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Canid Modification of Human Remains: Implications for Time-Since-Death Estimations

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ABSTRACT: Time-since-death estimations are usually based on physical decomposition of the corpse, insect succession, and contextual associations. The rates of change and succession are based on decomposition studies, most of which control access of scavengers to the corpse; however, many naturally exposed corpses are subject to scavenger modification. These modifications change the rate of decomposition, the pattern of insect succession, and the context of associations, thus altering estimations of time since death. A controlled feeding study with captive wolves and road-killed deer is pertinent to understanding canid scavenging and how scavenging may alter postmortem changes. During feeding, the wolves commonly dismember and devour the deer in a predictable sequence. Although there are some variations in the usual sequence, the carcass is always moved, and skeletal elements are separated, diminished in size and scattered. Scavenging must, therefore, be considered in estimating time since death.

KEYWORDS: pathology and biology, postmortem interval, scavengers, decomposition

Time since death of long-dead individuals is usually estimated using physical decomposition of the corpse [*1-3*],[3] insect succession [*4,5*],[4] associated plants [*6,7*], and deterioration of associated clothing [*3*]. For decomposition rates to be established, controlled studies have been conducted that eliminate such natural variables as scavenger access to the corpse. These controlled situations are in marked contrast to actual exposed forensic science cases, many of which are scavenged. For example, of 27 relatively complete skeletons recovered as surface "burials" now in the University of Tennessee's forensic collection, 22 (77.8%) show gnaw marks indicating scavenging.

In the United States, there are a variety of scavengers that consume human flesh. These scavengers include bobcats, rodents, pigs, racoons, opossums, and bears, as well as some birds, amphibians, and reptiles [*8*]. But the most ubiquitous and common scavengers of exposed corpses are dogs and coyotes.

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During the past three decades, archaeologists have become interested in the effects of wild carnivores, domestic dogs, and other scavengers on bone and subsistence debris in archaeological sites [*9,10*]. Actualistic studies of the effects of large carnivores on prey carcasses and resulting bone debris are now being conducted to detect and control this "noise" [*11,12*]. Paleoanthropologists have also become increasingly aware of the possible alteration of prehistoric human skeletal materials by faunal agents and are reassessing earlier suggestions of cannibalism by early humans based on breakage and disarticulation patterns of skeletal material [*13,14*]. Forensic anthropologists are beginning actualistic studies to investigate these alterations and their implications [*15*]. As a forensic anthropologist and a zooarchaeologist, we are struck by the parallels and potentials for information exchange between such actualistic studies and problems in forensic science.

Taphonomic research currently being conducted with road-killed deer and captive wolves is pertinent for a better understanding of corpse scavenging by modern canids. Results from the wolf-deer feeding study can be used to establish the sequence of dismemberment and consumption, gain insights into the scavenging process, and examine the effects of such disturbance on physical decomposition, insect succession, and contextual associations.

Overview of Wolf-Deer Study

In this study by Snyder, which began in spring 1986 [*16,17*] and is continuing, a group of captive timber wolves (*Canis lupus*) in East Tennessee is allowed unrestricted access to complete carcasses of road-killed deer (*Odocoileus virginianus*). Feeding activities are observed daily, and all bone debris as well as scats are collected regularly.

One adult female and four adult male wolves range freely in a wooded enclosure measuring approximately 38 by 15 m. Three of the males are litter mates weighing between 45 and 50 kg (100 and 110 lbs). The fourth male weighs about 49 kg (108 lbs); the female weighs approximately 32 kg (70 lbs). The wolves normally eat commercially prepared dry dog food fed daily and one chicken per wolf each week. In addition, they are occasionally fed portions of deer or beef carcasses donated by local hunters and farmers.

For this feeding study fresh, whole carcasses of road-killed deer are placed within the enclosure, and the wolves feed freely (Fig. 1). Before each carcass is introduced, the pen is surveyed and all bone debris removed. While the wolves are actively feeding on a carcass, they receive no other food. Over the past 2 years, a total of 15 deer carcasses, ranging in age

FIG. 1—*Wolves pulling adult doe (41 kg [90 lb]) on first day of feeding.*

from less than 6 months to 4.5 years and from 16 to 68 kg (48 to 160 lbs), have been monitored during all seasons of the year.

