An investigation of red fox (*Vulpes vulpes*) and Eurasian badger (*Meles meles*) scavenging, scattering and removal of deer remains: forensic implications and applications

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ABSTRACT

Within Northwest Europe, especially the U.K., the red fox (Vulpes vulpes) and the Eurasian Badger (Meles meles) are the largest wild scavengers capable of modifying a set of remains through scavenging. Knowledge of region-specific and species-typical scavenging behaviors of scavengers within the crime scene area and surroundings can aid in more efficient and accurate interpretations. The scavenging behavior of captive and wild foxes and badgers were recorded and compared through actualistic methods and direct observation. The scavenging by wild foxes and badgers of surface deposited baits and whole deer (Cervus nippon; Capreolus capreolus) in a woodland was observed and analyzed. Wild foxes were found to scavenge deer more frequently than badgers. The scavenging of deer remains by foxes was also compared to forensic case studies. The scavenging pattern and recovery distances of deer and human remains scavenged by foxes were similar but were potentially affected by the condition and deposition of a body, and presence of clothing.

Keywords: forensic science, forensic archaeology, taphonomy, scavenging, forensic anthropology, ecology

In 2011, there were 1,271 reported cases of missing persons in the U. K. and of those 267 resulted in fatalities. A total of 51.69% occurred in rural or peri-urban locations thus potentially exposing such human remains to wild scavengers which can greatly modify remains (1). Within cases of surface deposition of human remains, vertebrate scavenging can modify, remove and scatter soft tissue and skeletal elements, as well as obscure sites of trauma on soft tissue and bone. Scavenging is defined in this paper as an animal using their dentition to tear, remove, masticate, or break down soft tissue and bone. Knowledge of the region-specific and species-typical scavenging behaviors of those scavenger species within the crime scene area/surroundings can aid in more efficient and accurate interpretations of the crime scene. Likewise, a consideration of scavengers and their scavenging behaviors will enable a more effective strategy for the search and recovery of any missing skeletal elements that have been scavenged, disarticulated and scattered by scavengers. Maximizing the recovery of the human remains will contribute towards calculating the number of individuals, the identification of the deceased, the assessment of trauma, establishing manner of death, post-mortem interval (PMI), the interpretation of the deposition site, and any third party involvement.

Within Northwest Europe and specifically within Britain, the red fox (*Vulpes vulpes*) and the Eurasian Badger (*Meles meles*), henceforth referred to as fox and badger within this paper, are the most common wild scavengers which have the potential to rapidly modify and disperse a set of remains through scavenging and disarticulation. Avian scavengers, such as carrion crow (*Corvus corone*) and buzzard (*Buteo buteo*), are also common scavengers in this region (see submitted Young *et al.*). However, they disperse remains to a lesser extent than foxes and badgers, as well as produce a different pattern of modification through scavenging (see submitted Young *et al.*). Foxes and badgers are facultative, generalist, scavengers that are widespread in Northwest Europe and exist in the same woodland environments where they sometimes co-habit in badger setts (2-6). Research exploring the scavenging of human remains by the fox has so far been limited, despite an estimated population of 240,000 adult foxes and the addition of 425,000 cubs per year in Britain alone (7). Similarly, despite an estimated population of 300,000 badgers in Britain, as well as numerous ecological studies conducted on their diet and their social living system, published research investigating the scavenging of human remains by badgers is rare (5-12). Moreover, the issue as to the frequency and extent of badger scavenging of human remains is a highly contested topic. Accounts of fox and badger scavenging and their effects on human remains are frequently discussed amongst forensic professionals but these interpretations of scavenging are frequently based on anecdotal evidence. Thus, police officers and forensic professionals, and in particular forensic anthropologists, are often asking: What level of scavenging of surface deposited human remains should be expected by foxes and badgers? When do foxes and badgers scavenge (e.g. weather; degree of decomposition; time of day)? What body areas are scavenged primarily and to what extent? What skeletal elements are likely to be missing or recovered once scavenged? Where and how far to search for scavenged and scattered remains?

The aims of this paper are to describe the species-typical scavenging behaviors of foxes and badgers and to determine: 1) how foxes and badgers modify surface deposited remains/bodies; 2) how and when foxes and badgers scavenge, scatter and remove soft tissue and skeletal elements; 3) what skeletal elements are scavenged, scattered and removed by foxes and badgers; as well as which elements are scattered. This was achieved through experimentation and observations of both captive and wild foxes and badgers, as well as through the collation of forensic cases involving scavenging.

Materials and Methods

For this study, a total of 258 food items including fresh and dry pig bones (*Sus scrofa*) and fresh soft tissue were presented to seven captive foxes and three captive badgers whose subsequent scavenging behaviors were observed and recorded. The scavenging behaviors of wild foxes and wild badgers were also recorded in field experiments involving the deposition of six deer legs as baits, followed by the individual deposition of five whole deer over a period of 216 days. Wild badgers were observed at or near a set of remains in a total of 12 video recordings whereas wild foxes were recorded 435 times by infrared motion detection cameras.

Five fresh deer carcasses (*Cervus nippon*; *Capreolus capreolus*), received as part of a surplus of a culling operation unrelated to the research which aims to manage wild deer populations in a humane manner, were deposited on the ground surface of the site. Each deer died as the result of a gunshot wound (.308-calibre) on the right side of the trunk and when deposited as fresh for this study the wound was left exposed. Gunshot wounds ranged from about 30 mm to 50 mm in diameter at the entry site in the soft tissue.

Deer were chosen as human proxies for this research because human cadavers are not available for scavenging studies within the U.K. due to ethical, planning, and legislative restrictions (13-14). If human cadavers were available to taphonomic research, such as scavenging, there would still be limitations in recreating crime scene scenarios involving victims of different ages and health because the majority of donated cadavers are elderly, frail, and embalmed (15). In both North America and the U.K., animal analogues are commonly used in forensic studies to recreate and analyze crime scene scenarios due to the lack of access to human cadavers (16-22). Pigs are often used as animal analogues in forensic research (18-19) because of similarities in the skin and fat qualities of pigs and humans. However, in the U.K. the surface deposition of pigs is restricted by the Department for Environment, Food and Rural Affairs (DEFRA) because it poses a threat to domestic stalk and wildlife (23). Unlike pigs, deer can be surface deposited in the U.K. because as wildlife they do not pose a threat in the spread of disease to domestic livestock, thus allowing forensic research of crime scenes involving surface depositions. Since the focus of this research is the scavenging, disarticulation and scattering of surface deposited remains with an emphasis on damage and transportation of skeletal elements by scavengers rather than the analysis of soft tissue loss, decomposition chemistry, or microbial activity, deer were chosen as human proxies.

