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Taphonomy of Child-Sized Remains: A Study of Scattering and Scavenging in Virginia, USA*

ABSTRACT: Child-sized pig carcasses (*Sus scrofa*) were placed in surface deposit and buried scenarios in a wooded area of Virginia from May 1998 through December 2000, to examine the taphonomic effects of decompositional changes, predator scavenging, and the extent of remains scattering. Changes were observed through on-site examination, charting of remains, and recorded video imaging. Analysis of data revealed that utilization of corpses as food sources by vertebrates was dependent upon invertebrate colonization. Vertebrates avoided feeding on the corpses while invertebrate colonization was active, and would feed before invertebrates successfully colonized a corpse, or would wait until the invertebrate populations migrated away from the corpse. Among vertebrates, there was no apparent succession order for the animals utilizing the remains as a food source. Different vertebrates would feed at different times based upon diurnal or nocturnal predilection. Analysis noted an accidental cooperative relationship between the invertebrates and vertebrates scavenging on the corpses. Certain vertebrates gained access to the internal tissues by utilizing openings in the corpses caused by invertebrate and other vertebrate scavenging. Alternately, carrion-frequenting insects were afforded access to previously inaccessible colonization sites as a result of scavenging vertebrate activities.

KEYWORDS: forensic science, taphonomy, scavenging, child-sized remains

The FBI's National Center for the Analysis of Violent Crime (NCAVC) is routinely consulted by federal, state, and local authorities in cases of child abduction/homicide. According to recent research, in *c*. 94% of cases where abducted children are murdered, they are killed within 24 h of the abduction (1). One of the major investigative challenges in these cases is locating the child's remains, both for forensic value in prosecution and for closure for the family and the community. It has been observed that locating and identifying child remains through organized searches is often relatively unsuccessful. Skeletal elements blend into the environment and are difficult to recognize (Figs. 1 and 2). Scavenging activities and taphonomic influences further distort identification. Typically, child remains are discovered by accident, recovered through offender information, or not recovered at all.

Delays in recovery of victims often provide animals with opportunities for scavenging. The activity of scavenging animals can scatter, damage, and destroy major portions of these elements. Distinguishing animal and taphonomic changes from antemortem injuries is often crucial to an accurate determination of cause and manner of death. There is a plethora of research on invertebrate activity on corpses (2–4), but very little on vertebrate scavenging. Invertebrate colonization and subsequent scavenging is weather dependent, and during certain times of the year, portions of the United States experience cold weather temperature patterns that inhibit invertebrate activity. Although there has been research conducted on scavenging and scattering of human remains, these studies overwhelmingly involve adults, and the majority have taken place in the western United States (5–7).

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The aim of this research was to determine the extent of scavenging activity and identify the various animals utilizing child-sized remains as a food source in various habitats in northern Virginia, USA.

Materials and Methods

The research was conducted in a suburban area of Virginia, near the FBI Academy, Quantico, VA. A number of domestic pig (*Sus scorfa*) carcasses were deposited in a wooded area in a variety of surface deposit and buried scenarios. The research was conducted in four phases, beginning in May 1998 and continuing through December 2000. The first phase utilized five carcasses, and the final four phases each had two carcasses. The pigs were obtained from a commercial vendor, who provided freshly killed pigs on the first day of each phase of the research. The pig carcasses ranged in weight from 24 to 60 pounds (11.25–27 kg) with the majority falling within the 24–40-pound (11.25 to 18 kg) range. The pigs were placed in the respective scenarios and observation began at that time.

Pigs have been widely used in entomological and decompositional research as a human substitute (8). The size of the pigs was chosen because of comparative body weight with children, ages 2–11 years (9).

The first phase encompassed 74 days (Fig. 3), from May 1998 through July 1998. Study consisted of five small pigs, all under 30 pounds (13.5 kg). The pigs were placed in a variety of scenarios, including surface deposit, no covering; surface deposit, covered with tree branches and dead fall; surface deposit, enclosed in a rolled-up carpet; shallow burial (less than 1 ft); and hanging from a tree *c*. $2\frac{1}{2}$ ft above the ground. Remains were monitored weekly to chart disarticulation and scattering. Site surveillance was conducted before the weekly approaches to avoid impacting the scavengers. Scavenging effects were photographed and examined to identify the particular vertebrate species involved.