Results

Consumption and Dismemberment

A consistent pattern of carcass reduction and disarticulation has been observed. Initially, meaty sections such as the hindquarters are consumed, the thoracic cavity is opened, and the ribs are eaten. Often the throat is torn open, and the nose is eaten. Disarticulation of one or more limbs commonly occurs within 24 to 48 h, usually the forelimb before the hind limb. Following consumption of meaty parts, there is extensive destruction of limb bone ends, the vertebral column and the associated rib heads. Remnants of the vertebral column and hide are the last portions consumed, usually in four to seven days. The consumption sequence may take as little as 24 h for six-month-old fawns (16 to 20 kg) to four to seven days for fully mature deer (55 to 73 kg).

In addition to the general disarticulation pattern outlined above, individual deer elements and element portions are heavily damaged or completely destroyed and consumed by the wolves. The more porous long bone ends, such as the proximal humerus and both ends of the femur, are often destroyed as the wolves chew through the thin bone cortex and consume the spongier cancellous tissue inside the bone. In contrast, compact bone ends, such as the distal humerus and distal tibia, usually survive, although bearing tooth scoring and puncture marks. The harder, thick-walled shafts of humeri, femora, tibiae, and metapodials are likely to survive, either as "cylinders" missing the ends, or as a partial shaft still attached to the more compact epiphysis [*18*]. Ribs and vertebrae are virtually always destroyed. For example, from a sample of 4 deer carcasses, only 1 of 104 ribs was recovered uneaten, and only 15 of 104 vertebrae survived [*16*]. Smaller elements, such as carpals, tarsals, and phalanges, are invariably swallowed, often whole. These elements reemerge heavily gnawed and eroded, but often identifiable, in the wolves' scats [*16*].

Carcass Movement

The deer carcasses are invariably moved by the wolves. Soon after a carcass is placed in the enclosure it is dragged from its original location, and as feeding progresses, dismembered body parts are widely strewn about the compound. Carcass remains and body parts are moved freely and repeatedly unless obstructions, such as trees, stumps, and rocks, are encountered. Sometimes, then, the parts become tightly wrapped around the obstructions. Figure 2 shows the carcass of a fawn (0.5 years, 31 kg [68 lbs], Day 2) wrapped tightly around a sapling. At times, tugging against such objects aids disarticulation of the carcass.

Discussion

Applicability

Direct application of the wolf-deer model to forensic scavenging is complicated by several factors. First, a pack of five wolves fed upon the deer carcasses in this controlled study, and that undoubtedly hastened disarticulation (Fig. 1). In forensic science cases, although some exposed corpses are scavenged by coyote or feral dog packs, many are probably scavenged by one or a succession of individual dogs. However, individual scavenging, although slower than pack scavenging, probably follows the same sequence. Second, the gray wolves (20 to 80 kg) [*19*] are larger than coyotes (12 to 17 kg) [*20*] and most breeds of domestic dogs. Nevertheless some domestic breeds, such as coonhounds (18 to 36 kg), labrador retrievers (25 to 34

FIG. 2—*Carcass of a six-month-old fawn wrapped tightly around a sapling.*

kg), German shepherds (29 to 41 kg), great danes (54 to 68 kg), and bloodhounds (36 to 64 kg) are wolf-size or larger [*21*]. And field research has shown [*11,22*] that regardless of predator size, dismemberment sequences are essentially the same. Third, deer body and skeletal morphology differ from human, particularly in the deer's longer, thicker neck, elongated facial area, and elongated metapodials. Deer are also completely covered with a thick, hair-covered hide. While this hide may limit scavenger access to the carcass, it may be comparable to clothing on corpses. Despite these limitations, we have observed similarities between wolf-deer and canid-human scavengings, especially in movement of the body, consumption sequence, and alterations to bone.

Examples of the parallels between wolf-scavenged deer carcasses and the canid-scavenged human corpses are in order. A forensic science case involving a white male from Knox County, Tennessee, murdered in the winter of 1977, is striking. Despite the body being fully clothed and exposed only two days in cold weather, scavenging dogs opened the thoracic and abdominal cavities and consumed the internal organs (Fig. 3*a*). The meaty portions of the arms were also destroyed. Wolves, as noted above, scavenge deer carcasses in a similar manner. Figure 3*b* shows the carcass of a two-year-old buck, 59 kg (129 lbs), after being eaten by wolves for three days during April of 1986. Like the corpse, the deer's thoracic cavity is exposed, and the internal organs and meaty sections of the limbs have been eaten. In another close parallel, the soft portions of the face, particularly the nose, are frequently consumed. On the same human corpse, the nose, paranasal area, and soft tissue of the neck and face were chewed and missing after two days (Fig. 4*a*). Similar destruction is illustrated by the carcass of another adult male deer eaten by the wolves for four days in November 1987 (Fig. 4*b*).