Behavior of captive foxes and badgers

The scavenging behaviors of captive foxes and badgers were observed and recorded on a Panasonic SDR-S50EB-H digital camcorder from November 2010 to February 2012. In total, seven foxes were observed at the Wildwood Trust, Kent, U.K., and at the New Forest Wildlife Park, Ashurst, U.K. The Wildwood Trust allowed direct observations of captive foxes. The fox enclosure housed five foxes, aged from 3 – 10 years. The fenced enclosure had a natural woodland ground surface with some vegetation, trees, and tree stumps, as well as various shelters for the foxes that face towards the public path for viewing. The fenced enclosure at the New Forest Wildlife Park housed two foxes (age range of 2-3 years) in an area containing various wooden shelters and sand pits. The enclosures at both sites allowed the researcher to have unrestricted views of the foxes at all times. The foxes were fed a variety of foods that include mice, chicks, rats, pigeons, fish, chicken, and dog food (wet and dry).

The badger enclosure at the Wildwood Trust housed three badgers with ages ranging from 6 months to 13.5 years. The enclosure consists of an indoor viewing area which is part of a larger underground sett that connects to the outer area of the enclosure which is fenced. Badgers could be directly viewed in the outer and inner enclosure except for inside sett tunnels. Due to the crepuscular behaviors of badgers, some of the badgers within the enclosure did not become active until the early hours of the morning, during which food items were removed and taken down into setts as identified by keepers. The badgers were fed on a diet of dog food (wet and dry), chicks, and rabbits. For this study, foxes and badgers were provided with fresh domestic pig bones (varied skeletal elements) obtained from a butcher and dry roast ham bones (femora about 12 in in length) in addition to their regular diet. All food items presented to captive and wild scavengers were between 15 g to

59 kg and split into seven weight categories. Captive scavengers were presented with items assigned to either category 1 (15 g ≥ or < 45 g), 2 (45 g ≥ or ≤ 80 g), 3 (250 g ≥ or < 600 g) or 4 (600 g ≥ or ≤ 1 kg). Items weighing between 600 g to 1 kg were provided as two per scavenger and items weighing 15 g to 600 g were provided three to four per scavenger present.

Behavior of wild foxes and badgers

The scavenging behaviors of wild foxes and badgers were observed and recorded on a weekly basis at Bovington, Dorset, U. K. from November 2010 to July 2011 (Figure 1). The site at Bovington was about 450 m x 550 m of a typical British woodland environment including a temperate mixed forest of spruces (*Picea* spp.), pines (*Pinus* spp.), oaks (*Quercus* spp.) and birch (*Betula* spp.). Ground cover includes a mix of greater tussock sedge (*Carex paniculata*), bramble (*Rubis fruticosus*), and bracken (*Pteridium aquilinum*). Wild scavengers received food items, baits or whole deer, labelled as either category 5 (1 kg ≤ or ≥ 7 kg), 6 (23 kg ≤ or ≥ 35 kg), or 7 (59 kg). Wild animals' scavenging behaviors within the experiment site were observed and recorded with a single SPYPOINT IR-7 infrared camera secured to a tree overlooking deposited remains. The cameras were setup at a height of 55 cm above the ground surface and were able to detect and record motion at a vertical angle of 30˚ and up to 50 ft away. The cameras were set to remain active over all hours and were set to record 30 seconds long video clips when motion was detected. The delay between each detection of motion was set to the minimum setting of one minute. Baits were accompanied with a single motion detection infrared camera secured to a tree overlooking each bait. In contrast to the baits, two motion detection infrared cameras were fastened separately to two trees facing each deer (1 m from the hind end and the head) so that any animal activity occurring from either end of the deer could be observed and recorded as it occurred.

Prior to the deposition of complete deer carcasses for this study, a small pilot study was conducted using deer legs as baits (category 5) in order to assess the presence of wildlife. Deposited baits and deer were neither covered nor fenced in any way, this was to allow full access and exposure to the environment, weather conditions, insects and vertebrate scavengers. All six baits had their hides and hooves intact. Following the removal of all baits from the site by scavengers, Deer 1-5 were then surface deposited within the site at different times over a total period of 210 days (Table 1; Figure 1). Deer 1 was deposited in December and remained on site until the final day of the experiments (Table 1; Figure 1). Deer 2 and 3 were deposited on the same day in February and were placed c. 100 m apart. Following the removal and scavenging of Deer 2 and 3 by scavengers, Deer 4 and 5 were deposited on the same day in March and were placed c. 135 m apart (Table 1; Figure 1).

During weekly site visits, the rate of decomposition and level of scavenging for each bait and deer were observed, described, and recorded. The identification of different stages of decomposition was based on Galloway *et al*.'s (24) description of four stages of decomposition of a body. Photographs were also taken of any skeletal finds or evidence of scavengers (e.g. fur, scat, paw prints). Daily temperatures and monthly total rainfall measures over the length of the experiment were obtained from the Meteorological Office's Hurn, U.K., weather station (25). Recordings from the motion detection cameras were also retrieved at every visit and analyzed off-site for the presence of scavengers, weather, time of day, areas on a bait or deer targeted by scavengers, and scavenger behaviors at or near deposit sites. When it was evident that a carcass had been scavenged, disarticulated or scattered, a site search was conducted over an area of about 150 m^2 that included the deposit site. Site searches pertaining to Baits 1-6 included one searcher whilst searches for Deer 1-5 involved three additional searchers, all with osteological experience, walking through the area using a link method search, similar to the police search method of winthropping, which relies on adjusting your direction based on the identification of cues or reference points that will lead to the recovery of finds (26). In this study the link method involved identifying signs of drag marks in the soil, scattered or clumped fur, animal scat, depressed vegetation, thick vegetation, disturbed soil for caches, and setts.

Upon the discovery of a find, photographic and location recordings were taken. The locations of finds, such as fur, soft tissue and bones, and the movement of a whole carcass from its primary deposit site by scavengers, were recorded using a Leica FlexLine TS06 total station and mapped using ESRI *ArcGIS* 10. Scavenged bones were left where they were found to allow for the recording of further scavenging and movement of that skeletal element by scavengers. However, if the left and right bones of a skeletal element were located, then the disarticulated and most heavily chewed bone of that element was collected by the researcher to ensure a sample of scavenged bone was available for future analysis on bite marks. The total recovery rate of skeletal elements per deer was recorded, as well as the overall recovery rates of skeletal elements for all deposited deer.

