The pathology of sacrifice: dogs from an early Roman ‘ritual’ shaft in southern England

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The pathology of sacrifice: Dogs from an early Roman 'ritual' shaft in southern England

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ABSTRACT

Objective: To investigate the health of a large assemblage of Romano-British dogs recovered from the first century CE ritual shaft on the Nescot site in Surrey, England.
Materials: 5463 dog bones comprising an MNI of 140 individuals.
Methods: Bone fragments were visually inspected for pathology. In the case of suspected fractures, radiographic images were taken.
Results: Lesions were observed in 2.26 % of skeletal remains and 14.06 % of dentition.
Conclusions: The Nescot dogs have similar rates of skeletal pathology to those recovered from other 'ritual' or cemetery contexts but lower rates than those recovered from Romano-British urban contexts.
Significance: Nescot represents one of the largest dog assemblages recovered from a ritual context and thus is a valuable for investigating the treatment of dogs. This study has highlighted the importance of standardised recording and quantification of pathology in zooarchaeology, as well as the importance of specialist involvement during excavation.
Limitations: Limited recording at excavation level and the disarticulated nature of the bone limited examination at an 'individual' level. This made comparisons with other Romano-British sites challenging. No comparative data was available to assess the rates of dental pathology.
Suggestions for further research: Given that the majority of zooarchaeological assemblages are disarticulated, the use of prevalence rates by element would greatly expand the amount of comparative data available.

1. Introduction

Dogs were an important part of life in Roman Britain. Strabo lists hunting dogs as one of Britannia's chief exports (Strabo, *Geography*, IV:5), and their presence is found throughout the archaeological record in the form of paw prints, gnawed bones and skeletal remains (Allen, 2018). Dogs occupied several roles in society, from companion animals, herders, and guards to the 'stray' populations present in many urban contexts (Allen, 2018).

Dogs had numerous religious associations in the Roman world. Their connection with healing and purification rituals is clear throughout the Empire in the form of literary and pictorial evidence, as well as remains interpreted as sacrifices (Smith, 2006; Irvin and Lundock, 2021). Within Britain, dogs were depicted with the healing god Nodens at Lydney, Gloucester and were also associated with fertility, appearing alongside 'mother goddesses' (Smith, 2006). Several chthonic deities were associated with dogs in the Roman world, such as Hecate and Pluto (Green, 1993), and dogs are commonly found in infant burials in Roman Britain (Smith, 2006). Dogs are one of the most frequent finds from Roman ritual depositions in shafts, wells and pits (Fulford, 2001; Grimm, 2007; Smith, 2018; Wait, 1985); however, since they are associated with a wide range of deities and rituals, it is impossible to isolate their specific meaning in these contexts.

Despite being found on over 80 % of Romano-British sites (Allen, 2018; Bellis, 2020), the number of dog bones per site is often low. The Roman Rural Settlement Project, which catalogued faunal remains from almost 2500 sites in Britain, showed that dog bones generally made up between 2 % and 4 % of the total faunal assemblage at each site (Allen, 2018). A survey of 608 Romano-British rural, urban, military and civilian sites showed that the mean number of identified dog fragments (NISP) per site was just 59 bones (Bellis, 2020).

This paper presents an unusually large assemblage of dog remains (NISP = 5463) from a single first century CE quarry shaft from the Nescot site in Ewell, Surrey, England in order to investigate the age profiles, health and lifeways of the animals. This data is then contextualised by comparing their profiles against Bellis's (2020) survey of

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Romano-British dogs and those discovered in the settlement and ritual shaft at Springhead, Kent (Barnett et al., 2011).

2. Materials and methods

2.1. The Nescot Shaft, Ewell, Surrey, England

The area around Ewell, Surrey is characterised by a series of deep Romano-British shafts (1st-4th century CE) cut into the chalk. These were routinely backfilled throughout the period with a variety of pottery, bones, and metal artefacts. Drawing on comparisons with similar sites, these deposits have largely been interpreted as ritual in nature (Bird, 2004; Fulford, 2001; Wait, 1985). While shafts have been found elsewhere in England, the notable concentration at the small roadside settlement of Ewell, Surrey, implies that the area may have had religious significance (Bird, 2004; Smith, 2018). Unfortunately, the majority of these shafts were excavated in the late 19th and early 20th centuries before the advent of modern recording, and while the presence of animal bone was noted, more detailed information on the faunal assemblage is lacking.

In 2015, the Nescot College Former Animal Husbandry Centre, Ewell, was excavated by Pre-Construct Archaeology. These excavations uncovered a large area dominated by Roman quarry pits dating from the first to third centuries CE (Haslam, 2016). While the quarry pits represent a large scale mining operation, the backfill of several pits contained a range of material suggesting ritual deposition. The most striking of these was a 4 m deep oval shaft in the centre of the site that was backfilled in the late first century with human and faunal remains, as well as pottery, coins, metal artefacts and gaming counters (Haslam, 2016). The faunal assemblage from the shaft made up roughly 70 % of the animal bone recovered from the Roman phases of the whole site, with a NISP of 10,747. The large size of the bone assemblage of the Nescot shaft was unique amongst other Romano-British ritual deposits, particularly given the evidence that the shaft was only open for a relatively short period of time (Green in press; Green, 2024a). It also contained a high proportion of canine remains, making up one of the largest assemblages of Romano-British dogs recovered from a single feature.

The shaft appeared to have three phases of use, all dated to the late first century-early second century CE. The first two phases were characterised by large deposits of faunal remains in various states of articulation, as well as human remains, pottery, coins, metalwork and gaming tokens. These phases were interpreted as representing ritual deposition within the quarry due to their similarity to other Roman ritual shafts in Britain and the presence of human remains (Fulford, 2001; Wait, 1985; Woodward and Woodward, 2004). While the identification of ritual in the archaeological record is not a straightforward matter and the separation between rubbish and ritual is not necessarily applicable to societies in the past (Brück, 1999; Morris, 2008), it is notable that the first two phases of the quarries backfill are remarkably different from the third. The lack of evidence of butchery, unusual demographics, evidence of manipulation and handling of dog and human remains, as well as the presence of a red ochre stained bone, all support the idea that first two phases of use may have represented ritual deposition, or the deposition of 'ritual rubbish' rather than normal day-to-day waste (Green, 2024a; 2024b). The third phase, in contrast, contained only a small assemblage of disarticulated faunal remains and broken pottery. The faunal remains contained a statistically significant higher level of cut and chop marks, as well as 'fresh' fractures, which are often associated with processing bones for marrow, indicating that these bones were likely subject to butchery (Green, 2024a). The third phase was interpreted as evidence of rubbish disposal by the excavators, occurring after the cessation of the ritual function of the shaft (Haslam and Haslam, 2021); and while separating out rubbish and ritual deposition is inherently flawed, the assemblage is far more in keeping with domestic waste than that of phases 1 and 2.

2.2. Methods

The faunal assemblage was identified using the University of Reading's faunal reference collection and reference texts by Hillson (1992), Prummel (1987) and Amorosi (1989). The following information was recorded for each fragment: taxon, context, anatomical element, zonation (following (Dobney and Rielly, 1987), side, epiphyseal fusion, dental eruption, erosion and abrasion (following McKinley, 2004). The presence or absence of root etching, butchery, and pathology was also noted. The minimum number of elements (MNE) was calculated using the zonation data, and the minimum number of individuals (MNI) was calculated using repeating elements for each context.

The age of dogs at death was estimated using epiphyseal fusion following Sumner-Smith (1966), and dental eruption following Silver (1969). Dogs were categorised as either being perinatal, juvenile or adult. Given the disarticulated nature of the assemblage, an 'adult' bone fragment was recorded when all observable epiphyses were fully fused. Age estimations based on dental wear were not attempted, as these standards were developed on a small number of modern wolves (Horard-Herbin, 2000; Grouard et al., 2013), which are unlikely to have had the same diet, and thus rate of wear, as domestic dogs in Roman Britain. Sex estimation was not attempted due to both the high rate of fragmentation and the disarticulated nature of the sample; however, the presence of six bacula indicates that male dogs were present in the assemblage.

