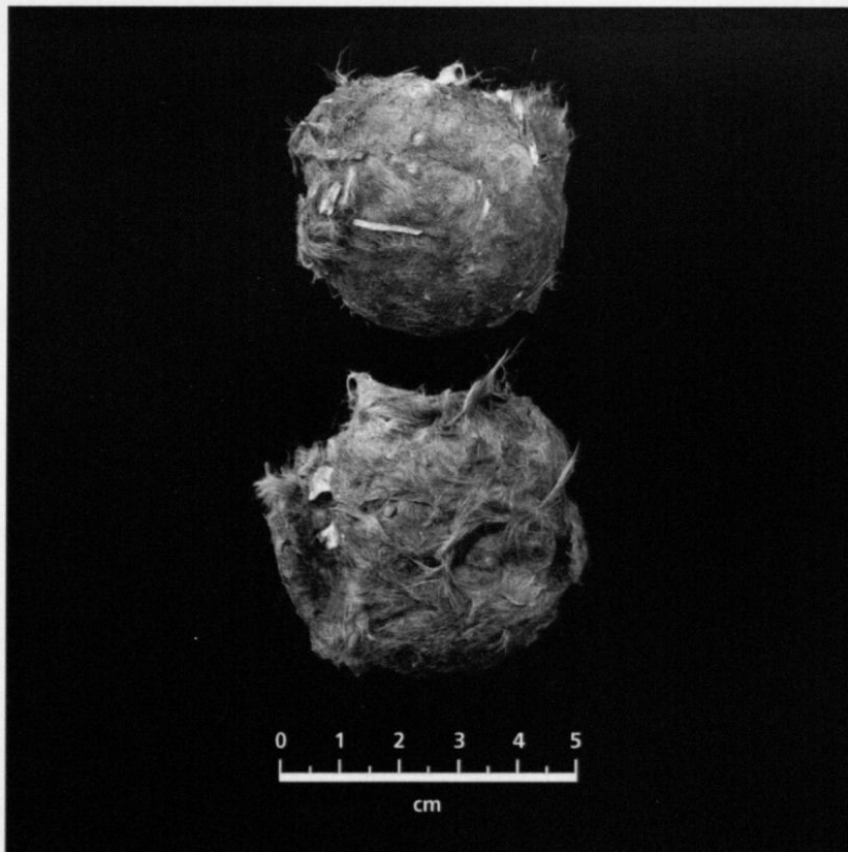


**Fig. 5** A Vindolanda owl pellet recovered from the East Granary. This is one of three pellets attributable to the Barn owl (*Tyto alba*) that were recovered relatively intact. This pellet measures 23 mm x 18 mm, smaller by half than pellets typical of the modern barn owl because the ancient pellet's outer "rind" of mucus-bound hair has eroded away.

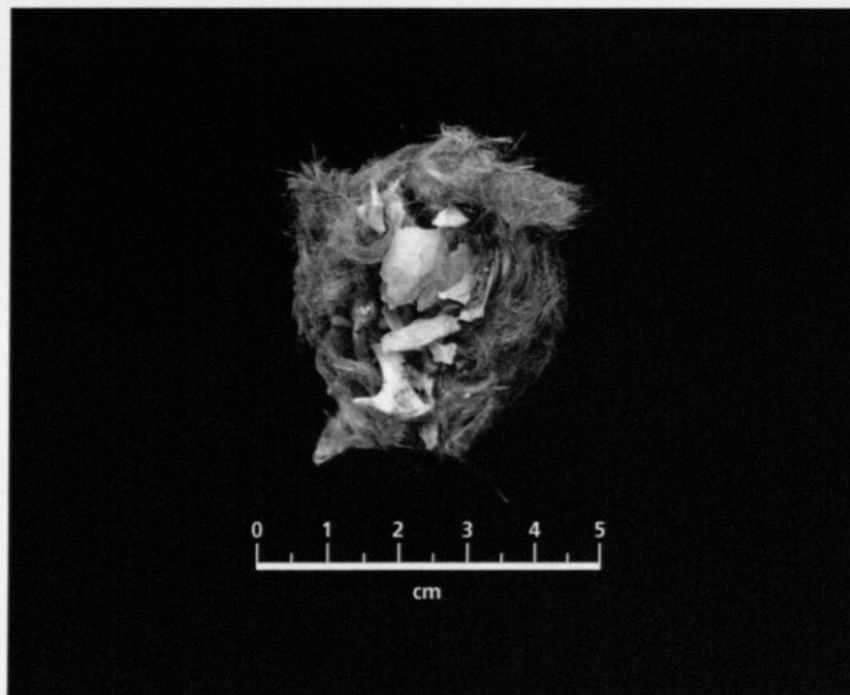


**Fig. 6** Closeup view of the pellet in Fig. 5. The length of Bone 1 is about 45 mm. Bone 1 is a partial scapula assignable to the Water vole (*Arvicola terrestris*). Bone 2 is the ilium of a Common toad (*Bufo bufo*). Bone 3 is the partially-exposed pelvis of a field vole (*Microtus agrestis*). Bone 4 is a tarsometatarsus of the house sparrow (*Passer domesticus*). Not only the size and rounded shape of the pellet, but its content of nearly-whole, uneroded bone are characteristic of the Barn owl (*Tyto alba*).