Statistical Methods

All statistical analyses were completed using PASW Statistics version 18. Separate chi-square tests were used to compare captive badger and fox scavenging, wild badger and fox scavenging, and wild fox scavenging versus different stages of decomposition. Full factorial multinomial logistic regression was performed twice: first, to analyze the relationship between the weight of deer, a deer's stage of decomposition, outside temperature, the time of exposure of a deer, and whether a wild fox scavenged or did not scavenge a deer; and second, to analyze the relationship between the same variables and whether a wild fox tried to remove or did not try to remove a deer from its deposit site. Binary logistic regression was employed separately to analyze the relationship between the condition (e.g. dry or fresh) of food, the weight of a food item, and whether a captive badger scavenged or did not scavenge, or tried to move or not move an item. Binary logistic regression was also used to analyze the relationship between the condition (e.g. dry or fresh) of food, the weight of a food item, and whether a captive fox scavenged or did not scavenge; moved or did not move; and cached or did not cache an item.

Recovery rates for the total of five deer were calculated individually as 20 categories of skeletal elements. All rates are presented as a percentage of each recovered category or body area per individual deer regardless if recovered as either fragmented or whole. A Kruskal-Wallis test was used to compare the distribution of recovery distances of scattered remains of each deer. Following the Kruskal-Wallis test, *post hoc* Mann-Whitney tests were conducted to further compare the recovery distances of scattered elements from each deer. A Bonferroni correction (0.05/4=.0125 level of significance) was used to avoid inflating the Type I error caused by the use of four Mann-Whitney tests.

Forensic Case Studies

In addition to the experiments with deer, five forensic case studies are presented which included the involvement (recovery, examination) of a forensic anthropologist. These have been anonymized here due to confidentiality issues. There were no signs of burning or dismemberment of the body in any of these cases. The cases are surface depositions of adult human remains from recent years in Britain and represent a number of different scenarios in environments typically inhabited by foxes and badgers. These cases showed a pattern of scavenging and scatter which is later discussed in the paper. Distances of recovery of scavenged and scattered remains are provided, along with the total recovery rate of skeletal elements per case.

Results

Behavior of captive foxes and badgers

The most common behaviors displayed by the observed captive foxes included the following: investigating (e.g. sniff or lick) food (11.93%, *n*=34), picking up food items (29.82%, *n*=85) either for scavenging or caching, scavenging (21.05%, *n*=60), and caching items (17.20%, *n*=49). To a lesser extent, captive foxes were also observed to search the ground surface of the enclosure (7.02%, *n*=20) and to pick up but not move items from the deposition site (5.61%, *n*=16).

Prior to any scavenging, foxes were observed investigating (e.g. sniff or lick) food items without making any bites, which sometimes lead to the item being picked up and moved by an individual fox to a different location from where it was initially deposited and then placed into a shallow hole dug (c. 12 cm depth) in the soil (referred to as a cache). Weight (p=.07) and the state of the food (dry or fresh) (p=.59) did not have a significant effect on whether a fox did or did not cache an item (R^2=.02, $x^2(2)$ = 3.85, p=.15). Likewise, weight (p=.09) and the state of the food (dry or fresh) (p=.13) did not significantly affect whether a fox moved or did not move food (R^2=.03, $x^2(2)$ = 5.90, p=.05). Foxes were recorded placing one or more food items into a single cache which was then covered in soil shovelled by the fox's nose and often concealed by loose twigs or leaves. Foxes were observed to scent mark some caches. When a fox uncovered a cache dug by another fox, including those which were scent marked, no signs of aggression between foxes were recorded. Instead, displays of aggression were only observed between foxes when items from categories 1-2 (15 g - 600 g) were present on the ground surface and yet to be scavenged or removed by a fox from its deposit site. When food was deposited into enclosures, foxes were observed to scavenge 44.7% of the time. The condition of a food item (fresh or dry) when deposited into the foxes' enclosure did not make a significant impact as to whether a fox scavenged the item or not (p=1.00). However, the weight (p=.03) of the item deposited did have a significant effect as to whether a fox scavenged the item or not (R^2=.10, $x^2(2)$ = 14.48, p=.001).

Captive badgers were observed to scavenge 87.8% of the time when food was present within the badgers' enclosure. Unlike foxes, there were no observations of captive badgers caching food items, displaying aggression (when food was present), or scent marking food items. Badgers scavenged food at deposit sites (41.84%, *n*=141) more frequently than moving items to be scavenged away from deposit sites (3.86%, *n*=13). Weight (*p*=.58) and the state of the food (dry or fresh) (*p*=1.00) did not have a significant effect on whether a badger moved or did not move an item (R^2=.25, $x^2(2) = 7.71$, *p*= .02). However, the state of the food (*p*=.01) did significantly affect whether a badger scavenged or did not scavenge, such that the fresher the item the less likely a badger would scavenge. The weight (*p*=.23) of the food item did not significantly affect badger scavenging (R^2=.10, $x^2(1) = 7.06$, *p*=.01). Badgers were significantly more likely to scavenge food items when deposited into enclosures than foxes (x^2 (1) = 42.66, *p*< .001).

Behavior of wild foxes and badgers

Wild badgers were not observed to scavenge any of the surface deposited deer or baits, whereas wild foxes were observed to scavenge both baits and deer. Badgers were only recorded at night walking past or slowly approaching and investigating deer weighing 23 kg-35 kg (category 6), as well as searching (e.g. sniffing with nose lowered and light digging) the ground surface near the deer deposit site both when deer were in an early decomposition stage and skeletonized. Badgers were also recorded clearing and taking bedding to sett entrances. There were no recordings of wild badgers making any bites to the remains. Badgers and foxes were not observed in any recordings simultaneously at or near a bait or deer but were recorded at different times using the same paths through the site.

Fox behaviors recorded at bait sites were not included in statistical analyses as the cameras captured animal activity at only three baits and were thus repositioned for the deer. Wild foxes were recorded scavenging deer in 76.6% of all video recordings. Foxes were not observed present near or at deer until the remains had been exposed for an average length of 11.2 days. Certain behaviors that were observed with captive foxes were not directly observed with wild foxes, such as caching, taking items down setts and dens, or scavenging that occurred away from the deposit sites where cameras had been setup overlooking the deposited remains and sites. Prior to scavenging a bait or deer, individual foxes were observed walking past and approaching deposit sites multiple times, followed by investigating the remains. The behaviors recorded most frequently of wild foxes included the following: investigating (8.03%, *n*=62), walking past sites (7.77%, *n*=60), approaching remains (4.92%, *n*=38), and scavenging (45.85%, *n*=354), as well as failed and successful attempts to remove or drag deer. The investigation of remains either involved just the sniffing or licking of remains but would often include a quick bite and release, as well as jumping back (e.g. cautious) from deer prior to scavenging. Foxes most frequently approached and investigated the hind end and hind legs of deer first. Individual foxes were also recorded attempting to remove whole baits and deer carcasses from deposit sites prior to scavenging and, if successful, the fox would drag the bait or deer from the deposit site (Figure 2). Removal or attempts to remove deer by foxes occurred on average after a time of exposure of 20.4 days (Table 1). Individual foxes were capable of removing a whole deer weighing 24 kg (c. 1.5 m length) from a deposit site, which is similar to the average weight of an 8 – 10 years old child, but could not remove a whole deer weighing 59 kg (c. 2 m length), similar to the average weight of an adult human female of 5’3” – 5’5” height. The most common area on deer at which foxes tried to bite and drag the deer from the deposit site were the hind legs (66.67%), both as fresh and skeletonized. Weight (p<.001), the time of exposure (p<.001), and stage of decomposition (p<.001) of the deer did have a significant effect as to whether a fox did or did not try to remove a whole deer. As the weight of the deer, the length of exposure, and stage of decomposition increased, foxes were less likely to remove deer from deposit sites. However, temperature did not have a significant effect (p=.61) (R^2=.10, $x^2(6)$=43.16, p<.001). If a fox was unable to remove the whole bait or deer from the site then scavenging would commence at the deposit site until a fox was able to remove remains.