The second phase encompassed 74 days (Fig. 3), from May 1999 through July 1999, and consisted of two pigs, less than 60

FIG. 1—*Photograph depicts phase #1 surface deposit site before removal of surface debris and leaf litter.*

pounds (27 kg) in size, which were placed in two scenarios: a surface deposit, no covering, and a shallow burial (less than 1 ft). Four high-resolution video cameras were set up using an infrared light source. Two cameras were used per site, one focusing on an overall site view, the other a closeup of the remains. The cameras were set to record a fixed 12-h time interval, from 19:00 to 07:00 hours. Taping was conducted on consecutive days for the first 2 weeks, and thereafter from Friday evening to Monday morning.

Phases 3 and 4 involved the use of two cameras and consisted of two pigs, less than 30 pounds (13.5 kg) in size, which were placed in two scenarios: a surface deposit, no covering, and a shallow burial ($<$ 1 ft). Two high-resolution video cameras were set up using an infrared light source. One camera was used at each site, providing a close-up view of the remains. The cameras were set to record a fixed 12-h time interval, from 19:00 to 07:00 hours. The third phase was conducted during May of 2000, and the fourth phase was conducted from November through December 2000. Phase 3 lasted 24 days, and phase 4 lasted 40 days. Taping was conducted on consecutive days for a 14-day period during the third phase, and a 40-day period for the fourth phase (Fig. 3).

FIG. 2—*Photograph depicts phase #1 surface deposit site after removal of surface debris and leaf litter.*

For all of the phases, the remains were physically monitored to chart disarticulation and scattering. Site surveillance was conducted before approach, to avoid impacting the scavengers. Videotapes were reviewed in their entirety and significant activity noted. At the completion of each phase, an archeological approach was used to recover the remains. The loose vegetation was raked and removed, and the various skeletal components were located and charted. Remains from each site were collected, sorted, and tabulated to identify missing skeletal components.

Results

Results of the four phases are reported separately.

Phase #1

Invertebrate activity was observed on the surface deposit, no covering, within 15 min of deposit. Invertebrates capitalized on the accessibility of the surface deposit, the surface deposit covered with branches, and the surface deposit enclosed within a rolled-up carpet. The shallow burial was not colonized immediately, because of the soil barrier. The majority of soft tissue consumption was by invertebrates. During the first week, the shallow-burial remains were removed from the grave, apparently by vertebrates, and scattered over a significant area. Each of the pigs, other than the hanging pig, was reduced to skeletal components (almost all soft tissue removed) within 6 days. The hanging pig remained in place for several months because the skin desiccated, creating a hard "shell" that held most of the skeletal components in place. Also, once the invertebrates (primarily blowflies) colonized the hanging pig and the larvae hatched, the maggots fell to the ground, and were unable to re-infest the corpse.

Skeletal components of all the pigs were most often recovered in the near vicinity of the original disposal site, with the majority located within 15 ft (Fig. 4). Disarticulated remains were scattered, and in some cases, difficult to locate. The majority of skeletal elements were recovered from all of the deposit sites except for the buried site from which less than half of the remains were recovered (Table 1).

The small size of many skeletal elements required careful and structured procedures to ensure recognition and recovery. Unexpectedly, remains interred in shallow burial were subject to greater scattering than those that decomposed on the surface. A skeletal element from the buried site was located the farthest distance from the disposal sites (60 ft away). The predators that were observed and identified through site observation and artifacts included red foxes (*Vulpes vulpes*), and turkey vultures (*Catharses aura*).

Phase #2

The surface site was visited by a number of scavengers including turkey vultures (*C. aura*), crows (*Corvus brachyrhynchos*), red foxes (*V. vulpes*), and opossums (*Didelphis marsupialis*). Vultures were observed on two occasions approaching the surface site, and fed on the surface-deposit remains on only one occasion. Crows visited the surface site almost immediately, and were observed feeding on fly larvae (maggots), but did not feed on the remains. Invertebrate colonization again delayed vertebrate activity. Red foxes did not start feeding on the remains until the remains had been in place for 6 weeks. At that point, the remains were very