Butchery was identified and described following Reitz and Wing (2008) and pathology was identified and described following Thomas and Worley (2019). Skeletal lesions were classified as: trauma, joint changes, lytic lesions, new bone formation and 'other'. Osteoarthritis was diagnosed using either the presence of eburnation on the joint surface or two of the following lesions: articular extension and lipping, the presence of osteophytes and porosity on the articular surface (Waldron, 2008). Fractures were confirmed using radiography. Enthesial changes were only recorded when they formed ridges indicating the ossification of muscle tissue; this was done to try to differentiate pathological changes from changes occurring due to age or normal biomechanical processes. Dental lesions were classified as: calculus, caries, ante-mortem absent tooth, periodontal disease, anti-mortem chipping and crowding. Ante-mortem absent teeth encompasses teeth lost during life and the congenital absence of the third molar (common in small dogs), as macroscopic examination of the alveolus is not sufficient for differentiating the aetiology in canine remains (Bellis, 2020; Schernig-Mráz et al., 2023). While congenital loss of the third molar is not strictly pathological, due to the difficulty in determining the aetiology, all examples of anti-mortem missing teeth have been included in the results. Periodontal disease was diagnosed using the presence of periosteal new bone formation and alveolar recession. In order to avoid recording new bone formation normal for the growth process, only jaws with fully erupted adult dentition were examined for periodontal disease. Crowding was identified by rotated teeth displaced to allow for the inclusion of all dentition within the jaw.

Chondrodystrophy, which causes the bowing of limbs, is a congenital trait seen in small dogs (Brown et al., 2017). While it predisposes dogs to a number of other conditions, particularly in the spine (Smolders et al., 2013), it is generally not harmful and is often the result of selective breeding. It is commonly observed in Romano-British dog populations (Bellis, 2020) and has not been considered inherently pathological for this study. The disarticulated nature of the collection meant that limbs showing chondrodystrophy could not be matched with other elements to investigate the correlation between the condition and other pathologies. The complete long bones showing evidence of chondrodystrophy have been noted. The height and slenderness index was calculated following Harcourt (1974). While the site report and paper archive of the excavations refer to some articulated and semi-articulated dogs being found, these were not recorded or bagged separately making individuals impossible to identify. This means that the same dog may be represented several times within the height and slenderness data. As only 62 long bones were complete enough to be used for metric analysis, all measurements have been presented in order to maximise data. Metric data was not taken for morphotypes, as no skulls recovered were complete enough for the full suite of measurements needed.

Due to the disarticulated nature of the assemblage, pathology was reported as a percentage of bones affected rather than by percent of individuals affected. This approach also helped to compensate for the different rates of survival of skeletal elements. Perinates were excluded from this study due to a lack of adequate reference collections.

The results of the pathological analysis were compared to those from other assemblages using X^2 ($p < 0.05$) in order to establish if the differences in overall lesion prevalence were statistically significant (Field, 2013). To assess pairwise comparisons between assemblages standardised residuals (z-scores) were used. Statistical analysis was completed in SPSS version 29.

3. Results

The Nescot shaft contained a total of 5463 individual dog bones, representing at least 140 animals (Table 1); making up 76 % of the faunal assemblage. The limited cut and chop marks (0.22 %) suggest that the deposit did not accumulate as the consequence of skinning or other butchering activity.

Each phase comprised multiple deposition events. The smallest single faunal deposition of animals in Phase 1 consisted of a minimum of 19 dogs, eight pigs, two horses, four sheep/goats and a cow, as well as four humans. All of the animals must have been deposited around the same time given the stratigraphic lack of evidence of silting and the very small numbers of 'pitfall' fauna (small animals such as frogs, which presumably fell into the shaft and became trapped) (Green, in press). The death of so many animals of different species at one time due to natural causes is rare; hence, it is likely that the animals were sacrificed. Phase 2 has similar patterns, but with an average of eight dogs per depositional event.

3.1. Demography

The ages of the dogs ranged from perinate to adult (Fig. 1). The presence of ossified costal cartilage and fused tibiae and fibulae in Phases 1 and 2 indicates that at least some of the animals were older adults. Sex estimation was not always possible due both to the disarticulated nature of the remains and the fragmentation of the majority of skulls. At least six male dogs were present, four within Phase 1, and two within Phase 2, based on the presence of baculae.

3.2. Size

The dogs in the Nescot Shaft ranged in size from 20.5 cm to 60.8 cm at the shoulder. All of the large (>50 cm) dogs were found within Phase 1, and the average height for Phase 2 is lower (31.2 cm) than that of Phase 1 (39.8 cm). The majority of the dogs within the shaft were small (<35 cm) in both Phases 1 and 2. Table 2 shows the measurements, heights, and slenderness index by element for all complete long bones (n = 62). Two complete long bones had lesions. The femur had two punctures on the distal end, likely caused by a dog bite (Fig. 8 A), and the tibia had a lytic lesion on the proximal joint surface.

3.3. Dental Pathology

The most common dental pathology observed in the assemblage was calculus (n = 56), followed by periodontal disease (n = 10) (Fig. 2). Phase 3 had a much larger percentage of dental calculus; however, this is likely an artefact of the small sample size, as only four instances of periodontal disease were observed.

3.4. Skeletal Pathology

Skeletal pathology was observed in 2.3 % (n = 98) of the dog assemblage and was most prevalent in Phase 1 (Fig. 3). No skeletal lesions were observed in the dogs from Phase 3. The true prevalence rate of lesions by element is presented in Fig. 4. Joint change was the most prevalent category of skeletal lesions across both phases, and lesions were most commonly observed in limb bones, in particular the scapula (9.49 %), ulna (7.19 %) and fibula (8.11 %). The sacra also showed a relatively high level of pathology (8.82 %), all of which was attributed to trauma.

3.4.1. Joint changes

The most prevalent lesions were joint changes, present in 1.8 % (n = 60) of joint surfaces. These changes included: osteophytic lipping at the margins of the joint, lytic lesions on the surface of the joint, grooving on the surface of the joint, and eburnation. While the majority of these lesions are likely due to degenerative joint disease, only 13.3 % (n = 8) of observed lesions on the joints met the diagnostic criteria for osteoarthritis. In one proximal ulna, joint degeneration occurred in combination with trauma; however, the joint changes appear to be older based on the degree of fracture healing. In Phase 2, only one distal femur had evidence for osteoarthritis (Fig. 6F). The distribution of other joint changes differed between Phases 1 and 2 (Fig. 5), with spinal lesions in particular being more prevalent in Phase 1.

The joint changes on the spine (n = 27) were all characterised by osteophytic lipping on the margins of the vertebral bodies (Fig. 6E), with the majority of lesions affecting the thoracic vertebrae. Osteophytic lipping of the vertebral bodies is consistent with spondylosis deformans (an age-related condition) and diskospondylitis (an infection of the intervertebral disk and adjacent vertebrae) (Platt, 2008). The lack of pitting, porosity and lysis in the majority of cases strongly suggests spondylosis deformans. Two vertebral bodies had eburnation present on the vertebral body, indicating the degeneration of the intervertebral disk to the point where the vertebral bodies were in contact with each other. This condition could be caused by trauma, but in the absence of other indicators on the bone it is more likely to be a degenerative condition such as Intervertebral Disk Disease (IVDD). IVDD is a condition particularly prevalent in chondrodytrophic dogs and is most common in the thoracic verterbrae (Platt, 2008). In chondrodystrophic dogs, the condition tends to affect animals by 1 year of age, while in achodrodytrophic dogs, it is primarily an age related condition. While it is impossible to say if the animal (or animals) in question was chondrodystrophic due to the impossibility of individuation, the size of the

Table 1
Quantification of humans and major domesticates in the Nescot Shaft.

Phase	Human		Dog		Pig		Cattle		Horse		Sheep/Goat	
	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP	MNI	NISP
1	21	675	92	3506	23	319	5	43	10	135	25	438
2	0	0	41	1909	15	342	1	3	6	16	5	32
3	0	0	7	48	2	5	6	42	6	23	4	12
Total	**21**	**675**	**140**	**5463**	**40**	**666**	**12**	**88**	**22**	**174**	**34**	**484**

Key: NISP = Number of identified specimens; MNI = Minimum number of individuals

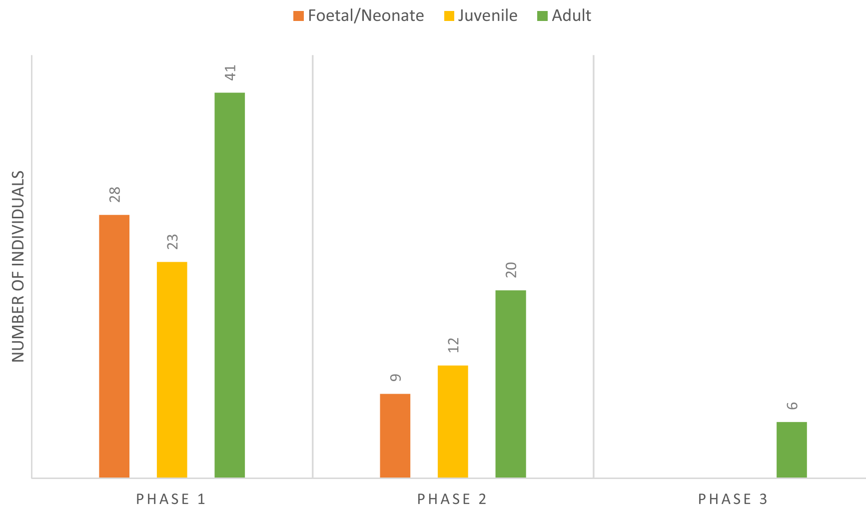

Fig. 1. Age at death of the Nescot Dogs.

vertebrae is suggestive of a small dog, and several chondrodystrophic long bones were recovered from the context. There is also a clinical association between some types IVDD and spondylosis deformans (Levine et al., 2006), which is consistent with the affected vertebrae.