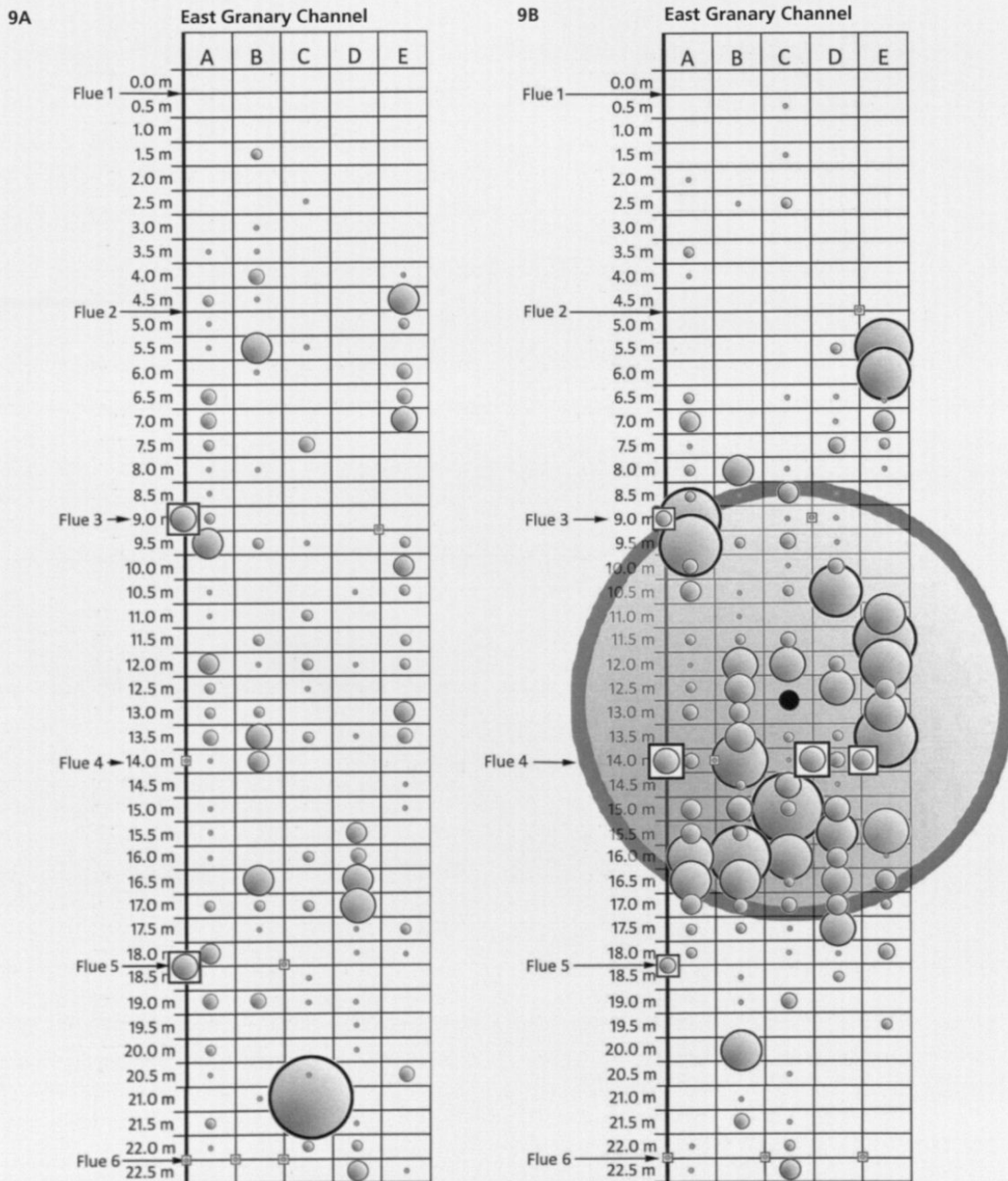




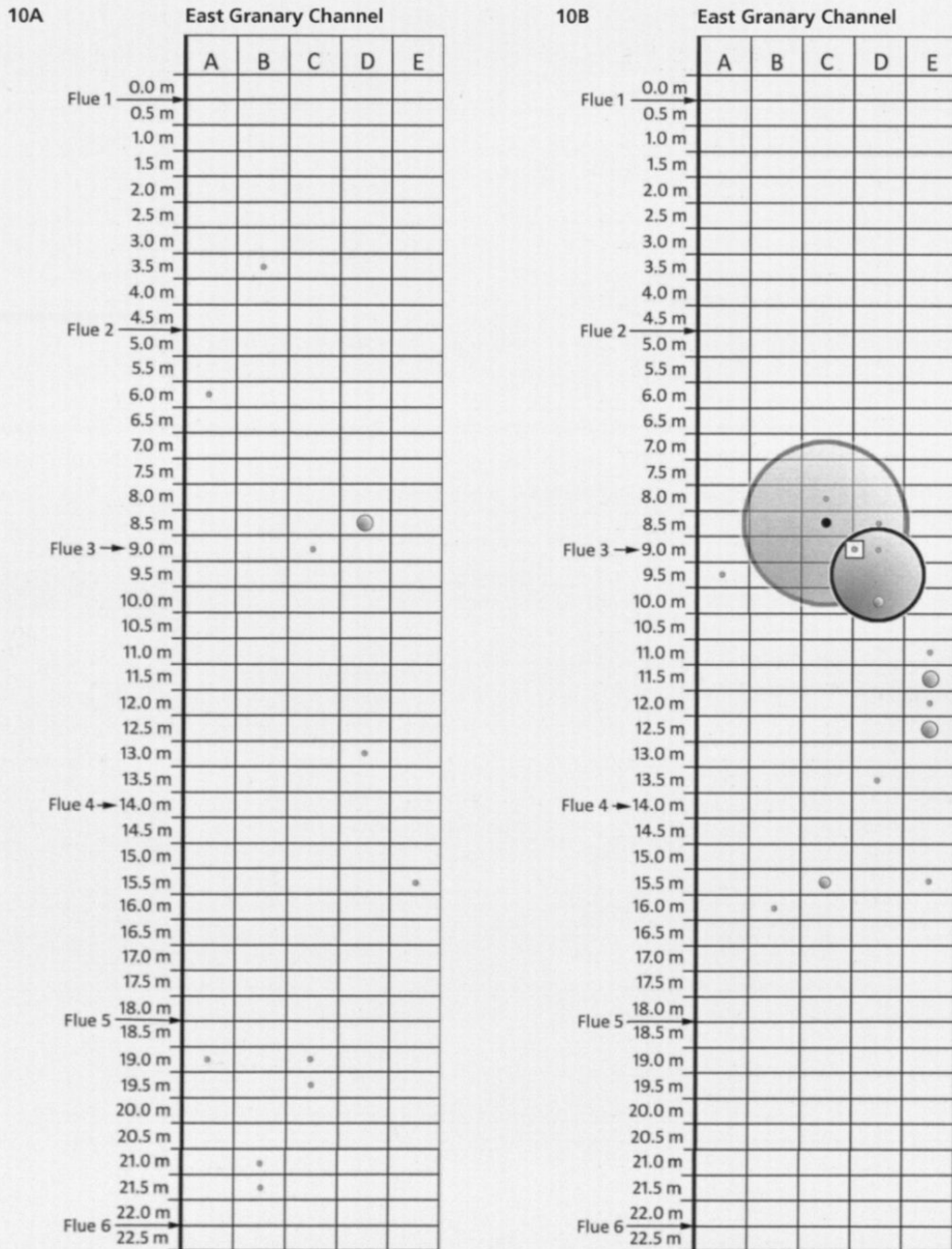
**Fig. 7** A pellet recently produced by a Barn owl (*Tyto alba*). Typically, barn owl pellets are coated by the fur or feathers of prey species, and held together by digestive mucus which becomes indurated upon exposure to air. This pellet measures 42 mm x 37 mm.



