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### A Novel Sizing Method for Analysing Amphibians from Archaeological Sites: A Case Study from the Medieval Manor Site at Lower Putton Lane, Dorset, England

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#### ABSTRACT

Amphibians from archaeological sites are used to assess palaeoenvironments but rarely investigated to answer archaeological questions other than consumption. They can, however, yield important information about site occupation, land use and the environment. We developed a sizing method to understand how and why amphibians were deposited in pit F76 under the Medieval Manor of Lower Putton Lane, England, which allowed us to answer broader questions about the site. Along with size, and, by inference, age at death, we recorded taxonomy and taphonomy of the amphibians. We demonstrated this was a breeding population which suffered catastrophic mortality in late spring. We inferred F76 was a working or refuse pit which flooded to become an amphibian breeding site, but was rapidly infilled in late spring, perhaps the cause of death, sealing the amphibians. After a brief hiatus F76 was chosen to be the site for the first Manor house. The builders did not know it was prone to winter flooding when they chose this site, suggesting they were probably from outside the area, certainly unfamiliar with it. We show that suitable recovery and analysis of amphibian remains enable them to contribute fully to discussions about how people lived in the past.

#### ARTICLE HISTORY

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#### **KEYWORDS**

Microfauna; sizing and ageing amphibian remains; manorial system; pits; manor house construction; common frogs

#### Introduction

#### Aims

This research focused on a small vertebrate assemblage, mostly amphibians, recovered from the Medieval Manor site of Lower Putton Lane, Dorset, England. The aim of this investigation was to demonstrate the value of analysing amphibian remains from archaeological sites and to develop a new sizing method to help understand how amphibians are deposited within archaeological contexts so allowing them to play a role in answering broader archaeological questions.

The purpose of the excavation at Lower Putton Lane was to further our understanding of how the manorial system developed in Dorset. In southern Britain, this development is poorly understood, partly because manorial centres often lay beneath current settlements (Webster 2008 cited by Randall 2020, 5). The excavation of a deserted early medieval manor in Dorset, England, by Context One Heritage and Archaeology provided an opportunity to address this. The amphibian assemblage beneath the first manor house, the interface between the previous land use system and the manorial system, was analysed to shed light on whether the introduction of the manorial system represented change or continuity in tenure, as well as in land use, and who might be responsible.

In central England, the common fields of 'champion landscapes' replaced ancient landscapes between 850 and 1150 (see Rackham 1986, 4–5; Roberts and Wrathmell 2000, 2–4; Oosthuizen 2006, 10). This planned re-organisation was based on the manorial system, a relationship between lord and serf that led to centrally organised cultivation and settlement nucleation around a manor house (North and Thomas 1971; Oosthuizen 2006, 19–20). We are not sure why and how the manorial system developed, but it was probably linked to rising population and the development of centralising authority and extensive estates in the middle to late Anglo-Saxon period (Oosthuizen 2006, 10).

#### **The Site**

Lower Putton Lane is in Dorset in the south of England (Figure 1, inset). Despite a Saxon place name and eighth- and eleventh-century metal finds, it has a long history of occupation, so it

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Figure 1. Inset: Location map. Top: Site plan. Bottom: Plan of Building 5, showing earlier pits F76 and F107 (amended from Figures 1.1, 1.13, and 1.28; Randall 2020, by Tara Fairclough, Context One Heritage and Archaeology).

was likely that the manorial system overlay evidence of activity based on earlier Romano-British landholdings (Randall 2020, 162, 184; Schüster 2020; Royal Commission on the Historical Monuments of England 1970, p. 41, Figure 1 cited by Randall 2020, 1).

The underlying geology, Cornbrash with impeded drainage in the north, and slowly permeable interbedded mudstones and sandstone elsewhere, made the site vulnerable to inundation (Randall 2020). Indeed, flooding delayed excavation in the winter of 2015–2016 (Randall 2020, 8–9). It was surprising that Building 5, the first manor house, was so close to the historic stream that passes through the site (Figure 1, Randall 2020, 21).

Several pits underlay Building 5, bottom (Figure 1). Animal bone, mostly from domesticated animals, but also wild mouse, field vole and songbird, as well as tenth—twelfth-century pottery was recovered from these (Randall 2020, 139, 149). F107 also yielded 131 fish scales (Randall 2020, 139, 148). These pits were filled in and levelled before the first manor hall was built (Figure 2, Randall 2020, 17).