Six scapulae, four from Phase 1 and two from Phase 2, had shallow, saucer shaped lytic lesions within the glenoid fossa (Fig. 4C). These lesions are consistent with osteochondrosis (Trout, 2008). Osteochondrosis is the failure of a portion of the joint surface to ossify correctly during development (Trout, 2008) and is common in modern large and medium sized dogs and can be caused both by genetic and mechanical factors (Trout, 2008).

3.4.2. Trauma

Evidence for trauma was present in 0.5 % (n = 20) of the assemblage. The prevalence of traumatic lesions was similar between Phases 1 and 2, and they were most commonly observed in the forelimb. Three fractures, four cases of ossified tendon sheaths, an ossified hematoma, and a single sharp force trauma injury were observed on the bones of the forelimb.

A scapula from Phase 1 displayed significant cortical thickening on the scapular spine consistent with a healing compression fracture (Fig. 7A). Post-mortem damage however, makes diagnosis difficult. Within Phase 2, a peri-mortem greenstick fracture was present on the distal third of an ulna shaft (Fig. 7B). While the fragment only represents a portion of shaft, meaning the individual it belonged to could not be aged, it is likely that this dog was young, as greenstick fractures are uncommon in adults (Bartosiewicz, 2013). A proximal ulna from Phase 1 displayed a small nodule of bone ankylosed on the anconeal process. When radiographed (Fig. 7D), this nodule appeared to be distinct from the cortical bone of the ulna and likely represents a fragment that had recently fused in the wrong place after injury. Given this, and the very advanced state of joint degeneration (Fig. 6A), it is probable that the animal suffered trauma as a result of repeated strain on the elbow joint, possibly due to overextension, based on the location of the fracture. Without the articulating humerus, it is difficult to categorise the exact nature of the injury.

Four bones from Phase 1 exhibited the ossification of soft tissue: two distal radii, a distal humerus and a proximal ulna. The lesions on the radii consist of the ossification of the *abductor pollicus longus* tendon, in one case forming a full arch on the medial portion of the bone, superior to the styloid process (Fig. 7C). The lesion on the humerus presents similarly, with a semi-circular projection of bone present on the lateral epicondyle, at the attachment site for the *extensor digitorum communis*. The lesion on the ulna presented as projections of bone forming a semi-circular channel inferior to the coracoid process and is a probable ossification of *m. brachialis*. These ossifications are most likely the result of calcifying tendinopathy, which occurs in cases of chronic strain on the muscle (Trout, 2008), or as the result of accumulated micro-damage over time combined with the increasing joint laxity of age, but myositis ossificans cannot be ruled out (Trout, 2008). An ossified hematoma was also present on the medial aspect of a proximal ulna, likely representing trauma to the soft tissue of the forelimb (Fig. 7F).

A single peri-mortem sharp force injury was observed in the forelimb of a dog in Phase 2 (Fig. 7E). The cut mark was 5.68 mm long, running transversely across the lateral aspect of the proximal humeral shaft, in line with the attachment point of *teres minor*. It is probable that this represents the dismemberment of the corpse rather than trauma in the living animal.

Traumatic lesions in the hindlimb were observed in both Phases. Two peri-mortem puncture wounds with crush marks around the edges were observed in the distal femur of a small dog in Phase 1 (Fig. 8A). The puncture marks are consistent in both size and angle with a bite from another dog. Injuries to the back legs are common in fights between dogs of a similar size; however, the depth of the punctures indicates a much more serious injury (Intarapanich et al., 2017). In Phase 2, a healed depression fracture was observed (Fig. 8B). A peri-mortem greenstick fracture was also observed in a distal shaft of a fibula in Phase 2.

Five traumatic injuries were observed within elements of the trunk. In Phase 1, these comprised: a rib fracture, a fractured atlas (Fig. 8F), a sacral fracture (Fig. 8D), and a fracture of the right transverse process of the first caudal vertebrae, where it had fused to the sacrum. In Phase 2, trauma to the trunk was only observed on a sacrum with a fracture similar to the one from Phase 1.

There was little evidence of trauma to the head, which was limited to two mandibular fractures (Phase 1) and a possible sharp force injury on a frontal bone that shows evidence of healing (Phase 2) (Fig. 8E). It is likely that the sharp force injury was a puncture resulting from a dog bite. No evidence of trauma was observed within the bones of the paw in either phase.

3.4.3. Lytic lesions

Lytic lesions were rare within the assemblage, seen in only 0.11 % (n = 5) of bones. Within Phase 1, they were observed on a radius and an ulna. The aetiology of these lesions is impossible to determine due to the disarticulated nature of the sample; however, the fibula, radius and distal ulna lesions had smooth rounded margins (Fig. 9A, B, C), consistent with being cystic in nature. Cystic lesions are more common in dogs than other animals and are often found on the metaphysis of the tibia, ulna and radius of young animals (Baker and Brothwell, 1980: 58). Infection can also cause lytic lesions, as is likely the case on the proximal

Table 2
Metric data for dog bones recovered in Phases 1 and 2.

Element	Context	Phase	Side	Length (mm)	Height cm	Midshaft Diameter mm	Slenderness Index	Size
Humerus	311	2	R	69.5	20.56	5.71	8.22	Small
Tibia	301	2	R	71.5	21.82	Na	Na	Small
Humerus	341	2	R	78.5	23.57	7.54	9.61	Small
Humerus	341	2	R	81	24.40	7.58	9.36	Small
Humerus	341	2	L	81	24.40	8.36	10.32	Small
Humerus	341	2	L	82	24.73	8.34	10.17	Small
Ulna	341	2	R	88	25.09	3.73	4.24	Small
Femur	**341**	**2**	**L**	**86**	**25.71**	**7.31**	**8.50**	**Small**
Radius	341	2	L	75	25.80	6.7	8.93	Small
Humerus	311	2	L	86	26.07	6.36	7.40	Small
Radius	341	2	R	77	26.44	6.75	8.77	Small
Tibia	**354**	**1**	**R**	**87.5**	**26.49**	**N/A**	**N/A**	**Small**
Tibia	**354**	**1**	**L**	**88**	**26.64**	**N/A**	**N/A**	**Small**
Radius	**354**	**1**	**R**	**78**	**26.76**	**6.6**	**8.46**	**Small**
Femur	**354**	**1**	**L**	**90**	**26.96**	**7.15**	**7.94**	**Small**
Ulna	**354**	**1**	**L**	**97**	**27.59**	**4.84**	**4.99**	**Small**
Radius	**354**	**1**	**R**	**82**	**28.03**	**8.53**	**10.40**	**Small**
Radius	**354**	**1**	**L**	**82.5**	**28.19**	**8.2**	**9.94**	**Small**
Tibia	**354**	**1**	**L**	**93.5**	**28.24**	**N/A**	**N/A**	**Small**
Tibia	342	2	L	95	28.68	N/A	N/A	Small
Femur	**354**	**1**	**L**	**98**	**29.48**	**9.03**	**9.21**	**Small**
Humerus	341	2	R	97	29.74	8.33	8.59	Small
Humerus	341	2	L	98	30.08	8.65	8.83	Small
Tibia	**350**	**1**	**R**	**100**	**30.14**	**N/A**	**N/A**	**Small**
Tibia	**350**	**1**	**L**	**101**	**30.43**	**N/A**	**N/A**	**Small**
Femur	342	2	R	105	31.67	8.88	8.46	Small
Femur	342	2	L	107	32.30	9.25	8.64	Small
Humerus	393	1	L	106	32.75	8.69	8.20	Small
Radius	341	2	L	97	32.80	6.71	6.92	Small
Radius	393	1	R	100	33.75	7.55	7.55	Small
Femur*	350	1	L	113.5	34.34	8.54	7.52	Small
Radius	**350**	**1**	**R**	**102**	**34.39**	**8.59**	**8.42**	**Small**
Tibia	393	1	L	115	34.52	N/A	N/A	Small
Tibia	350	1	L	116	34.81	N/A	N/A	Small
Tibia	311	2	L	116	34.81	N/A	N/A	Small
Humerus	419	1	R	113	35.09	8.01	7.09	Medium
Humerus	354	1	R	122.5	38.26	10.23	8.35	Medium
Radius	419	1	R	115	38.52	8.23	7.16	Medium
Radius	350	1	L	116.5	39.00	9.2	7.90	Medium
Radius	350	1	L	117	39.16	9.3	7.95	Medium
Tibia	341	2	L	133	39.78	N/A	N/A	Medium
Tibia	341	2	R	133	39.78	N/A	N/A	Medium
Tibia	342	2	L	139	41.53	N/A	N/A	Medium
Radius	350	1	L	125	41.70	10.29	8.23	Medium
Tibia	350	1	L	140	41.82	10.66	7.61	Medium
Femur	350	1	L	143	43.61	11.59	8.10	Medium
Tibia*	354	1	L	147.5	44.01	N/A	N/A	Medium
Femur	393	1	L	147	44.86	11.63	7.91	Medium
Humerus	301	2	L	145	45.78	13.76	9.49	Medium
Femur	301	2	R	152	46.43	11.94	7.86	Medium
Radius	301	2	R	140	46.47	10.81	7.72	Medium
Tibia	301	2	R	156	46.49	N/A	N/A	Medium
Tibia	301	2	L	157	46.79	10.56	6.73	Medium
Ulna	419	1	R	172	48.44	6.41	3.73	Medium
Tibia	354	1	L	166	49.41	N/A	N/A	Medium
Radius	419	1	R	151	49.97	12.01	7.95	Medium
Femur	419	1	R	169	51.77	12.69	7.51	Large
Humerus	350	1	R	165	52.46	14.88	9.02	Large
Tibia	393	1	R	180	53.50	N/A	N/A	Large
Tibia	350	1	L	181	53.79	N/A	N/A	Large
Femur	350	1	R	179.5	55.07	13.23	7.37	Large
Radius	354	1	R	169	55.69	13.92	8.24	Large
Femur	354	1	L	182	55.85	13.9	7.64	Large
Tibia	419	1	R	205	60.80	N/A	N/A	Large