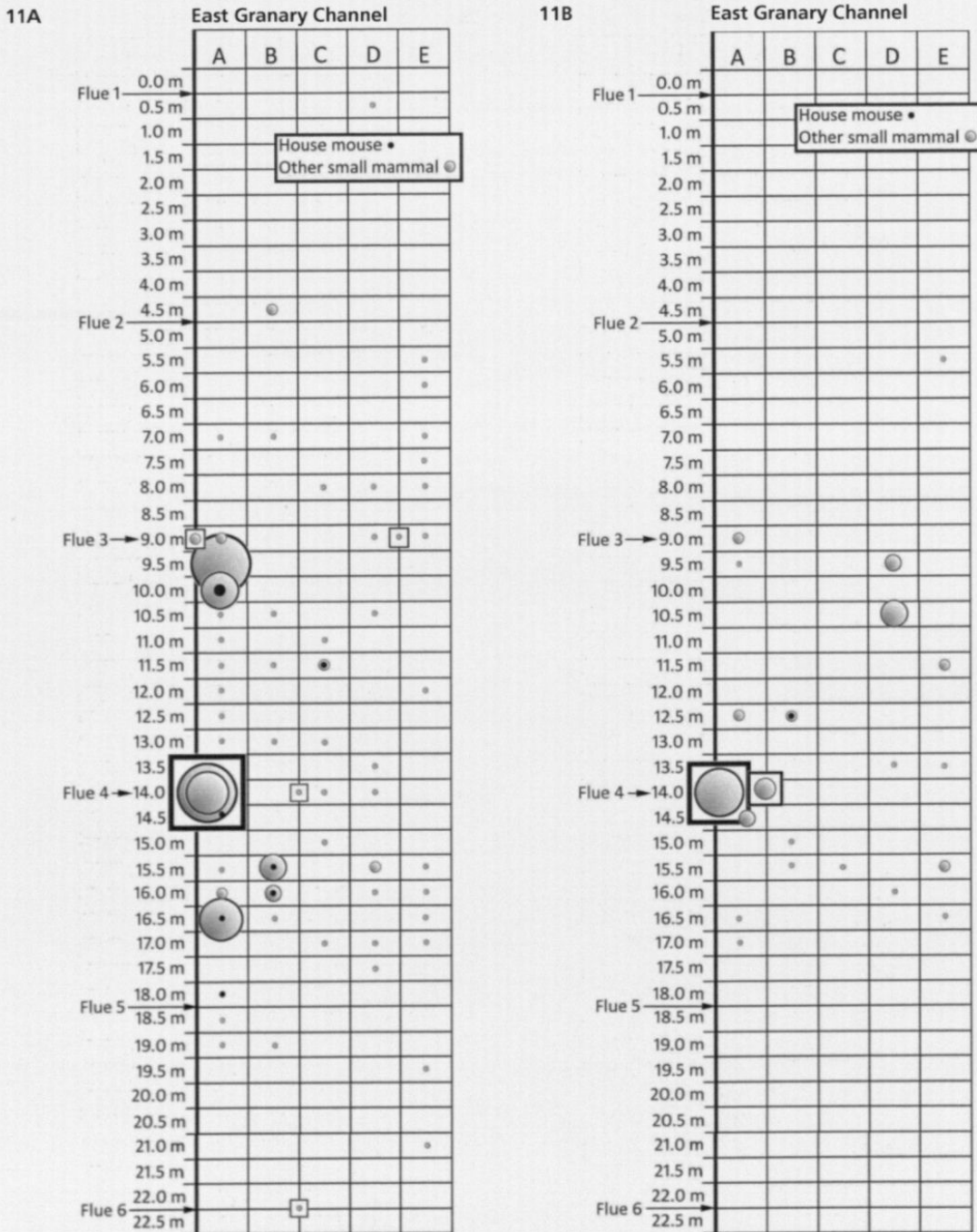
**Fig. 8** The same pellet as in Fig. 7 after having been broken open. The coating of hair and mucus is relatively thick and contains few bones. The core of the pellet is almost wholly composed of bones. This pellet, collected in central California, came from a barn owl whose main diet consists of California ground squirrels (*Otospermophilus beecheyi*). Barn owls typically alter their diet to reflect whatever is available, so the contents of the California pellet differ from that of pellets collected in Britain. The recent pellet contains many thin skull bones which have broken apart, but also sturdier limb bones and teeth which are mostly unbroken. None of the bones show significant signs of erosion by digestive juices.



**Fig. 9** Frequency and location of ungulate mammal remains from East Granary samples. 9A represents Level 2; 9B represents Level 1. These charts are intended to give the viewer a quick and fairly accurate visual impression of where and to what extent East Granary finds are concentrated. The unit bubble, representing 1 cataloged bone, is the smallest shown; bubbles get larger in proportion to the number of bones represented. A scale of bubble sizes is provided which pertains to this figure and Figs. 10 - 14. Squares surrounding bubbles represent those found in flues. Fainter grey tinting is used in some cases to enhance clarity. Figs. 9A and 9B represent all ungulate mammals together, including cattle (*Bos taurus*); hogs (*Sus scrofa*); "ovicaprines" (sheep, *Ovis ammon* and goat, *Capra hircus*); deer (red deer, *Cervus elaphus* and roe deer, *Capreolus capreolus*); and horse, ass, and mule (*Equus spp.*). See tables 1, 2, 11, 12, 21, 22, 27, 28, 33, 34, 43, and 44 for specific numbers of the individual species. The large circle in Fig. 9B represents the large number of cataloged bones from two different piglets found in Channel C, samples 12.5 and 13.0 (center of piglet bone concentration marked by black dot).