One of these pits, F76, contained a dense concentration of charred plant material and amphibian bones in the basal layer (13–105) (Figure 2; Carruthers 2020, 126; Randall 2020, 148). F76 was 0.85 m in diameter and 0.35 m deep, with moderately sloping concave sides and a concave base (Figure 2; Randall 2020, 17). Above the basal layer was a fill (13–122) containing twelfth–thirteenth-century pottery, giving a *terminus ante quem* for activity (Randall 2020, 17). Above this fill a levelling layer (13–116) made up the floor of Building 5, thought to be constructed in the early thirteenth century (Figure 2; Green 2020, 191; Randall 2020, 17).

# How Amphibians Die and Accumulate on Archaeological Sites

Individual mortality, produces a scatter of bones in the landscape.

Accumulations of amphibian bones, as in F76, represent mass mortality and are more interesting archaeologically. They can be caused by predation, direct human action, such as consumption or ritual, or indirect human

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**Figure 2.** Pit F76, showing basal layer, (13–105), infilled by (13–122) and levelled by (13–117) (amended from Figure 1.9; Randall 2020, by Tara Fairclough, Context One Heritage and Archaeology).

action, like pitfall, settlement activity and land use change. Identifying how amphibians died enables us to tell complex and subtle stories about how people lived and interacted with their environment.

To do this we examine the assemblage for perimortem taphonomic effects, such as breakage, loss and marking, which, with taxonomy and contextual evidence, can tell us how amphibians died. However, as we show below, taphonomic analysis can be problematic; some mortality leaves no signs and post-depositional processes can mask or obliterate peri-mortem effects or cause recovery bias. In addition, referential research is limited, and equifinality and causation may lead to problems interpreting evidence.

#### Predation

Predators adapt to living near settlements leaving indigestible amphibian bones at roosting or latrine sites. Predator identification focuses on recognising patterns of breakage and digestion in modern predator scats and pellets. If similar patterns can be recognised in archaeological assemblages, by analogy we can identify the predator responsible (Bisbal-Chinesta et al. 2020; Blain et al. 2013; Bohme 2020; Denys 2002; Pinto-Llona and Andrews 1999).

However, not all predators leave traces, and the assemblage an archaeologist records does not represent the predation assemblage: it has already been transformed by, for example, trampling, weathering, transport, soil processes, bioturbation, root marking, diagenesis, excavation, sampling and recovery (Andrews 1990; Denys et al. 2017; Efremov 1940; Fernandez-Jalvo et al. 2016; Lyman 2010). Although digestion may leave distinctive marking, archaeological assemblages are often heavily affected by the processes above, so a large assemblage is needed to conclusively identify predators (Rey-Rodriguez et al. 2019).

#### Direct Human Action: Consumption/Ritual

People discard non-digestible bones in refuse pits or mounds when they eat amphibians. Consumption sites are often rich in amphibian bones (Bailon 1997; 2005; Chiquet 2005; Feider 2022; Kyseley 2008).

Human consumption can be signalled by chewing, burning, butchery marks and hind limb bias. However, natural predators also chew amphibians, notably mammalian carnivores (Andrews 1990). Also burnt amphibian bones in middens may signal refuse disposal, rather than cooking. Amphibians are easily torn apart after cooking, so butchery marks are rarely found. Although we look for chewing, burning and butchery, only hind limb bias clearly signals human consumption as natural predators rarely select only meat rich joints. There is, however, no definitive guide to what hind limb bias is, and it will vary.

Some work has been done, particularly on consumption and predation, but there is still a dearth of research on amphibian taphonomic referentials (Bailon 1997; 2005; Denys 2002; Denys et al. 2017; Pinto-Llona and Andrews 1999; Rubinatto Serrano et al. 2022; Stoetzel et al. 2011).

Little is known of the taphonomic signs for ritual use of amphibians so only proximity to ritual sites suggests this (Brunton, Badenhorst, and Schoeman 2013; Rubinatto Serrano et al. 2022; Whyte and Compton 2020).

# Indirect Human Action: Pitfall and Mortality at Hibernation, Aestivation and Breeding Sites

People create amphibian mortality assemblages indirectly, digging pits, for example, which inadvertently trap amphibians, and other taxa. Animals which fall in, are unable to escape, so become pitfall victims and bones accumulate if pits are left open (Raxworthy, Kjolby-Biddle, and Biddle 1990; Whyte 1988; Whyte and Compton 2020).