* denotes pathology was observed on the bone, **Bold** denotes chondrodystrophic limbs

ulna presented in Fig. 9D, which also shows evidence of inflammation.

3.4.4. New bone formation

New bone formation was observed in 0.11 % (n = 6) of the assemblage (Fig. 10). All but one of the examples occurred in Phase 1: three ulnae, a frontal and a scapula. In Phase 2, an unfused fourth metacarpal had a patch of woven bone on the shaft. New bone formation can be caused by infection, inflammation, and neoplastic disease, as well as trauma. It is impossible, particularly in a disarticulated assemblage, to identify specific causes. Five of the six lesions were active at the time of the animal's death.

3.4.5. Other lesions

Eight bones (0.2 %) had lesions that did not fit into the above

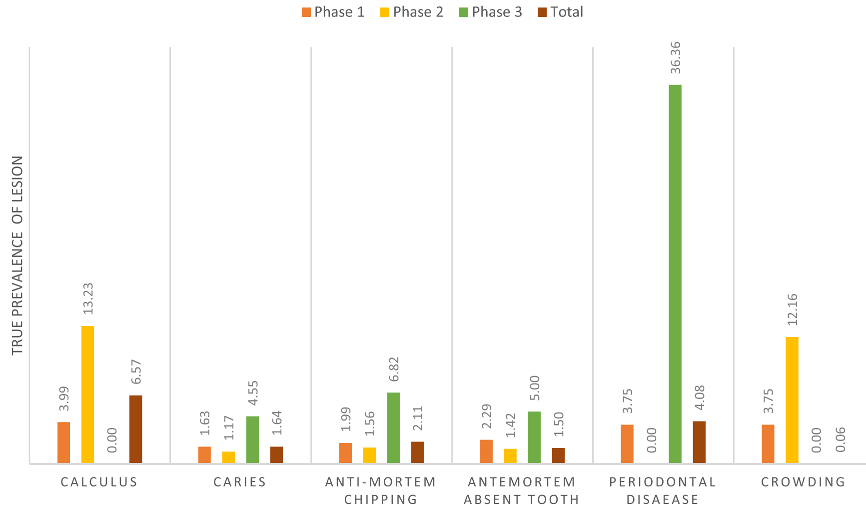

Fig. 2. True prevalence rate of dental pathology.

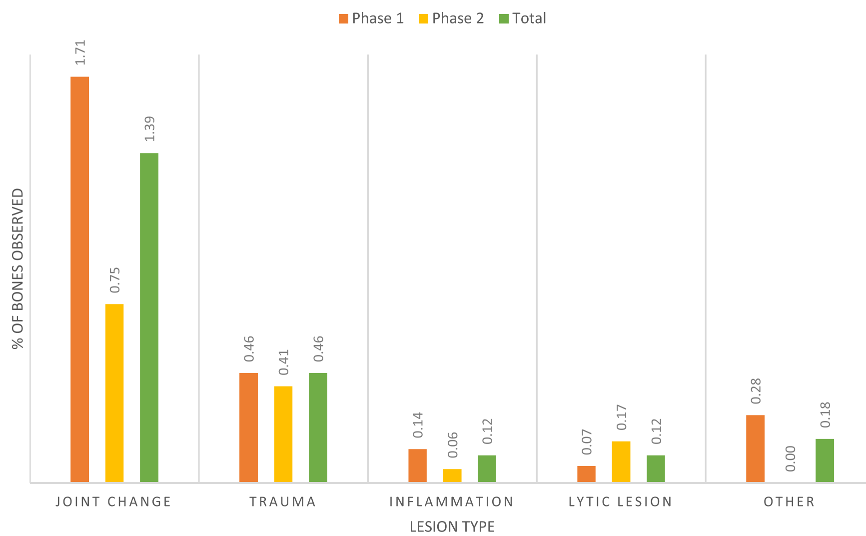

Fig. 3. True prevalence rate of skeletal lesions in the Nescot dogs.

categories, all from Phase 1. These consisted of two cervical vertebrae and four scapulae, which displayed incomplete fusion, and two lumbar vertebrae with unusually shaped articular processes. In the cervical vertebrae, the defect is present on the ventral aspect of the caudal vertebral body, and likely would have been asymptomatic in life (Fig. 11A). In the scapulae, the fusion defects are all present on the tuber scapulae and represent non-union of the secondary ossification centre in the caudal glenoid (Fig. 11B). This condition is reported in the modern veterinary literature (Monaco and Schwartz, 2011; Olivieri et al., 2004) and can cause lameness, although it may be asymptomatic in some animals. Incomplete fusion can be the result of a genetic disorders, abnormal growth, trauma, osteochondrosis or osteochondritis dissicens (Olivieri et al., 2004).

Two lumbar vertebrae had a compressed appearance of the articular facets and deviated spinous processes. These lesions are consistent with compression trauma (Fig. 9C); however, no fracture line was observed radiographically. Other potential causes include metabolic disease, the presence of hemivertebrae in the spine, canine scoliosis or biomechanical problems during life, leading to the asymmetrical development of axial muscles (Lawler et al., 2016). These causes are difficult to access with only isolated vertebrae; however, it should be noted that similar examples of asymmetrical articular facets in the spine have been noted both archaeologically and clinically (Lawler et al., 2016). This lesion can also occur as a result of twisting of the spine and is often seen in chondrodystrophic dogs, which have proportionally long backs. Given the small size of the vertebrae, this is the most likely cause.

4. Discussion

The dogs recovered from the Nescot shaft were not treated badly in life based on the small number of skeletal lesions observed and the probable advanced years of many of the animals. No fatal lesions were identified, and in the few cases of trauma, all were healed or healing, indicating that the animal survived the injury. Evidence of infection/ inflammation was also rare, occurring in less than 1 % of the sample. The majority of lesions in the Nescot dogs can be linked to age and activity rather than illness or mistreatment. Indeed, it would appear that a number of these animals survived to advanced age based on the prevalence of spondylosis deformans and other arthroses. This does not preclude the presence of acute disease that may have killed the animals before bone had the chance to respond (Bartosiewicz and Gál, 2018). Without the use of pathogen aDNA analysis, these conditions cannot be recognised archaeologically.