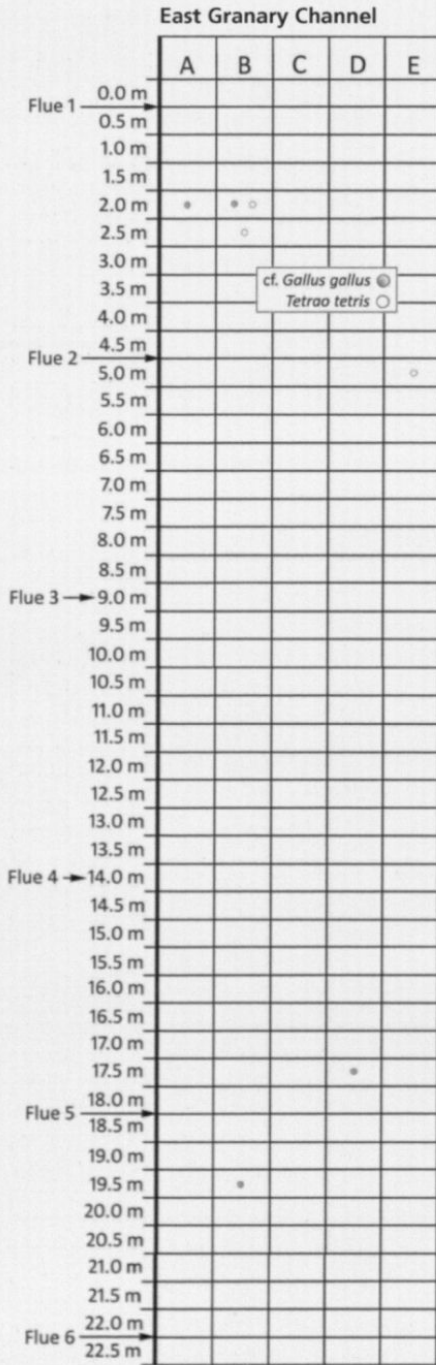


**Fig. 10** Frequency of Cats and Dogs from East Granary samples. 10A represents Level 2; 10B represents Level 1. These charts represent cats (*Felis catus*) and dogs (*Canis familiaris*) together. See tables 3, 4, 13, 23, 24, 29 and 35 for specific numbers of the individual species. The large bubbles in 10B represent the large number of catalogued ones from partial skeletons of two different puppies, one from Channel C, sample 8.5 (marked by black dot), and one from Channel D, sample 9.5).

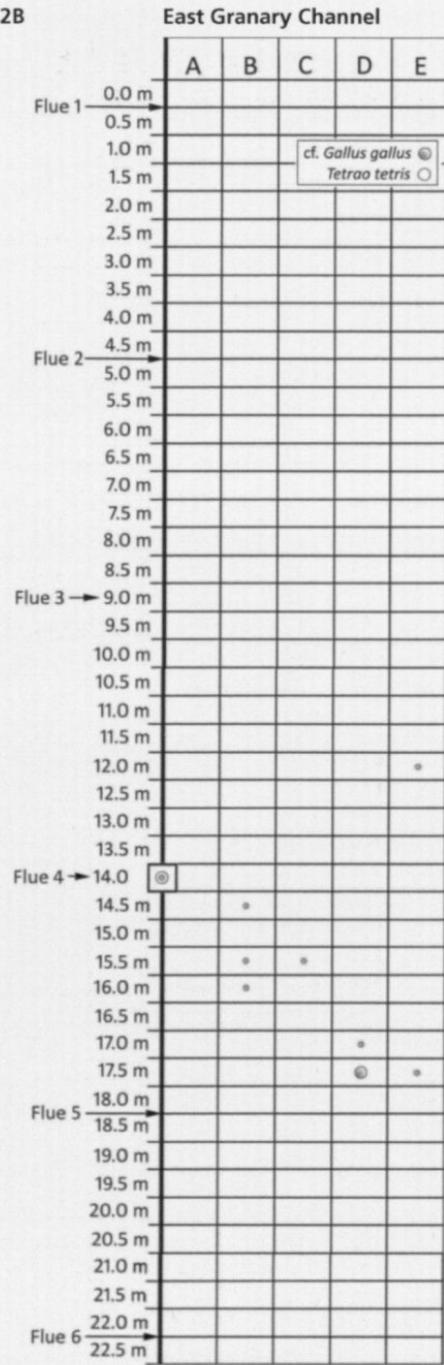


**Fig. 11** Frequency of small mammal species from East Granary samples. 11A represents Level 2; 11B represents Level 1. These charts represent small mammal species together, including common stoat (*Mustela cf. erminea*), European mole (*Talpa europaea*), water vole (*Arvicola terrestris*), Field vole (*Microtus agrestis*), bank vole (*Myodes glareolus*), commensal house mouse (*Mus musculus*), wood mouse (*Apodemus sylvaticus*), yellow-necked mouse (*Apodemus cf. flavicollis*), and European hare (*Lepus capensis*). See tables 5, 6, 14, 15, 25, 26, 30, 31, 36, 37, 45, and 46 for specific numbers of the individual species. Note the concentrations of small mammal remains in Level 2 in and near the mouths of Flues 3 and 4 on the west side of the granary, from which also come pellets of the barn owl (*Tyto alba*). Small mammal remains are also concentrated near the mouth of Flue 4 at Level 1. Unfortunately Flue 2's eastern mouth was not sampled, so we see no concentration of small mammal remains near Channel E, sample 8.2, from which one owl pellet comes.