There were no recordings of more than one fox scavenging a carcass or bait at a single time for any category of remains. If an additional fox was present near the same carcass or bait the number did not exceed two. When two foxes were present, one fox would be scavenging and removing soft tissue from the carcass whilst the other fox sat or lay down watching the other fox scavenge. Once the previously scavenging fox left the carcass, the stationary fox would then slowly approach the deer, investigate, and begin scavenging. Displays of aggression between foxes were only observed in a single scavenging event between two foxes. The onset of scavenging of each whole deer by foxes had an average length of 18 days until scavenging commenced (Table 1). Scavenging by foxes was observed more frequently after sunset (96.58%, *n*=311) but was also seen during the day (3.42%, *n*=11).

The thoracic cavity was observed to be the area of deer most often scavenged (74.55%, *n*=246), however, it is important to note that a large proportion of recordings of scavenging in this area was with Deer 1, which was the only deer scavenged by an unaccompanied dog that randomly appeared within the site. The dog was recorded scavenging and opening the thoracic cavity of that deer before any scavenging by foxes. For all other deer, foxes scavenged more often from the hind legs and hind end (70.21%, *n*=33).

Scavenging by foxes was observed during all stages of decomposition except for extreme decomposition as no deer reached that stage (Table 2). Foxes were more likely to scavenge deer that were in an early stage of decomposition (86.69%; Table 2) than later stages ($x^2(3) = 17.94$, $p<.001$) and without insect activity. Whether or not a fox scavenged from a deer was significantly affected by the time of exposure (p=.03) and stage of decomposition (p=.02) of the deer but was not by the weight of the deer (p=.99) or the outside temperature, such that as length of exposure and the stage of decomposition increased foxes were less likely to scavenge (p=.22) (R^2=.06, $x^2(6)$=23.03, p=.001). Seasonal temperatures did affect the rate of decomposition of deer and the presence of insect activity which in turn affected fox scavenging. Nonetheless, foxes were recorded scavenging throughout all seasons but in varying frequencies (Figures 3-5). Foxes were also recorded re-scavenging and re-scattering deer remains that had already been scavenged, disarticulated and scattered by previous foxes (Figures 3-5,9).

Scattering and Dispersal of Scavenged Surface Remains

The scatter pattern of scavenged and disarticulated deer remains led 80% of the time towards either areas of high and thick vegetation, a dense collection of fallen trees, or sett entrances (Figure 6). Scavenged and scattered remains were primarily recovered within a 45 m radius. The maximum distance of recovery of a skeletal element, a metacarpal with phalanges articulated, was 103.54 m (Deer 1) from a primary deposit site and the maximum distance of scattered fur was 41.98 m (Deer 3) (Figure 6-8). The mean distance of recovery for scattered bone was 18.13 m (SD = 15.51) from the deposit site and for fur, 10.00 m (SD = 7.47) (Figure 8).

The distribution of distances of recovered scattered skeletal elements for Deer 1-5 were significantly different ($H(4) = 25.07$, $p < .001$). Deer 1's distribution of distances was significantly different to Deer 2 ($U = 24$, $r = -.67$) and Deer 3 ($U = 50$, $r = -.40$), however, it was not significantly different to Deer 4 ($U = 444$, $r = -.04$) and Deer 5 ($U = 470$, $r = -.09$). These findings support results within this experiment, that Deer 2 and 3, deposited at the same time, were not affected by extreme weather temperatures like Deer 1, 4 and 5, nor were they scavenged by a large sized canid (e.g. dog) like Deer 1.

Overall the five deer deposited within the field site, ribs were recovered in 100% of searches, as whole and fragmented (Table 3). Other commonly recovered elements, including uncovered caches, were innominates in 70% of searches, as well as the cranium and vertebrae in 60% (Table 3). Front (not including scapulae) and hind limbs (not including innominates) were both recovered in 40% of searches, however, the individual skeletal elements of the hind limbs were found more often than those of the front limbs (Table 3). Deer 4 (81.82%) and Deer 1 (63.64%) had the highest recovery rate of categories of skeletal elements. The recovery rates for Deer 2 and Deer 5 were 21.21% and 30.30%, both of which deer had the longest PMI of all deer prior to the onset of a fox scavenging. Deer 3, which was successfully removed as whole by a single fox from the deposit site and was fully scavenged and disarticulated within a 24 hours period, had the lowest recovery rate of just

3.03% and primarily consisted of small rib fragments (2 cm - 5 cm) (Figure 2,4). Deer 1, 4 and 5's recovery rates were higher than those of Deer 2 and 3, possibly due to the effects of extreme temperatures associated with either decelerated decomposition and insect activity or increased insect activity and rates of decomposition, as well as the effect of dog scavenging on fox scavenging behaviors.

Forensic Case Studies

The provided cases represent types of scavenging activities observed at crime scenes involving scavenging within the U.K. in environments where foxes and badgers are the largest wild scavengers (Table 4). It is necessary to be aware that crime scenes do vary and will be influenced by different factors. Within the provided cases foxes were interpreted as the scavenger capable of causing the most modification and scattering of a body. Scavenging by foxes was interpreted based on the type of crime scene environment, damage (e.g. bite marks) to bone surfaces, and scattering patterns of skeletal elements.

Discussion

The observations, comparisons and analyses of badger and fox scavenging behaviour and patterns towards deer remains, as well as comparison of wild and captive scavengers' behaviour, provides insight into the modification and transportation of human remains by the red fox and Eurasian badger. The application of these results to the scavenging of human remains aids forensic investigations in the more accurate interpretations of deposition environments, condition of remains, and time of exposure. Additionally, the search and recovery of scavenged and scattered deer remains has identified key reference points at which scavenged deer and human skeletal elements can be recovered, as well as the condition and types of elements that investigators are likely to recover.