Calculus and periodontal disease were the most common dental

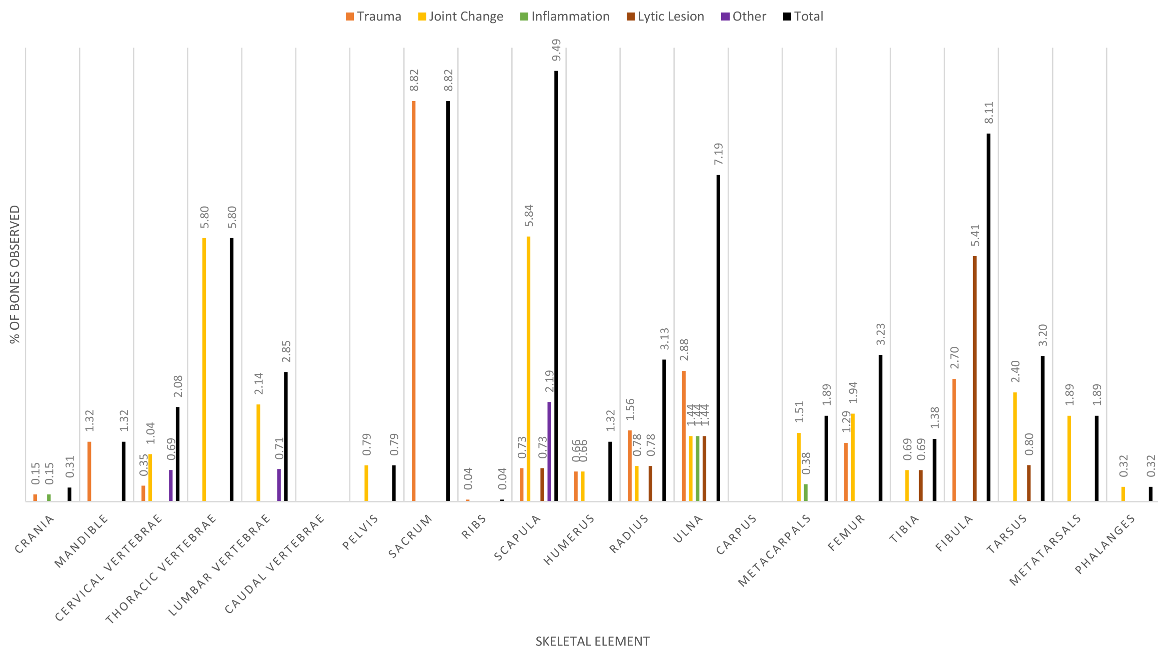

Fig. 4. True prevalence rate of lesions by skeletal element.

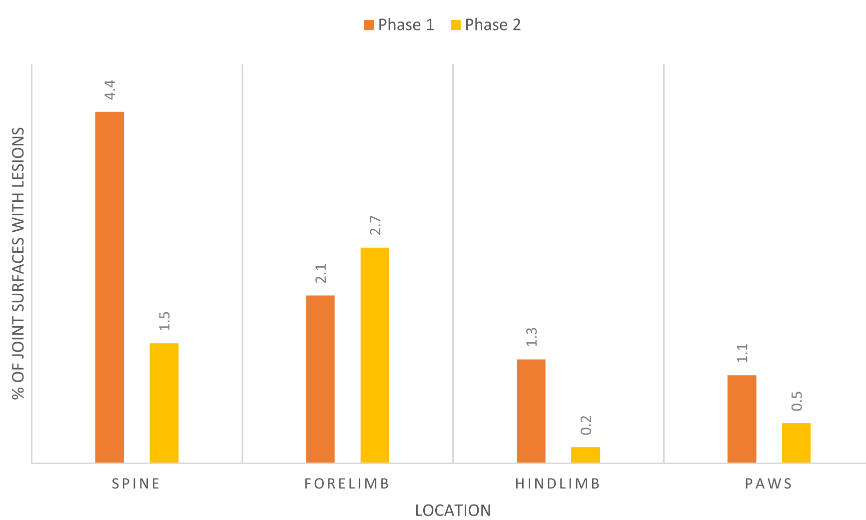

Fig. 5. True prevalence rate of joint changes by location.

pathologies recorded. Both are more common in small dogs today (Kyllar and Witter, 2005), and the two conditions are often correlated in both clinical and archaeological data (Holmes et al., 2021; Kyllar and Witter, 2005).This may be a reflection of the size of the animals rather than their health status. The small size of the dogs may also explain the high rates of dental crowding seen in Phase 2, as both chondrodysplasic and miniature dogs often suffer from this condition (Baxter, 2010). It is difficult to make any judgments about the dental health of the Nescot dogs, as there are few published studies on canine dental disease in the Roman empire, and those that exist only reported lesions by individual rather than number of teeth observed, and so cannot be directly compared with Nescot (Bellis, 2020; MacKinnon and Belanger, 2006; Schernig-Mráz et al., 2023).

The most common pathology identified in the Nescot dogs was joint change. This is also true in modern orthopaedic veterinary clinics (Ness et al., 1996), although it does not appear to be the case within Roman Britain more widely, where fractures are normally the most commonly reported condition (Bellis, 2018). Arthropathies can be caused by a wide number of factors, including trauma, infection and age. The majority of joint changes in the Nescot sample comprised osteophytic lipping around the edges of joints, which is very likely to be the early stages of degenerative joint disease. It is probable that the predominance of arthropathies in the Nescot sample is indicative of a number of older animals being present within the assemblage, particularly in Phase 1, where spondylosis deformans was more prevalent. This is supported by the presence of ossified costal cartilage, fused tibiae and fibulae, and enthesial changes, all indicative of an older population. In modern populations, 75 % of dogs over 9 years are affected by the condition, although it has been observed in dogs as young as 2 years, and while the condition can be secondary to trauma, it is in most cases simply a function of age (Levine et al., 2006).

While shoulder pathologies are common in modern dogs, lesions in the scapula are rare in modern clinical contexts (Marcellin-Little et al., 2007; Trout, 2008), but they make up 41.9 % of the lesions in the forelimb in the Nescot sample. Nine of these lesions could be attributed to osteochondrosis, the aetiology of which is complex and can be related

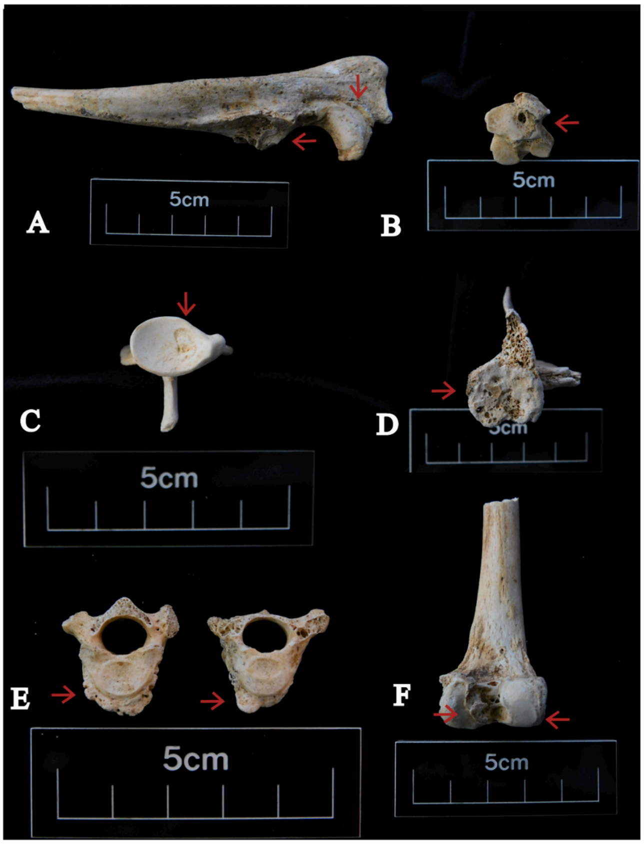

Fig. 6. A: ulna showing grooving, eburnation and osteophytic lipping. B: calcaneus with a cystic lesion on the joint surface. C: scapula with potential osteochondritis dissecans on the glenoid fossa. D: scapula with pitting on the joint surface indicative of degenerative joint disease. E: two thoracic vertebrae with osteophytic lipping around the vertebral bodies. F: distal femur with eburnation, contour change and osteophytic lipping on the lateral condyle and enthesial ridging on the lateral portion of the bone.