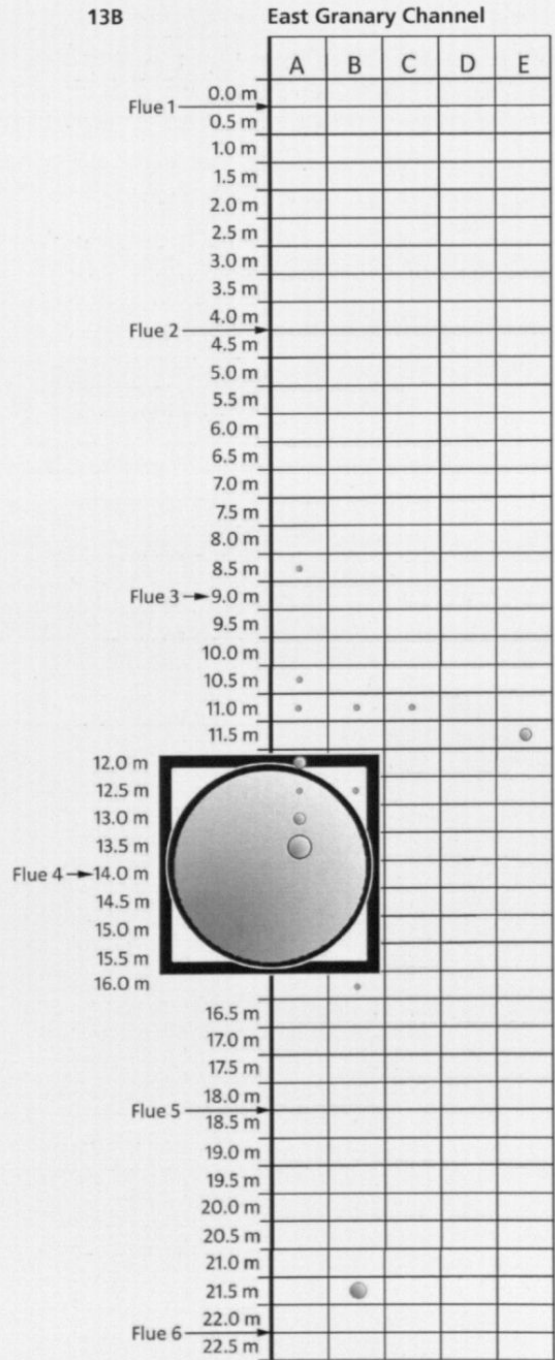
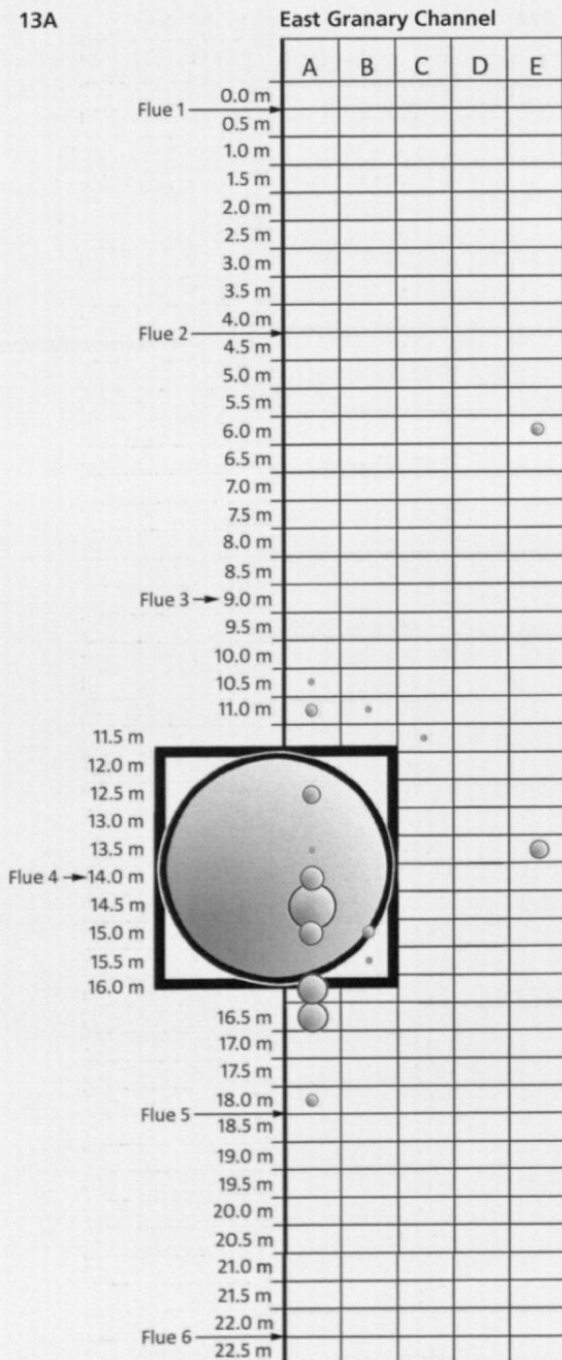
12A