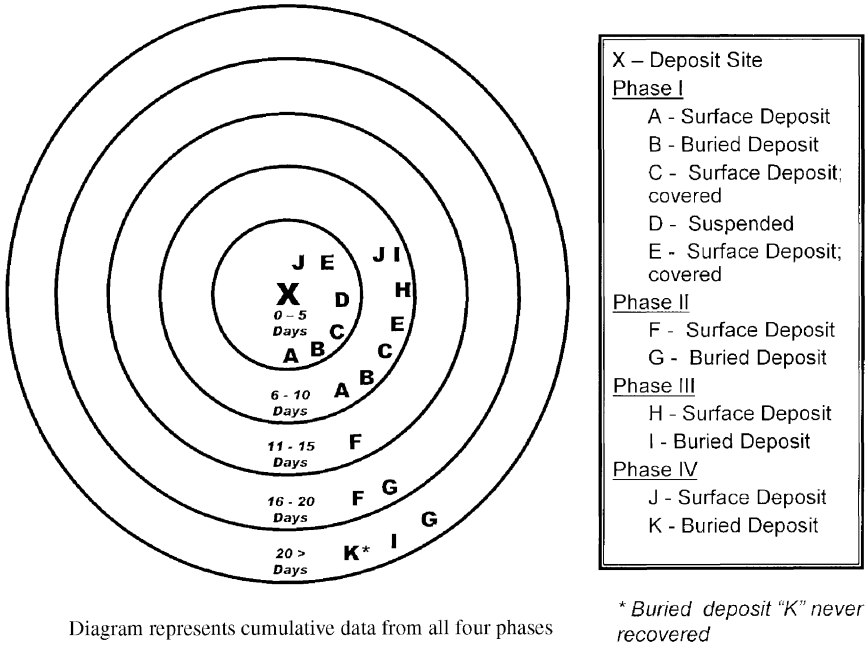

FIG. 3—*Diagram represents cumulative data from all four phases.*

desiccated and mummified. Foxes were observed on a number of occasions feeding readily on the desiccated surface-deposit remains. Feeding focused on the chest area, abdomen, and appendages, and a fox was observed disarticulating a front limb. A fox was also recorded "marking" the remains with scent, by rubbing against the corpse. Opossums started feeding on the surface deposit around the same time as the fox. Opossums fed directly on the remains and utilized the same feeding sites on the remains as the fox did, particularly the chest and abdomen area. An opossum disarticulated a number of skeletal elements, and was observed holding and chewing the epiphysial ends of rib bones.

The buried site was not visited or disturbed for 70 days, after which both opossums and foxes were observed digging an access hole down to the corpse. The corpse was removed from the grave and was reduced to skeletal remains by day 74 (Fig. 3). The invertebrates were not able to successfully colonize the buried remains due to the soil barrier.

Phase #3

This phase had a short duration before the corpses were reduced to skeletal elements. The surface-deposited corpse was reduced to

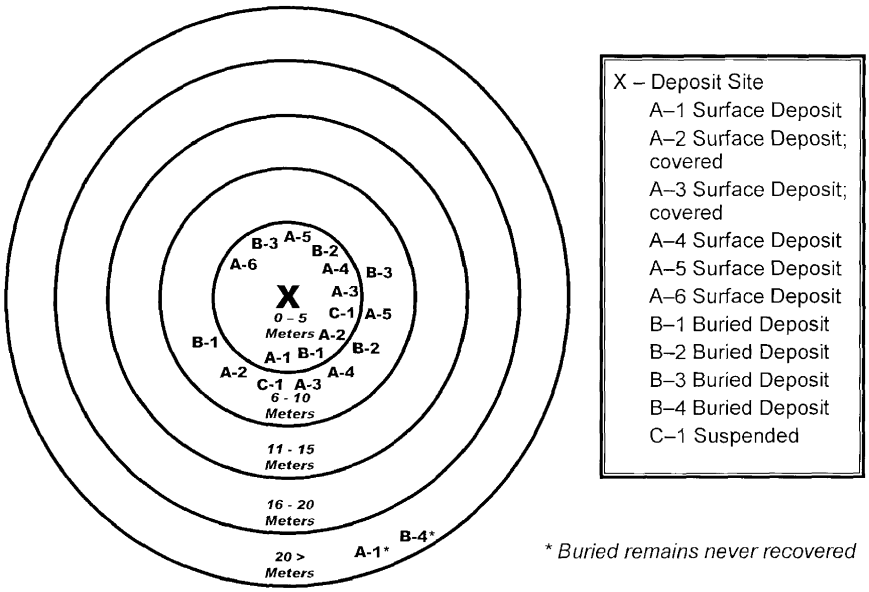

FIG. 4—*Diagram represents cumulative data from all four phases: A, surface deposit; B, buried deposit; C, suspended deposit.*