Pitfall assemblages can be identified because they consist of a variety of species, though predominantly amphibians, have no apparent size bias, and are entire animals with little bone loss (Whyte 1988; 1991). The contents of pitfall assemblages do, however, vary with the local environment, season, location, length of time they are open, and slope angle and depth of the pit (Whyte 1988; 1991). Pits near settlements, for example, have a smaller taxonomic range than those further away, reflecting the impoverishment of commensal taxa. The range and size of animals in a pit are dependent on the taxa around the site. Shrews occur more frequently in pits due to their poor eyesight (Andrews 1990; Rackham 1982). Size range will be affected if bank voles live nearby as larger older bank voles are more likely to be trapped than younger smaller voles (Andrzejewski and Rajska 1972). If pits are on amphibian migration routes more will be trapped. Pits in open landscapes contain fewer victims and a more limited range of taxa (Armitage 1985). Some small animals can escape from pits depending on the depth and slope angle. Deep, steep-angled pits trap everything, shallow pits with gently sloping sides only trap certain species. Frogs escape better than toads for example, because they can leap up to 40 cm, whereas pits with vertical sides over 20 cm will trap toads (Whyte 1988). Slope angle is particularly important for amphibians to escape so amphibian remains in shallow sided pits are unlikely to be pitfall.

How people affect the local landscape can cause accumulations of amphibian remains on archaeological sites. For example, amphibians are increasingly synanthropic in farmed landscapes, drawn to fish-free ponds, and uncultivated marginal land, close to settlements, to breed, feed, hibernate and aestivate, as suitable sites are no longer available elsewhere (Gleed-Owen 2004; Hulme-Beaman et al. 2016). When amphibians die at these sites due to disease, flooding, landslip, even human infilling, they leave bone accumulations in archaeological contexts (Blaustein and Wake 1995; Cochard 2004; Kyseley 2008; Price et al. 2014; Raxworthy, Kjolby-Biddle, and Biddle 1990; Rubinatto Serrano et al. 2022; Whyte 1988). Identifying what caused accumulations on archaeological sites may not always be possible but it is often linked to people.

#### **Sizing Amphibians**

Sizing amphibians helps to distinguish causes of mortality (O'Connor 1988). For example, larger amphibians are probably selected for consumption, and mortality at hibernation and aestivation sites and in pitfall involves all sizes (Kyseley 2008). When mortality affects a breeding population small juveniles and breeding age adults are involved. The distinctive bimodal size distribution of a breeding population distinguishes it from pitfall (O'Connor 1988). Gleed-Owen (2006) suggested pits can trap seasonal diasporas of newly metamorphosed froglets migrating to feeding grounds on wet nights that are difficult to distinguish from breeding site mortality; however, a high ratio of adults to juveniles, more older juveniles and any adults beyond breeding age indicate pitfall.

When mortality occurs at a breeding site, explosive breeders produce a different size distribution from prolonged breeders. Common toad, Bufo bufo, and common frog, Rana temporaria, produce eggs over a short time, usually less than 14 days (explosive breeding) to take advantage of 'temporary' ponds that dry up in the summer (Wells 1977). This produces similar sized juveniles at the same time, 'cohorts' of juveniles (Wells 1977, 666-667). Size synchronicity is maintained during desiccation as metamorphosis advances for every individual in the cohort, a form of developmental plasticity (Brady and Griffiths 2000; Merila et al. 2000). To identify mass mortality of breeding common frogs and toads we must identify cohorts of similar sized juveniles, and a small number of breeding aged adults. Water frogs and toads (prolonged breeders) on the other hand produce eggs over a longer period, so mortality produces a broad size range not dissimilar to pitfall (Wells 1977).

There are three methods previously used to sizing amphibians.

- 1. Estaban, Castanet, and Sanchiz (1995) used complete bones from a museum collection of adult *Rana temporaria*, of known weight and snout to vent length (SVL), to produce regression equations that predicted animal size. Proximo-distal long bone lengths predicted size better than transverse measurements. Elements that showed sexual dimorphism were used to predict different sizes of males and females. Their method only applies to adult common frogs and is difficult to apply to broken archaeological assemblages.
- 2. Kyseley (2008) assessed the size of *Rana temporaria* in a largely unbroken assemblage from Eneolithic contexts at Kutna Hora-Denemark in the Czech Republic. He measured the length of humeri, femora and tibio-fibulae, and the maximum diameter of acetabula, plotted on box whisker graphs. He suggested they were consumption debris