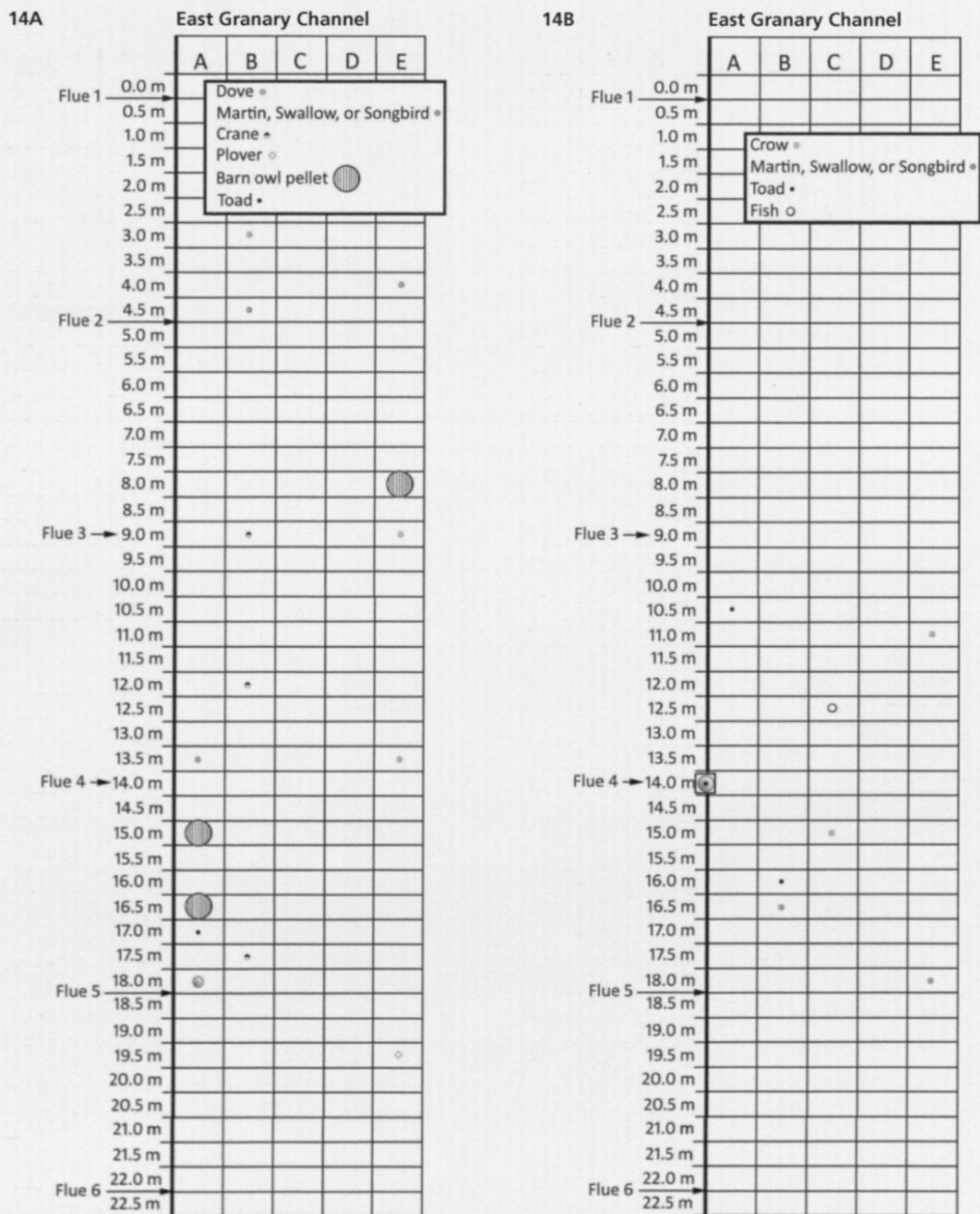
12B



**Fig. 12** Frequency of "table birds" from East Granary samples. 12A represents level 2; 12B represents level 1. These charts represent wild and domestic fowl, ducks, quail and plovers together, including domestic chicken (*Gallus gallus*), black grouse (*Tetrao tetris*), common quail (*Coturnix coturnix*), and garganey (*Anas querquedula*). See Tables 7, 16, 17, 32, 38, 39, and 47 for specific numbers of the individual species. These birds are relatively uncommon and their remains are scattered thinly beneath the East Granary, with few occurring near putative owl roosts.