TABLE 1—*Remains recovered from each phase.*

Skeletal Elements	A	B	C	D	E	F	G	H	I	J	K
Cranium	×	×	0	×	×	×	×	×	×	×	0
Mandible	×	×	×	×	×	×	×	×	×	0	0
Pelvis	×	*	*	×	*	×	×	*	0	0	0
Scapula	×	0	×	×	×	×	×	×	*	×	0
Humerus	×	×	0	×	*	×	×	*	*	*	0
Radius	×	×	*	×	×	*	×	0	0	0	0
Ulna	×	×	0	×	×	*	×	0	0	0	0
Femur	×	*	*	×	×	×	×	0	*	*	0
Fibula	×	*	*	×	×	×	×	0	0	*	0
Patella	×	0	0	×	*	*	×	0	0	0	0
Vertebrate	×	*	*	×	*	*	*	*	*	*	0
Sacrum	×	*	0	×	*	×	×	*	*	*	0
Caudal	×	*	0	×	*	*	*	*	*	*	0
Ribs	×	*	*	×	*	*	×	*	*	*	0
Carpels	×	0	0	×	*	*	×	0	0	0	0
Metacarpals	×	*	*	×	*	*	×	0	*	0	0
Tarsals	×	*	0	×	*	*	×	0	0	0	0
Metatarsals	×	*	*	×	*	*	×	0	0	0	0
Phalanges	×	*	0	×	*	*	×	0	0	0	0

Phase 1: A, surface deposit; B, buried deposit; C, surface deposit-covered; D, suspended; E, surface deposit-covered.
Phase 2: F, surface deposit; G, buried deposit.
Phase 3: H, surface deposit; I, buried deposit.
Phase 4: J, surface deposit; K, buried deposit.
×, found element; *, some or part of element(s) found; 0, not found.

skeletal remains within 7 days, and the buried corpse within 10 days (Fig. 3). A review of the video recordings conducted at the two sites revealed several scavengers visiting and feeding on the remains, including turkey vultures (*C. aura*), opossums (*D. marsupialis*), and raccoons (*Algonquian arathkone*). A raccoon was the first to visit the sites, and returned on 2 subsequent days, attempting to dig up the buried remains by digging down, and partially exposing the remains. Raccoons, however, were never observed feeding on the remains. An opossum approached the sites 2 days after deposition, and was observed feeding directly on the remains. The opossum managed to eviscerate the surface remains by pulling at the entrails. The turkey vultures were very aggressive in their scavenging behavior, visiting the site every day for a week. The soft tissue of the surface deposit remains were consumed within 5 days, primarily by the vultures. The vultures capitalized upon the access hole dug by the raccoon and attempted to dislodge the buried remains from the shallow grave by grasping and pulling at the remains. A number of different vultures worked continuously for several hours and were eventually successful in removing the intact remains from the buried site. The soft tissues of the remains were totally consumed by the next day, and skeletal elements scattered. Observation of the sites after the 2-week period revealed scattering of the skeletal elements over an area *c.* 30 ft in diameter (Fig. 4). The skeletal elements were discolored and trampled into the leaf litter. It was difficult to assess the short postmortem interval based only on the condition of the skeletal elements.

Invertebrates, particularly blowflies (*Calliphoridae*), were observed and active, landing and ovipositioning, but the voracious activity of the vultures precluded large-scale colonization.

Phase #4

A review of the video recordings conducted at the two sites revealed several scavengers visiting and feeding on the remains, including turkey vultures (*C. aura*), red foxes (*V. vulpes*), opossums (*D. marsupialis*), raccoons (*A. arathkone*), and striped skunks (*Mephitis mephitis*). The surface remains were visited almost immediately by a large number of vultures. Twenty-seven vultures were observed feeding at the surface disposal site, and within 5 days, they reduced the surface remains to skeletal elements. During the first 10-day period, the opossums were also observed feeding on the surface deposit. Beginning on day 11, a raccoon was observed digging at the buried site on several occasions.