3. O'Connor (1988) eschewed long bone length when assessing the size range of a common frog assemblage from Tanners Row in York. He used a transverse metric, dorso-ventral height anterior to the acetabulum, plotted as a bar graph (1988). Although Estaban, Castanet, and Sanchiz (1995) noted that transverse measurements were less predictive of individual size, it can reasonably be argued that O'Connor's measurements (1988) were not intended to measure individuals but to assess range of size. O'Connor's distribution had two peaks which he suggested were 2-year-old adults and newly metamorphosed individuals, either pitfall or breeding mortality (1988). We can use this method for many anuran species and on broken assemblages, as Ilia are often well preserved at this point. However, without an age reference point, it was difficult to distinguish adults and juveniles.

#### **Materials and Method**

A 20-litre sample, almost the entire base layer (13–105) of F76, was processed by flotation using 0.5 mm mesh. Residues were sorted by an experienced zooarchaeologist (CR). 363 identifiable specimens were retrieved, of which 350 were anuran.

A Brunel SX10 stereo optical microscope was used to identify skeletal element (henceforth element), taxa, side, completeness and to assess surface taphonomic alterations.

Taxonomy was identified using published guides (Aulagnier et al. 2009; Bailon 1999; Bohme 1977; Greene 1935; Hillson 1986; 2005; Jepson 1938; Ratnikov 2001; Yalden 1999) and by referencing the Bournemouth University collection. Diagnostic elements for micromammal were molar teeth; for reptiles were vertebrae; and for amphibians, ilia, sphenethmoid, scapula, and humeri. Dr Chris Gleed-Owen supported the identification of common frog and *Natrix Helvetica*, based on images.

Micromammal completeness was recorded using Weissbrod et al.'s (2005) classification, after Andrews (1990). Amphibian completeness was recorded in ascending order of completeness as <1/3 complete; 1/3 complete; 2/3 complete; and complete. Micromammal long bone zoning was recorded as proximal epiphysis, proximal quarter, proximal shaft, distal epiphysis, distal quarter and distal shaft, extending

Andrews (1990) classification. Amphibian zoning followed Feider (2022), figures redrawn from Baillon (1999), and Ratnikov (2001).

Digestion on micromammal specimens was identified using images from Fernandez-Jalvo et al. (2016) and on amphibian specimens followed Pinto-Llona and Andrews (1999). Weathering was assessed using Andrews (1990).

The number of identified specimens (NISP), minimum number of elements (MNE) and minimum number of individuals (MNI) were calculated using siding, zoning and completeness. Identification was conservative so post-cranial elements were mostly classified as Anuran', occasionally as Ranidae'. Only diagnostic elements were used to positively identify species level, common frog.

The Minimum Number of Individuals was calculated for common frog, after using zoning and siding to calculate the Minimum Number of Elements. It was likely that many non-diagnostic specimens assigned to unspeciated Ranidae and Anura belonged to the same Rana temporaria individuals whose MNI was previously determined by counting diagnostic elements. To avoid double counting of R. temporaria individuals, non-diagnostic element specimens that could already be accounted for by the minimum number of R. temporaria individuals were excluded when calculating MNI for Ranidae and Anura. MNI for Anura and Ranidae therefore represents MNI over and above that already accounted for by R. temporaria. In other words, many specimens in these categories contributed to common frog MNI not to their category.

The relative proportion of elements (RPE) was the ratio of elements recovered to the number of that element in the MNI, as for relative abundance in Andrews (1990), where  $R_i$  is the relative proportion (abundance) of element *i*,  $N_i$  is the total of element *i* in the assemblage (MNE), MNI is the minimum number of individuals, and  $E_i$  is the number of those elements in the skeleton:

$$R_i = N_i / MNI \times E_i$$

Neither the sizing method used by Estaban, Castanet, and Sanchiz (1995) nor used by Kyseley (2008) can be applied to broken archaeological assemblages. While O'Connor's (1988) method can be applied, it does not distinguish between adults and juveniles. We developed our sizing methodology to address these limitations.

Using a calibrated Brunel Microscope icam attachment (BM502000A-P), we measured the humeral width and condylar length of distal humeri, see measurements 14 and 15 in Estaban and Sanchiz (1985) and Sanchiz (1984). Distal humeri were selected as strong, recognisable and frequently recovered elements. To visually represent size range, we plotted these as a scatter graph. We estimated measurement error by how well these dimensions correlated.