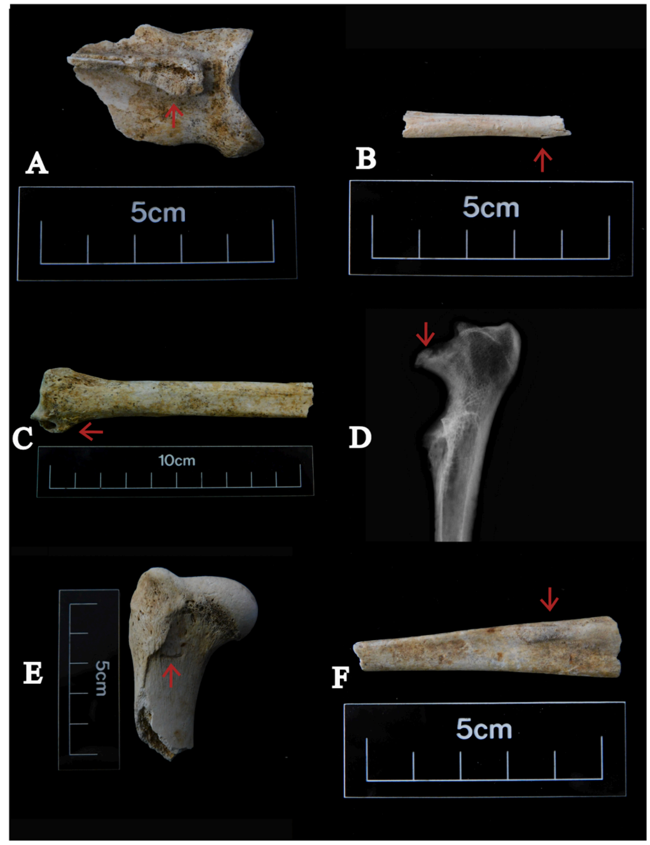

Fig. 7. A: scapula with possible fracture callus on the scapular spine. B: ulna with peri-mortem greenstick fracture. C: cranial view of radius with ossified tendon sheath. D: radiograph of proximal ulna showing extra bone fused to the aconeal process. E: humerus with peri-mortem cut mark. F: ulna shaft with ossified hematoma.

to exercise and excessive mechanical loading, as well as nutrition and a genetic predisposition (Trout, 2008). Interestingly, these conditions are almost always noted in medium or large breed dogs in the modern literature (Monaco and Schwartz, 2011). However, when comparing the length (GPL) and width (BG) of the glenoid fossae (following Von den Driesch, 1976:74) showing these pathologies, the majority of the affected scapulae have smaller glenoid cavities than the unaffected elements (Fig. 12) and are likely to represent small dogs. These lesions may have a genetic aetiology, as small dogs are unlikely to be used in a way that would put undue mechanical strain on the shoulder. While dogs have historically been used for traction, most notably in the Arctic Circle (Sheppard, 2004; Vitale et al., 2023), these have tended to be large breeds, and the associated pathology has mostly been focused in the spine (Bieraugle, 2023). Furthermore, there is no evidence of dogs being used for traction in Roman and Iron Age Britain or in the wider Roman Empire. The increased rates of scapula pathology more likely indicate inbreeding within the Nescot population, as these conditions are very rare on the scapula in modern populations.

Understanding the health of the Nescot dogs within the wider context of Roman Britain is challenging. Assemblages of dogs in this period tend to be small. This problem is further compounded by the variability in quantification methods used within zooarchaeological reports, as well as the lack of standardisation in the recording and reporting of pathologies in faunal remains. The final problem is the tendency for reports to focus only on articulated individuals. The result of these issues is that comparing reports from different sites is difficult, and in some cases impossible. Pathology that is quantified by individual (crude prevalence) rather than by bone affected (true prevalence) cannot be compared to disarticulated material without risking over recording lesions that may appear multiple times in a single animal. Furthermore, reporting pathology only in articulated animals creates a bias towards animals that have been deliberately buried. It is possible that the latter group is reflective of canine health in general: however, it is likely to be skewed towards companion animals, or animals that have been deposited for ritual purposes (Sykes, 2014). While there have been studies of the health of dogs in Roman Britain (Allen, 2018; Bellis, 2018, 2020; Clark, 2012) and in the Roman world more generally (MacKinnon, 2010), they have not addressed these issues.

Three sources were used as a comparison with the Nescot shaft assemblage. The first is a compilation of data for all regions and periods of Roman Britain (Bellis, 2020). Only adult, articulated, and relatively complete animals were analysed within that study; the total NISP comprised 2821 bones. For the purposes of the present study, the raw data from Bellis's work was re-analysed in order to create comparative prevalence rates, after the exclusion of chondrodystrophic lesions. The second and third sources relate to the site of Springhead in Kent. Springhead was a large sanctuary and roadside settlement, similar to Ewell, which was occupied from the second century CE (Barnett et al., 2011). Within the sanctuary, a large ritual shaft comprising a NISP of 1006 mostly articulated dog bones was excavated (Grimm, 2007; Grimm and Worley, 2011). The skeletal pathology for this site was reported in enough detail to allow prevalence by element to be calculated. The roadside settlement at Springhead was published in similar detail, and provides a comparison from a less specialised context than the ritual shaft; however, only 50 dog bones were recovered from that site (Grimm and Worley, 2011). The results of these comparisons can be seen in

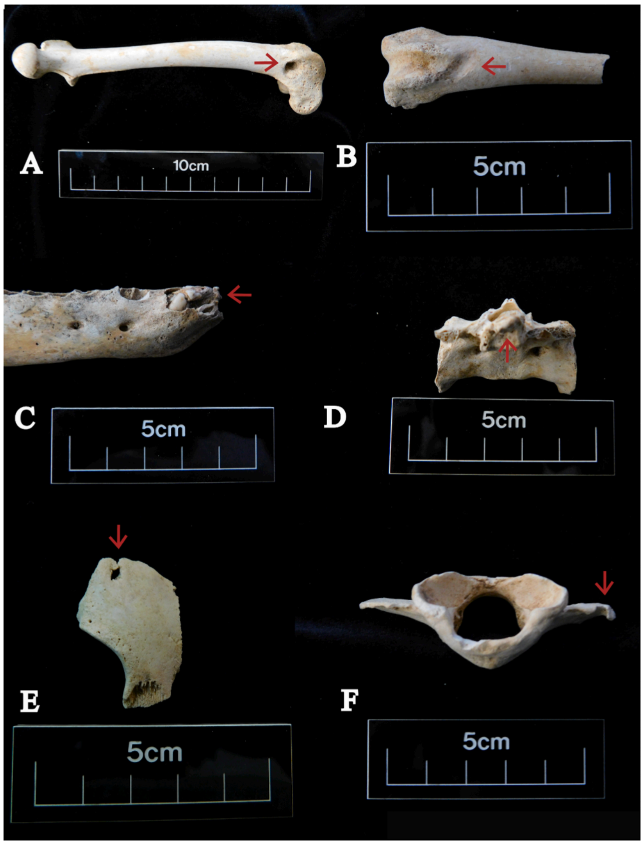

Fig. 8. A: femur with puncture wound on distal end. B: femur with depressed fracture. C: mandible with healed fracture that has disrupted the dentition. D: sacrum with a healed crush fracture. E: frontal bone with sharp force injury, potentially resulting from a bite from another dog. F: atlas with a healed compression fracture to the wing, resulting in a 'folded' appearance.

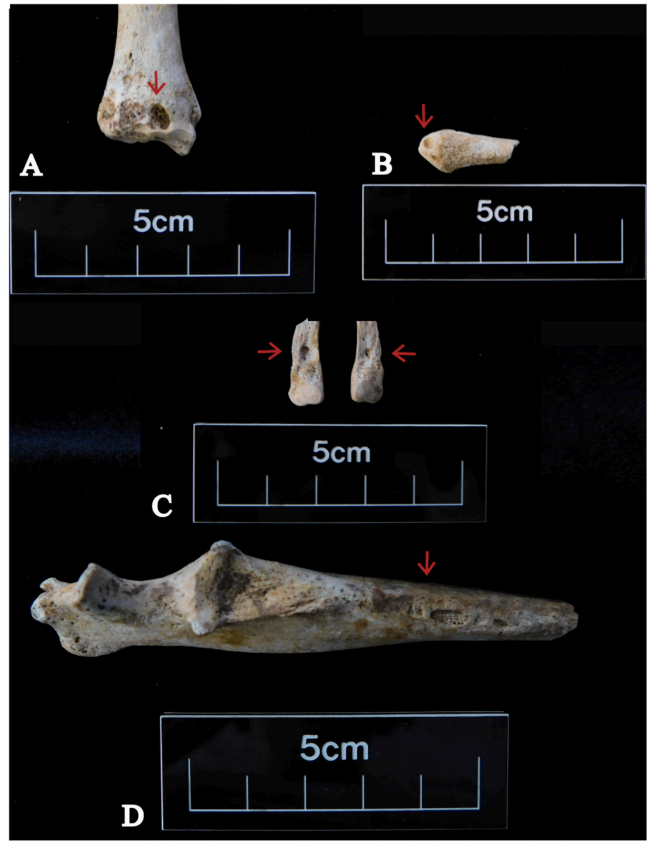

Fig. 9. A: lytic lesion in the distal radius. B: cystic lesions in the metaphysis of an ulna. C: bilateral lytic lesions in the fibula. D: sub-periosteal new bone formation in an ulnar shaft.