Foxes are more likely to scavenge surface deposited human remains than badgers in a rural or peri-urban environment within Britain. Scavenging by foxes is most frequent during colder seasons for a variety of reasons such as low trophic resources, delayed rate of decomposition of remains, and decreased insect activity. Foxes avoid scavenging remains whilst there is increased activity or will concentrate scavenging from areas on a body where there is less insect activity. Once insect activity has decreased and remains have begun to dry, foxes will scavenge at a faster rate.

The scavenging and scattering of deer and human remains is similar but can differ due to the presence of clothing, footwear, the condition and positioning of a body which can restrict scavenging, as well as the manner of death which may attract or deter scavenging and/or insect activity. Scavenging by foxes for both deer and human remains is initially focused at the extremities and less likely at the site of trauma (e.g. gunshot wound). Foxes' scavenging behaviour towards deer remains indicated that a fox will first try to remove a whole carcass via the extremities from the deposit site. If a fox is unable to remove the remains then it will proceed to scavenge and disarticulate remains at the deposit site so that smaller elements can be transported. Foxes will scavenge, scatter, and remove deer and human remains from a deposit site but, most notably, will re-scavenge and re-scatter remains from original and new deposit sites, as well as from previous caches (Figure 2). The majority of scavenged and scattered elements for deer and human remains were recovered within an 18 m – 45 m radius.

Badgers versus foxes

Although wild badgers were not observed scavenging any deer remains, observations of captive badgers did show that badgers do scavenge both fresh remains with soft tissue and dry skeletal remains, as well as take items down into setts. Captive badgers were found to scavenge more frequently than both wild badgers and captive foxes. The inclusion of captive badgers within this study allowed for normally crepuscular activities of badgers to be observed. Captive foxes were observed to scavenge food less frequently than wild foxes due to a stable diet of provided food. However, studying captive foxes allowed for fox scavenging activities that occur away from deposit sites, such as caching and further scavenging, to be recorded. Both captive and wild foxes tried to remove food items or baits and deer prior to any scavenging.

The diet of wild badgers relies primarily on invertebrates such as earthworms (*L. terrestris*) and beetles (6,12,10). When earthworm density in a badger's territory is low it will need to seek alternative resources to meet its metabolic needs (8,27-29). Within this study, the lack of any observations of wild badgers scavenging from the deer carcasses and the recordings of badgers digging the ground surface suggest that the badgers' main prey met their metabolic needs. Badgers enter a state of torpor or semi-hibernation during winter and are most active from spring to fall, whereas foxes are active year-round (3,30-32). Likewise, scavenging activity can be increased due to imminent breeding seasons and semi-hibernation which will require higher metabolic needs (33-39).

The diets and environments of badgers and foxes are known to overlap but the main diet of foxes relies more on small mammals and birds (28,38,40-42). Foxes, like badgers, can also seek alternative food sources when their main sources are low (6,8,27-28,43-44). Foxes were recorded in this study scavenging baits and deer during all seasons that remains were deposited but badgers were not observed scavenging any remains. There were also no observations of badgers and foxes acting aggressively towards each other at or near remains despite both species recorded using the same paths at different times. The experiment site may have provided enough trophic resources that there was no competition between these species over access to baits or deer. Alternatively, it may be a reflection of a low badger or fox population density.

Scavenging behaviour and pattern of the red fox

The pattern of scavenging and utilization of a deer carcass by foxes in this study differs to that of dogs, coyotes and wolves. Foxes are solitary scavengers, whereas, wild dogs, coyotes and wolves hunt and scavenge in packs (35-36,44-46). The larger body size, jaw strength and pack advantages to hunting, enable these larger canids to hunt larger sized carcasses (47-52). Within this study on deer carcasses, foxes were observed scavenging from all accessible areas of a carcass at various stages but was concentrated first on the extremities and/or areas of a carcass that were still within the early stages of decomposition and not at the head, neck or site of trauma. A red fox's species-typical scavenging pattern is as follows: after multiple visits and investigations to the carcass, the fox will slowly approach the point of the body that is farthest from the head where there is the risk of a bite, in this study this point was the hind end or hind legs of deer. The fox will then proceed to make non-invasive bites to the remains, which has the potential to cause damage to the surface of the skin. A fox will then try to transport the remains from its deposit site for further scavenging and disarticulation of remains where there is less of a chance of inter- or intra-species aggression and competition for a food source. In contrast, larger canids (e.g. coyotes and wolves) focus on scavenging remains where they are deposited (22,46,53). The sequence of scavenging for foxes then continues from the hind to front limbs, followed by the thorax which includes the scavenging, disarticulation and scatter of vertebrae, ribs, sternum, and scapulae. The final stage of fox scavenging cannot be generally described as total disarticulation but instead partial to complete disarticulation followed by the re-scavenging and re-scattering of skeletal elements (Figure 9). This pattern of fox scavenging differs to Willey and Snyder's (22) study on the scavenging of deer by captive timber wolves (*Canis lupus*) in North America in which wolves concentrated first at a site of trauma, if present, and tore soft tissue from the face and neck, followed by scavenging concentrated at the thoracic cavity.

In environments where the red fox is not the largest canid scavenger their access to remains can be restricted by the presence of larger canids, such as dogs, coyotes and wolves, which gain access to a set of remains before smaller sized scavengers and show aggressive territoriality over remains (34,43,46,53-55). The presence of such larger sized canids has the potential to affect the scavenging behaviors of foxes and the areas on a carcass that are modified by foxes. As observed in this study, foxes avoided approaching, investigating and scavenging from deer when a dog was present at the deer deposit site or scavenging. Scavenging by larger canids may both expose areas of soft tissue that may otherwise be inaccessible by foxes (e.g. restrictive clothing) or scavenge and consume areas of a body usually scavenged and removed by foxes from the deposit site. If based on the North American studies of larger canid scavenging patterns of human remains, the most commonly recovered skeletal elements are vertebrae, skull, pelvic girdle, and femora when there is scavenging by larger canids (56). Thus, damage by foxes in such environments would be expected to be restricted mostly to these elements. However, this study has shown that in an environment where the fox is the most common canid scavenger, fox scavenging has a different pattern of deer carcass utilization involving a wider variety of skeletal elements than in environments where it is not the most common or largest scavenger.