To provide us with a size/age reference point on our scatter graph, we measured the humeral head width and condylar length of an adult common frog from the Bournemouth University reference collection and inserted this onto our scatter plot.

We then calculated the snout to vent length (SVL) of this specimen, 57.22 mm, by measuring two femora, two radio-ulna, and one humerus longitudinally, and using Estaban et al. regressions (1995). These longitudinal measurements more accurately predict size than transverse humeral head measurements (Estaban, Castanet, and Sanchiz 1995).

We used this SVL, 57.22 mm, to assess the age of the specimen, by referring to ecological research into common frog size/age relationships. Common frogs grow continuously throughout life, albeit more slowly later, so increasing size indicates increasing age. However, size and longevity vary geographically. For example, the mean SVL of frogs in the French Alps (83.6 mm for females and 77.8 mm for males) was larger than frogs in subarctic Finland (76.62 mm for females and 70.66 mm for males) despite having shorter longevity, 12 and 15 years, compared to 18 and 14 in Finland (Miaud, Guyetant, and Elmberg 1999; Patrelle et al. 2012). Gibbons and McCarthy's study (1984) of Irish common frogs was geographically the nearest to Dorset. Irish frogs were smaller, 66.6 mm (female) and 62.2 mm (male), and longevity was only 7 years for males and 6 years for females (1984). By comparing the size of our reference specimen to size/age tables, based on skeletochronology, in Gibbons and McCarthy we deduced that it was a 1+ or 1-year-old subadult (1984, 421-422).

As we had now calculated this reference specimen as 1+, we could use it to distinguish adult and juvenile specimens by comparing elements from the assemblage with those from the reference specimen, classifying specimens in F76 (13–105) as older (larger) or younger (smaller) than 1+. We reassessed RPE and MNI based on these separate adult and juvenile populations. Phalanges, metapodials, and broken vertebrae, were not classified.

#### Results

363 specimens were identified from basal layer (13-105), F76, Table 1, which was 18.15 specimens per litre. Ninety-six percent of the assemblage was anuran, common frog (*Rana temporaria*) being the only identified species (Figure 3A). Two snake (Figure 3B) and one fish vertebra (Figure 3C) were recovered, and a harvest mouse mandibular tooth row (*Micromys*)

Table 1. Number of identified specimens (NISP) and minimum
number of individuals (MNI) recovered from F76 (13–105).

	NISP	MNI
Anura	294	2
Rana temporaria	31	7
Ranidae	24	1
Bufonidae	1	1
Natrix helvetica	1	1
Snake	1	0
Micromys minutus	1	1
Rodentia	2	0
Micromammal	5	0
Fish	1	1
Shellfish	2	1
Total	363	15

*minutus*) (Figure 3D), two mollusc shells, and a few rodent and micromammal bones.

51.9% of anuran bones were complete or two-thirds complete (Table 2).

There was limited evidence for predation. Flaking occurred on two specimens, and one, a vertebra, had a corroded articular surface. Rounding, splitting, thinning and incurving, typical of anuran digestion, were absent. Harvest mouse teeth were, however, thinned suggesting light digestion.

Evidence of exposure before burial was inconclusive. Eight amphibian specimens showed possible signs of weathering, mostly light and three showed possible trampling. There was no evidence that any taphonomic processes had affected the grass snake, fish and molluscs. One rodent lower incisor was, however, burnt.

#### Adult and Juvenile Common Frogs

By calculating MNI separately for juvenile and adult bones, the anuran MNI rose slightly, from 10 to 11, excluding bufonid (Table 3). Using different sized populations reduced mismatch between larger and smaller elements leading to greater precision. Juveniles dominated, two-thirds of the MNI being smaller than the one-year-old reference specimen.

Skeletal representation was high given how susceptible these bones are to loss by bioturbation and recovery, with over 90% of some elements being recovered (Figures 4 and 5). Adult skeletons were better represented, possibly because they were larger.

There was no apparent recovery bias except for a relative lack of cranial bones (Figures 4 and 5). An absence of anuran cranial bones was not surprising as they are thin, flat and easily broken, so do not survive well, and are often mistaken for plant residues (Whyte and Compton 2020). In Whyte and Compton's experiments, inexperienced sorters missed 31.7% of cranial elements compared with 16.6% of axial and 9.8% of limb elements (2020).



Figure 3. Specimens recovered from F76 (13–105): 3A common frog ilia, *Rana temporaria*; 3B grass snake vertebra; 3C fish vertebra; 3D harvest mouse mandible (Darko Maričević, Bournemouth University).