Fig. 13.

The Nescot dogs present similar rates of pathology to those from the Springhead sanctuary and Bellis's (2020) study. The Springhead shaft, like Nescot, represents a ritual deposition of several dogs of varying ages and sizes, deposited as full carcases (Grimm and Worley, 2011). While the material retrieved from the two shafts are not identical, they are likely to represent similar beliefs and practices and, as such, it is probable that a similar selection process was used for the animals deposited. While acute pathologies often do not leave traces on the skeleton, the dogs selected for ritual deposition do appear to have been better treated than those recovered from settlement sites. This may have its roots in Roman ideas of sacrifice, which dictated that only healthy animals should be used as offerings (Mantzilas, 2016) or in other selection criteria, which would not have been applied within settlement contexts. It is also notable that while sacrifice has been suggested in both instances, no fatal lesions were observed in the Nescot or Springhead shafts. It is likely, given Roman conventions around sacrifice, that the dogs had their throats cut (Mantzilas, 2016); however, no cut marks were observed on the cervical vertebrae of either assemblage.

Bellis's (2020) overview selected only dogs that were both articulated and relatively complete. While providing a useful sample for analysis, this sampling strategy selected for animals that were buried intentionally, and thus is unlikely to be representative of the wider canine population (Sykes, 2014). These animals are more likely to have been cared for during their lifetimes than, for example, strays or nuisance animals. Roman sacrifice was governed by a series of rules regarding which animals were appropriate, which included that the animals must be healthy (Mantzilas, 2016). This likely would have incentivised the use of cared-for animals for ritual deposition. Equally, there has been a wealth of evidence showing care of companion animals within the Roman Empire (Allen, 2018; Bellis, 2020; MacKinnon, 2010).

The prevalence of pathology from the Springhead settlement site is statistically significantly higher than the other study assemblages, as shown by the application of the X^2 test (X^2 (3) $= 35.079$, $p < 0.001$, $z = 5.6$) despite only traumatic and inflammatory lesions being reported. Within the literature, it is often the case that pathology, particularly trauma, is more commonly reported on settlement sites (Bellis, 2018). For example, bearing in mind that direct comparison is impossible due to the lack of published NISPs, the Roman towns of Silchester, Baldock and Chichester all have high numbers of traumatic and inflammatory lesions within their assemblages. This has been taken as evidence of unwanted stray populations within the settlements (Allen, 2018; Clark, 1994; Smith, 2006). Analysis of pathologies on the disarticulated remains was performed on the assemblages, as well as those from the Springhead settlement. These results are more likely to be representative of the entire canine population in their respective areas, in contrast to studies that only analyse articulated remains. It should be noted that some of the dogs showing large amounts of trauma from the Roman town of Silchester were found in contexts that were interpreted as ritual pits (Fulford et al., 2006), so it is possible that overall site type (e.g. settlement vs sanctuary) may have a stronger correlation to health than if the context in question is ritual or not. More work on the prevalence of pathology in whole-settlement assemblages is needed to draw any firm conclusions. The available data, however, points to a different pattern of pathology within the Nescot sample to those from urban centres.

The Nescot sample has a high prevalence of joint changes when compared to the other sites. Although precise ageing was not possible, this pattern suggests that many of the dogs were living into older adulthood, which is supported by the presence of ossified inter-costal

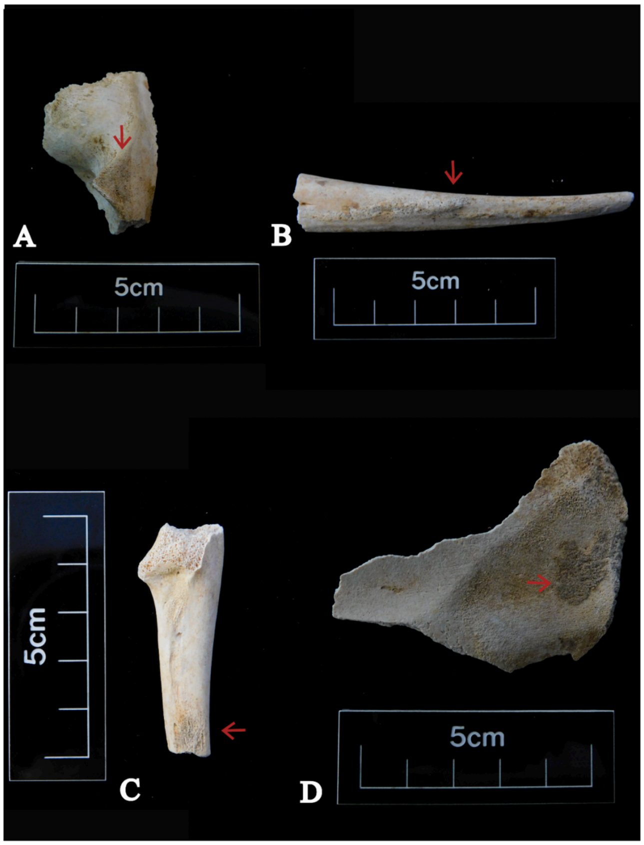

Fig. 10. New bone formation on the: A: orbit. B: interosseous crest of an ulna. C: interosseous crest of an ulna. D: scapula blade.

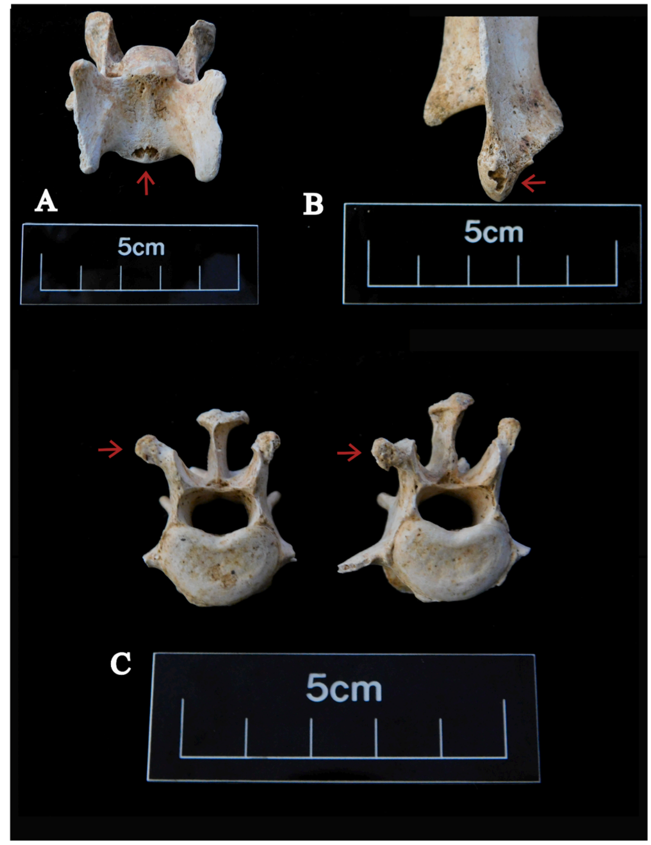

Fig. 11. A: non-union of the apophasis and vertebral body in a cervical vertebra. B: non-union of the secondary ossification centre in the caudal glenoid of the scapula. C: lumbar vertebrae with abnormal contour change.

cartilage and fused tibae and fibulae. The Nescot dogs also have a very unusual frequency of pathology in the scapula in comparison with both Springhead sites and Bellis's overview. Bellis reports a single comparable lesion in a glenoid, and no similar pathologies were observed in either Springhead assemblage (Bellis, 2020). These pathologies are likely genetic and may be an indication of inbreeding in the Nescot population. Intensive breeding of the Nescot dogs is supported by the high number of perinatal individuals found within the shaft.