Comparison of deer and human remains: red fox scavenging behaviour and pattern

Within this study, foxes were observed to more frequently scavenge a deer carcass either when it was fresh, at an early stage of decomposition with slight bloating but no maggot mass present, or when it was partially to fully skeletonized. Seasonal variations in temperatures can affect the rate of decomposition of a set of remains which, in turn, affects the frequency and type of scavenging by foxes, as well as which areas of a body are utilized. Foxes were observed to scavenge deer more frequently in colder temperatures (e.g. late fall to winter). Colder, freezing, temperatures can allow a carcass to remain fresher for a longer period of time and with limited insect activity (57) which presents foxes with a more desirable food source to scavenge and cache or consume. The effects of freezing may limit a fox’s ability to manipulate and remove a whole carcass from a deposit site, whereas warmer temperatures contributable to increased insect activity and decomposition rates delay and restrict fox scavenging until the departure of a maggot mass and the desiccation of soft tissue as observed in this study. If the pattern of decomposition of a set of remains is not uniform then a fox, unlike wolves (22), will scavenge from the areas where insect activity is limited or a maggot mass is not present. Moreover, the decomposition or breaking down of joints will also affect the sequence in which different areas of a body are disarticulated and removed by a scavenger.

In general, the most persistent joints of a human body which would be more difficult for a fox to disarticulate prior to advanced decomposition include joints that support more weight, such as the knee joint or the lumbar spine (58). In contrast, areas such as the cervical vertebrae and scapulae decompose at a faster rate and would thus be disarticulated at an earlier stage and with more ease than other persistent joints (58). Pasda's (59) study on the scavenging of reindeer (*Rangifer tarandus groenlandicus*) found a similar rate of decomposition for persistent joints but found that the cervical and thoracic vertebrae stayed articulated the longest. Additionally, the front legs of reindeer disarticulated at an earlier stage than hind legs.

Within this study, foxes were observed removing soft tissue primarily from the hind end or limbs of deer until it was possible for a fox to remove the deer from its deposit site. This pattern of scavenging of deer by foxes only differed for the one deer which was scavenged first by a dog that opened the thoracic cavity, thus providing foxes access to that area first. In contrast, the scavenging sequence observed in Haglund *et al*.'s (46) study on scavenging patterns in forensic cases in the Pacific Northwest saw a pattern beginning with the removal of soft tissue from the face and neck of a body, and then proceeding to the thorax, in a type of head to toe pattern of scavenging. Additionally, Haglund *et al*.'s (46) study on coyotes and dogs identified a model of five stages of canid scavenging on human remains starting with no bone involvement, followed by scavenging to the thorax and upper limbs, then the lower limbs thus leaving only the vertebral column articulated until, finally, total disarticulation. While scavenging by foxes in this study on deer was found to be more dynamic and occurred in a different order to that of larger canid scavengers both of deer and forensic cases (Figure 9).

The recovery of skeletal elements of deer scavenged by foxes are as follows in descending order of their recovery rates: ribs, pelvis (innominates), cranium and vertebrae, scapula, hind and front limbs at the same rate as the mandible, phalanges, and sternum with lowest recovery rate. Although the cranium and vertebrae had the same recovery rate, vertebrae were often recovered alongside scavenged ribs or limbs. Foxes were found to be capable of removing and fragmenting the majority of deer skulls, thus the cranium and mandible did not have the highest recovery rate. It is important to note that the morphology of a deer's skull differs from that of human and the presence of the elongated nasal bones of the deer allow it to be transported more easily than that of a human's skull. Despite the differences in skull morphology, the presence of soft tissue, a delay in the disarticulation of the mandible from the cranium, trauma to the skull and the presence of a downward slope could allow a fox to remove a human skull. Nonetheless, foxes were able to fragment the entire cranium of deer within this study and were able to transport skulls a short distance. It is during the scavenging and removal of the skull that the cervical vertebrae can be damaged and transported from the deposit site, especially if these bones are still articulated.

Interestingly, despite foxes first scavenging from the hind end or hind legs of the deer, the front and hind limbs were recovered at the same rate. This is contradictory to this study's forensic cases and Haglund *et al*.'s (44) findings of lower extremities from human cases being recovered more frequently than upper extremities and scapulae. The recovery rates of scavenged human remains in Haglund (56) suggest that the cranium and mandible should be the most recovered elements (80-100%) and then in descending order: vertebrae, pelvis and femur (60-90%), upper and lower extremities, the sternum and scapulae (40-59%) and finally, the hands and feet as the least recovered elements (20-39%).

Although foxes appeared to be more resilient in their total scavenging and modification of a deer carcass, the areas of a deer and a human body that show signs of scavenging, disarticulation and scattering are alike. For both deer and human remains, the extremities were scavenged and removed most frequently by foxes, because it was the farthest area of a body to access.

The scavenging of upper or lower extremities of a human body in the provided forensic cases was likely influenced by the presence of footwear and clothing. In some of the forensic cases reported, lower limbs were recovered still clothed and with feet contained in socks and/or shoes, which may have restricted access to the lower limbs more than the upper limbs. This is in contrast to Willey and Snyder's (22) study on wolf scavenging of deer which stated that deer hide was comparable to the presence of clothing on a body. Interestingly, the acetabulofemoral joint, although an area where there is increased weight on a body, deteriorates at a faster rate than other persistent joints due to the positioning of the femoral head (58). This would imply that this area would be easily disarticulated by foxes. However, the recovery rate of lower limbs within the provided forensic cases was high like in Haglund's study (56). Therefore, the presence of footwear and clothing appears to greatly influence the recovery rates of lower and upper extremities on a human body scavenged by foxes, whereas in the scavenging of deer, foxes were not restricted by the skin or fur of the deer. In the authors' experience, the weight, muscle mass, and position of the body (if prone or facing down, if crouched) will affect the scavenging, disarticulation, scattering and removal. Additionally, scavenging will be influenced if an individual has been wrapped in a blanket, contained in a bin liner, or even tied, thus causing only some areas, if any, of the body to be exposed and accessible to scavengers. There may also be scattered surface remains which may have resulted from a hanging where the feet and lower limbs will usually be more accessible than the upper limbs or head. The identification of scavenging and the areas of a body modified by scavengers, as well as those not scavenged, can contribute to interpretations of time of exposure, deposition sites, trauma, and the condition of remains.

Comparison of deer and human remains: red fox scattering pattern

The scatter pattern of fox scavenging within this study led towards areas of high vegetation, raised trees or fallen tree branches, or setts and dens. The majority of scatter patterns, both for the deer and human cases, were in a linear pattern extending from the deposit site towards these areas. Nonetheless, the scavenging patterns and average distance of recovery from deposit sites found in the forensic cases of this study are similar to those found in the experiments with deer (c. 18 m bone; c. 10 m fur). The removal of scavenged remains by foxes towards areas of high vegetation or collections of overturned tree trunks and branches that could provide a fox cover from other foxes and scavengers that would have been attracted to the deposit site where the scent of the deer was strongest.