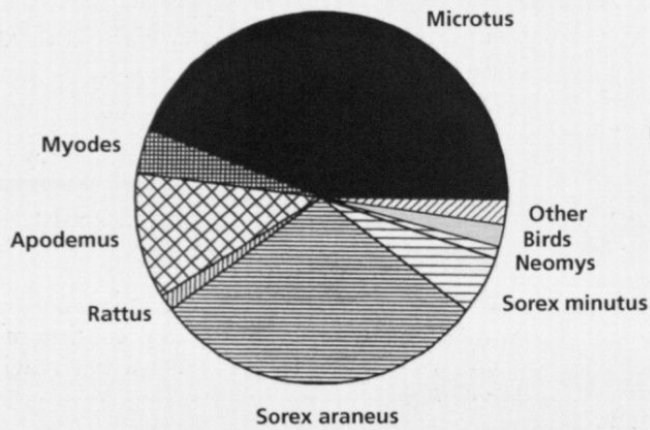
**Fig. 13** Frequency of bones of small bird species from East Granary samples. 13A represents Level 2; 13B represents Level 1. These charts represent only the house sparrow (*Passer domesticus*); see Tables 8, 9, 20, 42, 48, and 49 for specific numbers from different samples. At both stratigraphic levels investigated, remains of these birds are strongly concentrated at the mouth of Flue 4, beneath the putative barn owl roost.



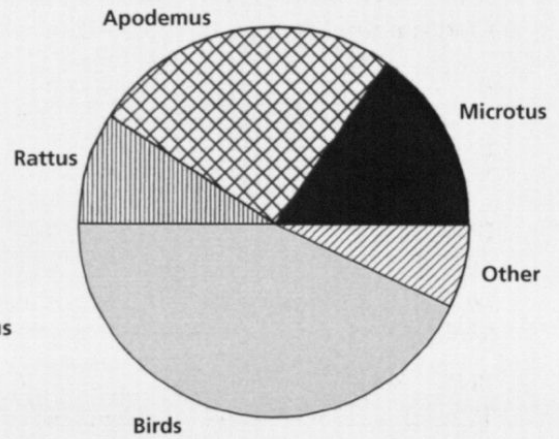
**Fig. 14** Frequency of songbirds, crows, cranes, plovers, toads, and fish from East Granary samples. The location of intact individual pellets of barn owl (*Tyto alba*) is also represented on these charts. 14A represents Level 2; 14B represents Level 1. These charts represent different species with different symbols, including common Crow (*Corvus corax*), carrion crow (*Corvus corone*), golden plover (*Pluvialis apricaria*), stock dove (*Columba oenas*), starling (*Sturnus vulgaris*), European swallow or barn swallow (*Hirundo rustica*), martin (*Riparia riparia*), song thrush (*Turdus philomelos*), yellowhammer (*Emberiza citrinella*), and corn bunting (*Emberiza caesia*). See Tables 7, 8, 9, 10, 16, 17, 20, 32, 38, 39, 42, 47, 48, and 49 for specific numbers of the individual species.

15A

### Barn Owl Diet from Mixed Field-Forest Habitat

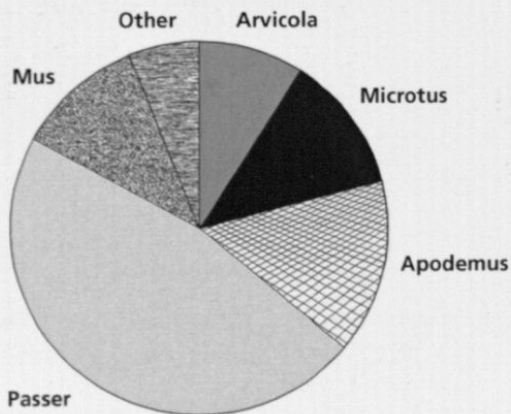


### Tawny Owl Diet from Urban Habitat

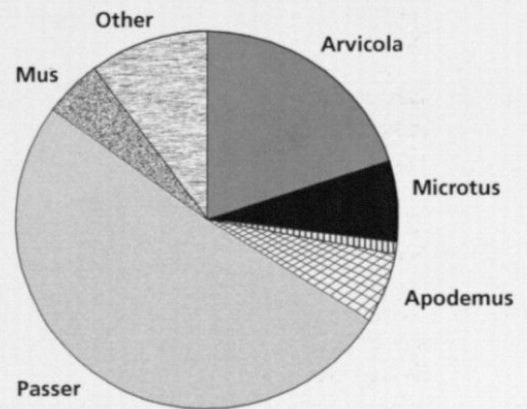


15B

### Earlier Vindolanda Owl Level 2 (218-280 A.D.)



### Later Vindolanda Owl Level 1 (300-400 A.D.)



**Fig. 15** Percentage representation of species identified from bones in owl pellets, calculated from raw numbers of specimens. 15A contrasts the diet of a barn owl (*Tyto alba*) living in mixed field-forest edge habitat with that of a tawny owl (*Strix aluco*) living in London, England (after Glue, 1974; Love et al., 2000; and Yalden, 2009). 15B shows the putative diet of owls roosting in the East Granary. The diet resembles that of the tawny owl in containing a high percentage of house sparrows but no shrews; nonetheless the East Granary owls were almost certainly barn owls. Species percentages change over time (see text).



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