 Table 2. Amphibian completeness from basal layer of F76 (13-105) showing percentage in each category.

1/3 complete		34.4%
1/3 complete		13%
2/3 complete		25.1%
Complete		26.8%

#### Anuran Size Range

Condylar length and humeral width of adult distal humeri were linearly correlated, within the oval (Figure 6). Both variables were dimensions of the same specimen, so we expected a high correlation unless there was significant measurement error. The correlation coefficient r was 0.9996 for adult humeri, greater than the critical value at 95% confidence level, suggesting this was not the case. Using Estaban, Castanet, and Sanchiz's (1995) regression equations adult SVL were 66, 66 and 55 mm. Combined with our assessment of sex based on characteristics of the humeri, these SVL suggested there were two 3- to 4year-old females and one 2-year-old male (Gibbons and McCarthy 1984).

There were two groups of juvenile frogs, synchronous cohorts of the same size and age, in Figure 6, within the rectangle. Correlation was lower for juveniles than adults, r = 0.7613, reflecting a greater spread of measurements in Figure 6 but was still greater than the critical value at 95% confidence level. Lower

Table 3. NISP and MNI calculated ser	parately for larger, sm	aller and unsized anurans from	n the basal layer of F76 (13–105).
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	Larger NISP	Larger MNI	Smaller NISP	Smaller MNI	Unsized NISP	Unsized MNI	Aggregated MNI	
Anura	73	1	121	0	100	0	1	
Rana temporaria	13	3	18	5	0	0	8	
Ranidae	7	0	17	2	0	0	2	
Bufonidae	0	0	1	1	0	0	1	
Natrix helveticus	0	0	0	0	1	1	1	
Snake	0	0	0	0	1	0	0	
Micromys minutus	0	0	0	0	1	1	1	
Rodentia	0	0	0	0	2	0	0	
Micromammal	0	0	0	0	5	0	0	
Fish	0	0	0	0	1	1	1	
Shellfish	0	0	0	0	2	1	1	
Total	93	4	157	8	113	4	16	



Figure 4. Relative proportion of elements of adult anurans in basal layer (13–105) of F76.



Figure 5. Relative proportion of elements of juvenile anurans in basal layer (13–105) of F76.



**Figure 6.** Size range of anurans in the basal layer (13-105) of F76, n = 12. 1+ year-old reference specimen, arrowed, divides adult frogs, right and above, from juveniles, left and below.

correlation was probably because of the difficulty of measuring small dimensions accurately. Bone erosion was likely to have more impact when measuring smaller specimens.

#### Discussion

#### **Depositional Pathways**

The isolated broken bones of grass snake, fish, shellfish, toad and harvest mouse suggest these animals died elsewhere, after which their remains were distributed widely, one or two ending up in F76: a depositional pathway known as background scatter. They may have been thrown into F76 with charred plant remains or, as these animals are known to live in or near water, may have been deposited by flooding from the nearby stream. The larger number and greater density of anuran bones in (13–105) suggested a different pathway for these animals.

There was little evidence for rounding, flaking, thinning, splitting and incurving of bones, which are signs of predator digestion. However, some nocturnal predators, such as barn owls, leave little evidence of digestion so an absence of taphonomic marking does not exclude predation.

However, the relative proportion of recovered frog elements, and their completeness, suggested entire frogs were deposited in F76 not predation debris (Figures 4 and 5; Table 2). Small frog bones are easily lost by scattering and bioturbation, and during sampling and recovery, so 26.2% of juvenile skeletons and 40.5% of adult skeletons testifies that frogs were probably deposited as complete animals and the context quickly sealed. That 56% of frog specimens were complete or two-thirds complete, suggested there was little peri-mortem breakage, and supported the idea that entire, possibly live, animals initially entered F76.

The relative proportion of elements suggested human consumption was unlikely as there was no evidence of hind limb bias. This view was reinforced by the size of anurans, largely smaller juveniles rather than meatier adults.

Given that animals were likely to be complete when they died in F76, a more compelling pathway was pitfall. However, this accumulation was not typical of pitfall. Low diversity of taxa, just common frogs, and a bipolar size distribution not a full-size range, makes this less likely (Whyte 1988). The relatively gentle sides of F76, suitable for breeding, would not be much of a barrier for frogs to escape (Whyte 1988).