When foxes and badgers are considered as scavengers within a rural or peri-urban environment, this study found that the key areas to search for scattered remains are dense trees or collections of fallen trees and branches, setts and dens, and animal paths. Nevertheless, there are a variety of factors that can affect the dispersal of scavenged remains and should be considered. For instance, the condition of remains and how they were deposited can limit dispersal distances, such as heavy textiles or an outdoor shed; the rate of decomposition of a set of remains; competition at the deposit site such as inter- or intra-species aggression causing a scavenger to take an item further from the site or a dominant scavenger obtaining the remains and taking them further than the previous scavenger; the distance of the deposit site to setts, dens, or areas of concealment favoured by foxes; topography (e.g. downward slope enabling easier transportation); bone destruction caused by scavengers ingesting bones; and the availability of a scavenger's main food source affecting whether that scavenger needs to seek alternative food sources, will all affect dispersal. Moreover, the re-scavenging, re-scattering, and re-caching of already scavenged remains, both soft tissue and dry bone, by foxes not only extends recovery distances but also highlights the necessity to conduct a search at a site more than once. Thus it is not possible to assign a maximum recovery distance for all scavenged remains as scatter distances will be affected differently in each forensic case but it is possible to target search areas when the environment and scavenger species are known. At scenes of scavenging, assessing the environment, condition of remains at deposition, scavenger species present in the area, and those scavengers' species-typical scavenging behaviors are factors that can aid in the more efficient and effective search and recovery of scavenged and scattered remains.

Foxes often co-habit active and inactive badger setts which provide not only a den but also an additional place to hoard food (3,5-6,59). Paths to setts and dens should be searched for any remains and/or personal effects that have fallen or become disarticulated through the dragging process by foxes or badgers to the setts or dens. Sett entrances should not only be searched for evidence that remains have been taken down but also for skeletal elements that badgers have pushed out of the setts' tunnels. Badgers regularly clear out their setts and bring in new bedding material, which is often a visible trail of dried vegetation leading into entrances. The clearing process by badgers produces a large soil heap directly outside of the sett entrance which has the potential to contain scavenged skeletal elements. The identification of soil drag marks, produced by the removal of remains by scavengers, and animal tracks can also aid in the recovery of remains and associated materials.

Wild foxes in this study were not observed caching but cached scavenged deer remains were recovered. However, captive foxes were recorded caching more frequently and at a faster rate when food items were of a smaller weight and consisted of either their preferred food or an item that required prolonged mastication, such as long bones. Caching allows foxes to hide disarticulated skeletal elements and/or soft tissue to ensure that metabolic needs are met at times when the availability of main prey is low (60-61). The observed caching by captive foxes in this study is in contrast to Caraeu *et al*.'s (61) perishability hypothesis on arctic fox (*Vulpes lagopus*) caching which suggested that food items that do not perish quickly will be cached more frequently than items that perish at a faster rate. Caraeu *et al*.'s (61) work with arctic foxes also identified short-term caches as a tool for temporarily hoarding food whilst going after another food source. Although this was not observed with the captive and wild foxes in the U. K., the use of short-term caches could allow a fox to fully remove, scavenge and disarticulate a full carcass in a shorter span of time without exceeding its energy constraint and avoiding inter- or intra-species competition, rather than scavenging and consuming the carcass where it was deposited.

Caches should also be searched as these may hide key skeletal elements for identifications and interpretations. Caches are more likely to be located through the use of a fingertip search method which allows closer inspection of the ground surface. Common locations, as was observed with captive foxes and the recovery of deer scavenged by wild foxes, for caches are at the base of trees, areas of thick vegetation, or at semi-permanent fixtures (e.g. fencing) within the scene.

Conclusion

In a rural or peri-urban environment, red foxes are more likely than Eurasian badgers to scavenge a set of remains. Badgers do scavenge but are less likely to scavenge in an environment rich in their main trophic resources. Foxes, being a solitary scavenger, will first attempt to remove a set of remains away from a deposit site to a more secluded area at which to scavenge or cache without threat of another scavenger. This study found that an individual fox is capable of removing a whole deer that is similar to the average weight of an 8 – 10 years old child, but cannot remove one that is similar to the average weight of an adult human female of 5'3" – 5'5" height. The scavenging patterns and recovery distances of deer remains were found to be similar to human remains scavenged by foxes. The scatter distances of deer and human remains scavenged by foxes were between 10 m – 45 m from the deposit site and led to areas of high or thick vegetation, dense tree cover or fallen trees, and setts co-habited by badgers and foxes. However, the presence of clothing and footwear on human remains appear to restrict areas on a body that a fox can successfully scavenge and disarticulate.

Scavenging of deer remains by foxes, although observed during the entire study, was more frequent in colder seasons and during the fresh and early stages of decomposition. The average length of exposure of deer until scavenging by foxes began was found to be 18 days. Foxes did not scavenge during advanced stages of decomposition or when insect activity was increased, unless other areas of the same deer were at an earlier stage of decomposition. The scavenging pattern of the foxes, in regards to deer remains, was found to differ to that of larger canids, such as the domestic dog, wolf, and coyote. Red fox-typical scavenging pattern is as follows: multiple visits and investigations with quick bites to remains; attempts to remove remains from the deposit site; and then the scavenging, disarticulation, caching and scatter of the extremities followed by the thoracic cavity including vertebrae and damage to the skull. Red fox scavenging does not end there but instead is characterised by the re-visiting, re-scavenging, and re-scattering of dry remains over an extended period of time.

Forensic cases involving scavenged, disarticulated and scattered surface deposited human remains can occur in a wide variety of scenarios or contexts which may influence or determine the areas of the human body to be scavenged and transported. Therefore, experimental studies like those for the present paper, which can test taphonomic factors, are extremely valuable in forensic investigation since it is not always possible to reconstruct or interpret the circumstances around death, deposition and post-mortem factors affecting the scattering of human remains in surface deposits. Likewise, skeletal elements may be missing and understanding which and how far these are transported by scavengers may assist in the search for those remaining skeletal elements. It is also not within the expertise of the forensic anthropologist or police to know exactly how and when scavenging by animals take place without these experimental studies on animal behavior. Direct observations and actualistic methods enable the use of species-typical, region- and environment-specific studies to better recreate and interpret the crime scene. The use of such studies not only aids in the reconstruction of the circumstances surrounding death and deposition but also assist in the more effective search and recovery of scattered human remains that are essential to interpretations and identifications.

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Tables

Table 1. Month and year of deposition for baits and each deer and the average temperature during the total number of days of exposure. The first and final occurrences of fox scavenging behaviors, based on video recordings, towards each bait and deer.