Starting on day 29, a fox was observed digging at the buried remains site, and continued digging for several more days. On day 30, a striped skunk was observed digging at the buried site. On day 39, the fox was observed chasing an opossum away from the buried site. On day 40, the fox was observed digging at the buried site and eventually removed the carcass from the grave. The fox carried away the intact corpse. A careful search of the surrounding area found no trace of the pig carcass (Table 1).

Invertebrate activity was limited during this phase due to the lower fall and winter temperatures. Invertebrates were observed during the day when temperatures were warmer, but there was never any colonization activity.

Discussion

The object of this work was to document the extent of scavenging activity in child-sized remains to help separate postmortem animal activity from offender disposal activity and to identify the various vertebrates that utilize these remains as a food source. The use of video recordings of nocturnal behavior proved to be very beneficial in documenting scavenger behavior. This technique has not been used extensively in the past. The activity of both invertebrates and vertebrates revealed several general trends.

A variety of vertebrates, including red foxes (*V. vulpes*), turkey vultures (*C. aura*), opossums (*D. marsupialis*), raccoons (*A. arathkone*), crows (*Corvus brachyrhynchos*), and striped skunks (*M. mephitis*), used the remains as a food source. For the purposes of this study, invertebrates were observed and noted; however, no collection or identification of any invertebrates was conducted.

The competition for food resources between different animal species was keen. Invertebrate colonization delayed vertebrate

activity. Once invertebrates colonized, vertebrates would not feed until the invertebrates migrated away from the corpse. If invertebrate populations were unsuccessful in colonizing because of a physical barrier or weather conditions, vertebrates would feed within a shorter time frame. Temperature had a dynamic effect on any invertebrate activity. The cooler temperatures (below 50°F) inhibited observed invertebrate activity. In phase 4 particularly, the cooler temperatures (30–50° F) suppressed any ovipositing by female blowflies. During phase 1, the invertebrates were successful in colonization and devoured most of the soft tissue on the surface deposit remains within 6 days. The exceptions were the hanging pig, which mummified, and the buried remains, which were removed from the grave site and consumed by vertebrates. In phase 2, the invertebrates were successful in colonization of the surface remains and vertebrates did not utilize the remains as a food source until week 6, when the majority of invertebrates had migrated away. The remains at this point were very desiccated and hard, with little soft tissue left. During phase 3, the turkey vultures were very aggressive and fed on the surface remains daily for 5 days, reducing the remains to skeletal elements. In phase 4, the surface site was visited by up to 27 vultures at one time. They summarily reduced the remains to skeletal elements within 5 days.

Among the vertebrates, there was a clear division of activity based upon diurnal or nocturnal predilection. The vultures visited the disposal sites entirely during the daylight hours. The foxes, raccoons, opossums, and skunks visited the disposal sites after daylight hours. The different species of nocturnal animals visited the disposal sites, for the most part, at different times. There was one exception observed, occurring during phase 4, wherein a fox was observed chasing away an opossum from the disposal site.

Analysis noted an incidental cooperative relationship between the invertebrate colonization and vertebrate scavenging, and also between different vertebrates. Vertebrates utilized body access openings caused by both invertebrate feeding activity and other vertebrate scavenging.

Examination of the skeletal remains revealed many postmortem artifacts inflicted by the observed vertebrates. These included gnaw marks, chewed epiphyseal bone ends, teeth marks, and beak marks. These artifacts were readily attributable to vertebrate scavenging activity.

Patterns of remains scattering were variable according to the specific invertebrates or vertebrates that fed upon the remains. Scavenging patterns were also dependent upon when in the time sequence a particular vertebrate fed upon the remains. If invertebrates successfully colonized remains, then scattering of skeletal elements was limited. If vertebrates were the primary scavengers of the remains, skeletal elements were extensively scattered, over a larger area, and many skeletal elements were not located (Table 1).

Further research in the area of vertebrate scavenging may provide a vital link in decompositional studies by identifying vertebrates in specific areas of the United States and their scavenging behavior.

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