5. Limitations of the study

There were two major limitations to this study: the disarticulated nature of the assemblage, compounded by the recording choices made at excavation stage, and a lack of comparative data.

When the Nescot shaft was excavated, no faunal or human remains specialists were present on site. No photos or plans were made of the bones and, while excavators attempted to separate out what they believed to be articulated bone groups, upon examination, these groups proved to consist of multiple individuals and species. As a result, despite the site report and excavators notes referring to articulated and semi-articulated animals being present, there was no way to individuate any of the material. Disarticulated material is challenging to assess pathologically, as each bone must be taken in isolation and patterns of lesions cannot be identified over multiple elements. It also provides additional challenges with finding comparative material, as the majority of zooarchaeological pathology reports only quantify lesions by individual rather than by element.

The lack of comparative data is a serious challenge within the field of animal palaeopathology. Without clear, consistent quantification methods, it is almost impossible to look at how different sites compare to one another. Analysis and interpretation of the Nescot sample would benefit from comparison with a wider range of sites within Roman Britain, particularly those which were not necessarily ritual in nature, in order to establish if the animals had indeed been treated differently. Using the limited available data, what can be said with certainty was that the prevalence of pathology was very similar to those seen from the ritual shaft at Springhead and the general overview conducted by Bellis (2020). However, as outlined above, neither of these data sets can be taken to represent a "normal" health profile for dogs in Roman Britain. The Springhead shaft, like the shaft at Nescot, is a ritual context. While the exact criteria for animals chosen for ritual deposition in Roman Britain are not known, it is likely some selection criteria were used, given what is known about religious practice in the rest of the empire. Likewise, the focus on relatively complete, articulated skeletons in Bellis's general review artificially selects for animals which were likely companion animals or ritual depositions.

While the sample from the Springhead settlement is likely to be more representative of the norm, as it includes both articulated and disarticulated animals from a non-ritual context, the small sample size creates problems and, thus, it must be used with caution. While numerous larger and more suitable assemblages of Romano-British dogs have been published, the lack of detail, both in terms of which specific lesions were present and the number of bones examined, renders them unusable as comparisons. In particular, a focus on reporting crude prevalence rates of lesions rather than true prevalence rates, means that the vast majority of published data cannot be compared with disarticulated assemblages, however well recorded. This issue has been highlighted before (see Thomas and Worley, 2019; Thomas and Mainland, 2005; Vann and Thomas, 2006; Vann, 2008), but until zooarchaeological standards are put in place that require the reporting of skeletal lesions by the bone affected (as a percentage of the number of those bones observed), larger scale research into the health and

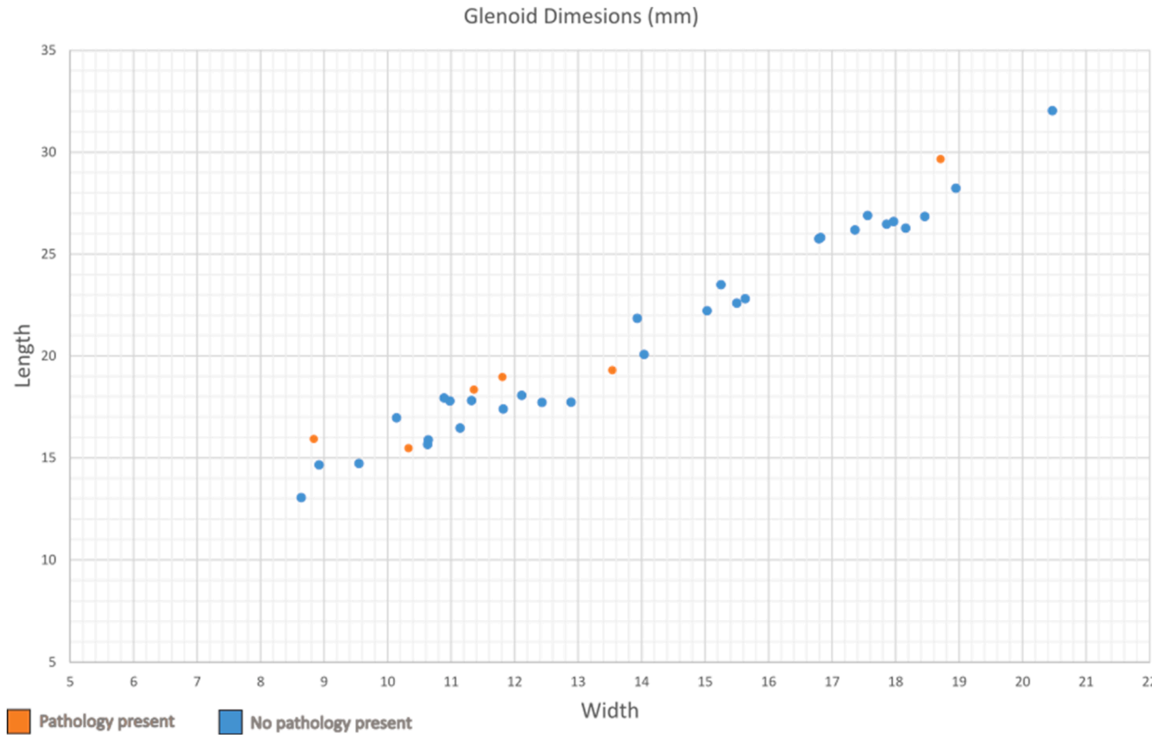

Fig. 12. Size of the glenoid fossa in the Nescot assemblage (n = 36 bones).

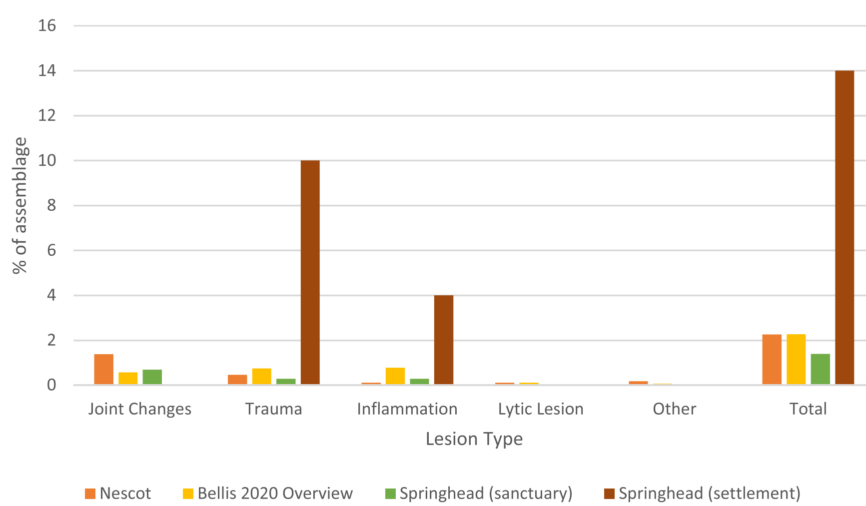

Fig. 13. Comparison of lesion prevalence rates at Nescot and in other Romano-British dogs.

treatment of dogs in Roman Britain (and beyond) will remain limited.

6. Conclusion

The low rates of skeletal pathology observed in the unusually large sample of dogs recovered from the Nescot shaft suggest a fairly healthy population. The majority of lesions can be correlated to activity and ageing, and traumatic and infectious/inflammatory lesions were rare. The lesions present indicate that the Nescot dogs may have been inbreeding to some degree. It should be noted that this may not have been intentional. There is evidence from Vindolanda, as well as elsewhere in the empire, that dogs were often turned out at night and left to their own devices, including procreation (Benett, 2012; Bennet and Timm, 2021), and it is probable that a similar practice occurred at Nescot. The Nescot dogs have similar health profiles to those from Bellis's (2020) earlier review of dogs from Roman Britain, as well as to those from the Springhead shaft, and much lower rates of pathology than those from the Springhead settlement. This implies, to some extent, that the dogs from Nescot were cared for. The Nescot shaft, while providing a health profile for one of the largest assemblage of dogs ever found in Roman Britain, also serves to highlight the importance of consistent quantification methods within zooarchaeological recording. Despite the fact that dogs are found on the majority of Romano-British sites, very little can be said about the Nescot assemblage in terms of how it fits into the larger picture of the province because of the absence of adequate comparative data. This problem is not limited to the dogs of Roman Britain however, and the standardisation of pathological recording and reporting in zooarchaeology can only serve to strengthen the field as a whole.

CRediT authorship contribution statement

Ellen Green: Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation.

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