					First Fox Present	First Fox Investigation	First Fox Bite	First Fox Attempt to Drag	Final Fox Present	Final Fox Bite
Deer #	Weight (kg)	Deposit Month & Year	Total Exposure (Days)	Average Temperature (˚C)	Exposure (Days)	Exposure (Days)	Exposure (Days)	Exposure (Days)	Exposure (Days)	Exposure (Days)
Bait 1-6	6	December '10	6	2.57	2	2	2	2	6	5
1	59	December '10	210	9.51	2	2	3	10	106	106
2	24	February '11	44	7.17	16	16	27	32	32	31
3	24	February '11	8	8.10	7	7	7	7	32	7
4	23	March '11	103	12.58	17	20	20	20	57	46
5	34	March '11	103	12.58	14	14	33	33	88	88
Average	32.80		67.71		9.67	10.17	15.33	17.33	53.50	47.17
Minimum	6		6		2	2	2	2	6	5
Maximum	59		210		17	20	33	33	106	106

Table 2. The stages of decomposition at which fox scavenging of deer occurred. Stages of decomposition are based on Galloway *et al*. (24).

	Deer 1		Deer 2		Deer 3		Deer 4		Deer 5		Total	
Stages of Decomposition	%	n	%	n	%	n	%	n	%	n	%	n
1.Fresh	94.38	252	0.00	0	100	15	0.00	0	0.00	0	86.69	267
2. Early Decomposition (e.g. discolouration and bloating)	0.00	0	100.00	7	0.00	0	0.00	0	0.00	0	2.27	7
3. Advanced Decomposition (e.g. moist soft tissue decomposition; maggot activity; some bone exposure and mummification)	0.00	0	0.00	0	0.00	0	100.00	15	50.00	2	5.52	17
4. Skeletonization	5.62	15	0.00	0	0.00	0	0.00	0	50.00	2	5.52	17
5. Extreme decomposition	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0

Table 3. Overall recovery rates per category of skeletal element based on the presence of each category from Deer 1-5.

	Overall Recovery Rate
Skeletal Element	%
Sacrum	0
Sternum	20
Ulna	20
Radius	20
Humerus	30
Carpals	30
Metatarsal	30
Phalanges	35
Mandible	40
Lumbar Vertebrae	40
Metacarpal	40
Femur	40
Tibia/Fibula	40
Scapula	50
Tarsal	50
Skull	60
Cervical Vertebrae	60
Thoracic Vertebrae	60
Pelvis	70
Ribs	100

Table 4. Forensic case studies involving the scavenging of surface deposited adult human remains by foxes from different outdoor scenarios across Britain.

Case #	Cause of Death	Deposition Environment	Deposition of Body	Length of Exposure	Condition of Recovered Body	Scavenged Skeletal Elements	Scattered Skeletal Elements & Recovery Distances	Percentage of Recovered Elements; Missing Skeletal Elements
1	Unascertained	Wetland	Clothed; surface deposited lying on a prone position	Several years	Completely skeletonized; adipocere within the right sock; lower limbs were fully clothed, including shoes; a jacket covered some bones.	Axis, ends of ribs, right humerus, right scapula, a metacarpal, hand phalanges, left femur	All elements scattered within a 3m x 4m area: vertebrae, ribs, & some lower limb bones (in anatomical alignment); (under moss) right humerus, sacrum, left pelvis (innominate), femora, some ribs, left scapula & lumbar vertebrae; (underneath a jacket) manubrium, talus, vertebrae, ribs & clavicle. At c. 0.50 m West of the trunk was the right scapula; 1m southwest were the right humerus, right pelvis (innominate) & right femur; c. 2.5m North (near bramble) were a cervical vertebra and the disarticulated cranium & mandible.*	≤ 75%; hyoid, four cervical vertebrae, right clavicle, right ulna, left upper limb, left calcaneus, 13 foot phalanges, 5 teeth
2	Unascertained	Woodland near a public footpath	Clothed; surface deposited lying extended and supine	Several months to a year	Mostly skeletonized (some hair & nails present, slight soft tissue on some hand bones, the mandible & cranium; lower limb bones articulated; some vertebrae and finger bones articulated); upper limbs, torso & skull disarticulated. Lower limbs clothed within some trousers, belt, socks & the left shoe.	Sternal end of ribs; base of 1 proximal hand phalanx	Scattered <4m from the lower limbs were teeth, hand bones, ribs, some forearm bones & a small number of vertebrae (arm & shoulder bones found clothed c. 3m from the trousers). At 4m West of the trousers were 3 anatomically aligned vertebrae; 9m West were eight articulated vertebrae & some disarticulated ribs; 6 m southwest was the cranium.	> 75%; 1 rib, at least 1 tooth, 5 hand phalanges, the hyoid
3	Unascertained	Woodland	Unclothed; surface deposited lying face down (prone) with the right arm flexed across the chest and legs flexed.	Several years	Completely skeletonized with no presence of soft tissue.	Some ribs & vertebrae; the right tibia; possibly the left arm	The cranium, mandible, some ribs & vertebrae were disarticulated; some left hand bones recovered near the skull; the left pelvis (innominate) recovered 0.35m from the deposit site; the right tibia recovered 0.30m West of the deposit site. Lower limbs recovered in anatomical connection or alignment.	> 75%; 5 thoracic vertebrae, scapulae, left arm bones, 10 carpal bones, 6 hand phalanges, 5 tarsals, 2 metatarsals, 14 foot phalanges, the left & right 12th ribs
4	Hanging	Woodland	Clothed; Some remains hanging near ground surface and some located at the tree base.	Several months to a year	Completely skeletonized with no presence of soft tissue.	Clavicle; ribs; left scapula; left fibula; 5th left metatarsal	0.15m - 1.50m southeast of the tree were femora (partially clothed), innominates, and a number of thoracic & lumbar vertebrae; 0.35m East were several ribs; 1m to the East was the left scapula; 0.25m - 0.30m West was the cranium, mandible & 2 cervical vertebrae; 0.44m - 0.70m North was a clavicle, several ribs & some foot bones; 1.95m North was the right tibia; 2.23m North was the right fibula; 9.50m North was the left tibia & fibula.**	Between 50% - 75%; Sternum, 2 cervical vertebrae, 6 ribs, right scapula, bones of the right arm (except 1 metacarpal), bones of the left arm/hand, left patella, foot bones, part of the hyoid bone
5	Unascertained	Embankment in a rural setting near a motorway	Clothing for the upper body present; Surface deposited	Several years	Completely skeletonized with no presence of soft tissue.†	Right femur; left tibia; right tibia	All elements scattered; vertebrae and ribs found within clothing.	c. 75%; Mandible, 3 cervical vertebrae, 1 rib, bones of the left & right upper limbs, patellae, fibulae, all the foot bones

*Two proximal hand phalanges, right radius, a metacarpal & the axis found near bramble during a search at a later date.

** Lower limbs recovered 3m from the tree during an additional search.

†The forensic anthropologist did not attend the scene for this case but was requested to attend the mortuary