Size assessment was the defining evidence for taphonomic pathway. Comparing frogs in F76 to a young adult reference specimen demonstrated that juveniles dominated the assemblage. Distal humeri measurements showed F76 contained synchronous cohorts of young spring born juveniles and several breeding age adults. This age distribution is a snapshot of a frog breeding population at one time meaning they all died in one period of mortality. As many juveniles were very small, this is likely to have been in spring. The adult common frogs in F76 were typical of a breeding population: larger 3–4-year-old females and a smaller 2-year-old male (cf Patrelle et al. 2012). This compares to the mean age of breeding of 3.2 years for females, and males, 2.8 years, in one Swiss study (Ryser 1988).

#### The Story of F76

Combining zooarchaeological with archaeobotanical and contextual evidence suggests how F76 was used, abandoned and built over.

The basal fill (13-105) that produced this amphibian assemblage had the highest concentration of charred plant remains on site, largely burnt cereal grain and weeds. This included a small number of wheat nematode galls, possibly removed from seed-corn to avoid future contamination (Carruthers 2020, 126). There was no evidence of burning on the sides of the pit or on the amphibians, so we concluded that plant waste, possibly animal bedding, or infected or spoilt grain, was burnt elsewhere and disposed of in F76, along with one burnt rodent incisor (Carruthers 2020, 126).

At some point F76 flooded, because of excess ground water or stream overflow and became a breeding site for common frogs, presumably in winter and/ or spring when water tables were highest (Randall 2020, 9). We cannot be sure which occurred first, the dumping of charred plant remains or the flooding and subsequent breeding, as burnt grain and unburnt frog bones were recovered from the same context. It seems more likely that F76 was dug for waste disposal, and later flooded, than plant waste was thrown into F76 to fill it in. We do know that breeding occurred only once, at the end of the life of the pit, when F76 was no longer being used for any other activity.

Shallow with moderately angled sides, F76 was ideal for breeding common frogs. The synchronous groups of juveniles and young mature adults found in F76 suggest this had happened here. We suspect the fish vertebra from F76 was residual as frogs avoid ponds with fish in them as they prey on larval tadpoles (Laurila and Aho 1997).

Before the breeding season was complete, these frogs suffered sudden mass mortality. This occurred in spring as indicated by the deaths of successive waves of tadpoles which had metamorphosed but not left the pond, and by the continued presence of breeding adults. There is occasional mortality at breeding sites, when mature frogs die from exhaustion after breeding and froglets are too weak to emerge from the pond, but the number, size and synchronicity of juveniles here suggests mass mortality.

This could have been due to a long cold period, or a particularly dry period, but, as the area was subsequently levelled prior to the construction of Building 5, it is perhaps more likely that people inadvertently buried these frogs when they filled in the possibly still waterlogged pit.

This then raises interesting questions about who built the first hall, whether they were from the local area and whether they understood the local environment. The presence of breeding frogs clearly indicates a waterlogged area; if F76 was dry due to an early drought, the frog bones would already be buried in basal silt, so perhaps builders unfamiliar with the area may have believed this was a dry site. Similarly, if F76 and other pits had been infilled in spring and a hiatus followed, there would be no evidence for flooding. However, builders with local knowledge would know the site flooded. Whoever built Building 5 did so as part of a planned arrangement which utilised the course of the stream in the creation of the western and southern sides of a manorial court (Randall 2020, 202-3) and apparently did not understand the risk of building on this flood prone land. The construction of the manorial buildings here was apparently dictated by architectural and social imperatives against a backdrop of the increased administrative and legal role of the manorial court (cf Bailey 2002, 3), rather than a detailed understanding of topography and hydrology.

The propensity of this part of the site, near the watercourse, to flood was possibly why Building 5 was eventually abandoned and the succeeding thir-teenth—fourteenth-century manor house (Building 2) built upslope to the north (Green 2020, 195).

#### Conclusion

#### A New Method for Sizing Amphibians from Archaeological Sites

This study demonstrates how amphibian assemblages can contribute to a better understanding of archaeological sites, identifying breeding mortality allowing us to tell nuanced stories about the site that are often lacking. Juvenile synchronicity was the main indicator for identifying breeding common frogs and was critical in interpreting the assemblage from F76 as a breeding population that incurred sudden death.