Obscuring Cause and Manner of Death

The first portions of a deer carcass investigated by the wolves are those with broken skin and open wounds. When blood oozes from the deer's nose, mouth, or wound, the wolves concentrate their initial efforts on those areas, licking, chewing, and where possible, enlarging them. Similarly, we expect that other canids would concentrate first on the bloody parts of corpses, including areas that may be critical for establishing the cause and manner of death. Gunshot, blunt trauma, and knife wounds thus may be obscured—even obliterated—by opportunistic scavenging. Scavenging patterns deviating from the expected ones, therefore, should be examined closely for indications of perimortem trauma.

FIG. 3a—*White male scavenged by dogs for two days. Chest cavity is open, organs consumed, and meaty parts of arms eaten.*

FIG. 3b—Adult deer eaten by wolves for three days. Thoracic cavity is open and the organs and meaty portions of the limbs have been consumed.

FIG. 4a—*Head and neck of white male scavenged by dogs for two days. Note missing soft tissue and missing nose.*

Modifications of Time-Since-Death Estimation

Observation of wolf-scavenged deer carcasses indicates that physical decomposition, insect activity, and contextual associations are modified. Physical decomposition is hastened, and with consumption and movement, the carcass is reduced in size and dismembered. The rate of reduction and dismemberment varies with the number and size of the scavengers and

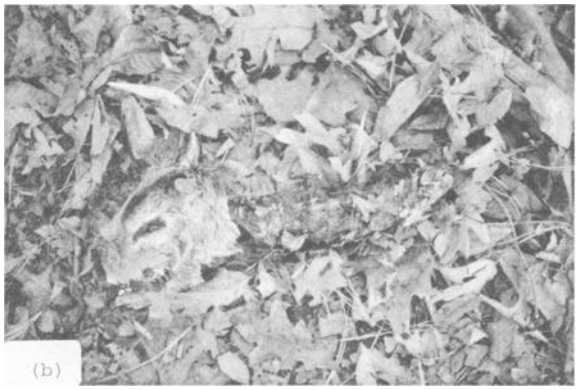

FIG. 4*b*—*Head and neck of adult male deer eaten by wolves for four days. Nose and soft tissue surrounding the vertebral column are consumed.*

the size of the prey. For instance, although the number of wolves remained constant, two 18- to 27-kg (40 to 60-lb) fawns were consumed in 24 h with no identifiable bone remaining, while bone fragments and hide remnants of a larger, mature deer remained in the pen after 14 days.

As a consequence of scavenging, insect species succession appears to be hastened although insect numbers and activity are reduced. Insect succession—the sequence of species attracted to a body depending on decompositional stage—is quickened as a consequence of rapid decomposition caused by scavenging. While species succession is hastened, the number of insects and their activity is reduced. Because the deer carcass is being moved and turned, many favored insect habitats are exposed to sunlight and drying, necessitating insect movement and inhibiting the adults from laying eggs. In addition, the canids are steadily eating newly exposed areas of soft tissue and bone, and insects, eggs, and larvae are swallowed as evidenced by maggots occasionally found in the wolf scats.

Movement and dismemberment may also alter associated plants and personal effects used to estimate time since death. Because the carcass is being moved, reduced in size, and dismembered, clothing may be removed and displaced. In some cases, associated roots, stems, leaves, or mosses may be lost or altered when scavengers move the carcass. Such loss of associations should be infrequent, however, because canids have little interest in dried, dessicated remains late in the decomposition sequence.

Conclusions

For time since death to be estimated more accurately, natural variation must be considered and used to assess models based on controlled experiments. Canid scavenging is one source of natural variation. The physical results of scavenging must be identified [*23*], rate of scavenging estimated, and the degree of scavenging established. Because these factors alter the decomposition rate, insect succession, and contextual associations, time-since-death models must be adjusted to account for their potential influence. Studies of actual cases with known time since death and clear evidence of scavenging are essential for modifying present standards. Only when all naturally occurring variables, including scavenging, are considered will time-since-death estimations become accurate.

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