Sizing amphibian bones is a key analytic tool. It enables us to distinguish between pitfall, predation, human consumption and natural mortality during hibernation and aestivation. Some pathways are likely to show size bias, such as human consumption, while others show the full range of sizes, such as pitfall. Juvenile synchronicity is particular to mass mortality of breeding common frogs and toads. Our sizing method broadens potential archaeological interpretation by incorporating a size/age reference point. It allowed us to distinguish adult and juvenile populations giving a better picture of the assemblage as similar sized elements were matched to calculate MNE and MNI. We identified the balance and relative ages and synchronicity of adult/juvenile populations, conclusive evidence of a breeding population that died in spring. This in turn suggested the order in which F76 was used: working pit, redundancy, flooding, breeding, infill, hiatus and construction. The hiatus in use of F76 before the construction of the first stone buildings suggested the manorial system may have been introduced from outside the area.

This method can also identify other amphibian mortality pathways. For example, larger amphibians are likely to be selected for consumption (Kyseley 2008) and ritual practice probably involves larger individuals so this method can be applied whenever consumption or ritual use of common frogs is suspected. This method could also help identify predators as some show prey size bias (Andrews 1990). It would also identify the entire size range that occurs in pitfall and natural mortality at hibernation and aestivation sites (Whyte 1988; 1991). This methodology would probably have confirmed whether Tanners Row was a breeding or pitfall event (O'Connor 1988).

This method of sizing and what we know of amphibian behaviour and biology also enables us to identify the season of accumulation so adds detail to our knowledge of the local environment and can enhance our understanding of what was happening at the site. We have analysed a micromammal/amphibian assemblage from the English fenland and this size/age method helped to identify the season of accumulation, likely predators and possible changes in land use this must have involved (Clarkson et al. in prep).

The methodology has wide application, is easily replicable and can be used in broken archaeological assemblages. Several age reference points may be calculated for a more detailed interpretation of size/age scatter plots. This methodology can also be applied to mixed assemblages of micromammals and amphibians ( Clarkson et al. in prep).

However, it is limited to species that have suitable size/age data available, such as common frog. Measuring distal humeri also requires precise measurement, otherwise small differences will not be recorded. Measurement can be problematic if distal humeri are strongly corroded or digested and omitting these will lead to an unpredictable recording bias.

#### Lower Putton Lane and the Builders of the First Manor House

The amphibians from a pit directly under the medieval manor at Lower Putton Lane gave us insights into how

the manorial system developed, what it replaced and which actors were involved.

Combining amphibian results with archaeobotanical and context evidence we see how F76 was used, abandoned and built over. The charred plant material in F76, fish remains in F107, and domestic animal bone elsewhere suggests these were originally working or refuse pits with specialised functions before the manor house was built. F76 was used to dump burnt plant material. Common frogs began to breed in F76, taking advantage of temporary flooding probably when F76 fell out of use. The common frog bones from F76 resemble just 1 year's breeding population suggesting breeding took place in the last year before it was infilled. The remains of groups of juvenile froglets synchronous in size and age and a few remaining late breeders, two older females and a younger male, a cross section of a breeding population, suggest death occurred in late spring. This could have been due to natural causes, but as F76 was filled in before Building 5 was built, people may have been responsible. The sudden demise of this breeding population in late spring and subsequent infilling suggests F76 was being prepared for the construction of the first manor house. We cannot be sure whether burnt plant material was part of this fill, had been in the pit before breeding, or both. There may have been a further hiatus before construction, concealing site vulnerability to flooding.

The amphibians in F76 suggest who may have built the manor house, and how the transition to a manorial system was phased. They suggest the builders of the first manor house did not understand the local hydrology, possibly misled by a hiatus in use of the site, and perhaps reflecting a change in ownership, which can also be inferred from the introduction of new architectural styles and the use of stone.

The story of the frogs in F76 provides a snapshot of life in medieval Putton Lane, putting the fine grain of chronology and detail into broad statements about how people lived here. It also illustrates how combining microfauna analysis with other archaeological data can produce a narrative that is sometimes lacking when specialist reports are confined to appendices at the end of archaeological reports. People manipulate the local environment and microfauna adapt to this, so their lives reflect how people lived.

The full potential of microfauna may be lost without specialist input at an early stage, as sampling and recovery are very site dependent. Using a fine mesh size and undertaking careful sorting is necessary to recover the full-size range of a breeding population of amphibians. It is doubtful whether this breeding population could have been recovered without using a 0.5-mm mesh and an experienced zooarchaeologist (CR) to guide the recovery of the assemblage.

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#### **Disclosure statement**

No potential conflict of interest was reported by the author(s).

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