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Postmortem scavenging by the Virginia opossum (*Didelphis virginiana*): Impact on taphonomic assemblages and progression

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ABSTRACT

The Virginia opossum (*Didelphis virginiana*) is a highly active scavenger whose behavior has significant impacts on rates of decomposition and skeletonization, which have previously not been addressed. In this study, scavenging by the opossum led to the skeletonization of carcasses in half of the accumulated degree days (ADD) of a comparable non-scavenged control carcass. Opossums used body orifices, as well as natural tears caused by the decomposition process, to access internal tissues and consume them. This activity resulted in little movement of the carcass and the retained appearance of natural undisturbed decomposition. This concealed activity has the potential to cause drastically incorrect estimates of time since deposition and post-mortem interval. Scavenging by opossums was also found to leave distinct tooth mark and other defects on bone, which have not been previously distinguished in the literature. This research suggests, beyond effects on PMI, that scavenging by opossums has been historically overlooked and misattributed to canid scavengers.

1. Introduction

Scavenging by vertebrates is recognized as impacting forensically important factors such as rate of decomposition, dispersal of remains, recoverability of remains, the ability to properly identify remains, and the differential diagnosis of trauma on remains [1–5]. Many species of scavengers have been identified and their associated taphonomic impacts have been illustrated. For example, scavenging behaviors of domestic and wild canids, as well as rodent modification, have been described in some detail, particularly in the Pacific northwestern United States [1–3,6,7]. The Virginia opossum (*Didelphis virginiana*), although having been recognized as a scavenger of remains [3,4], has received very little taphonomic consideration. A recent study of scavenger guilds in north central Oklahoma suggests that the opossum partakes in frequent scavenging activity, which may have significant implications to forensic investigations, both in terms of estimations of post-deposition and post-mortem intervals, as well as the differential diagnosis of trauma, injury patterns, and artifacts from other scavengers.

The Virginia opossum is distributed in large numbers throughout the central and eastern United States, and the western coastal states of California, Oregon, and Washington [8]. Its range has slowly expanded into the other western states and it has recently been found in Arizona [9]. Adults are, on average, 2–3 kg in size [8]. The opossum is the only marsupial species in North America. Having an opposable hallux, as well as prehensile tail, renders it a highly adaptable forager [8]. Opossums have a diverse opportunistic diet, consisting of considerably high percentages of carrion and insects [8]. The opossum does exceedingly well in habitat that is encroached upon and fragmented by human activity. Under such conditions the opossum becomes a major suburban scavenger and carrion recycler [10]. An understanding of how opossums utilize remains, what impact they have on the condition of those remains, and what taphonomic artifacts they leave behind are significant to death investigations, particularly in metropolitan and semi-urban areas.

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2. Materials and methods

2.1. Site location

This study was conducted at the Oklahoma Department of Wildlife Conservation's, 226.6 ha Arcadia Conservation Education Area, in north central Oklahoma (35.625424 N, −97.381582 W). The preserve covers a mix of riverine habitat, mixed grassland prairie, and cross-timbers [11]. This diverse landscape provides habitat for a wide variety of mammalian species including large predators and mesopredators, as well as small omnivores, avian and reptile species [11]. Public access is allowed to the area for hiking and fishing year round. Hunting access is limited to a small number of archery deer permits annually and no other hunting or trapping is allowed. The preserve is surrounded by suburban residential housing, with the closest housing to the carcass drop location being 0.54 km to the southeast, and is in close proximity to the greater Oklahoma City metropolitan area.

2.2. Specimens

Domestic pig (*Sus scrofa*) carcasses were used as analogs to human remains, as has been established in previous forensic scavenging and taphonomy studies [4,5,12,14]. Three pig carcasses were used for each of the experiments. The specimens were obtained from the University of Oklahoma, College of Medicine, the Oklahoma State University, Swine Research Center, and from donations by a local farmer. Carcasses obtained from the University of Oklahoma were used previously for endoscopic surgical curricula at the college, and were euthanized by anesthesia. Carcasses obtained from the Oklahoma State University Swine Research Center were natural deaths. The donated carcasses were euthanized by .22 caliber rifle shot to the crania due to illness. The project was conducted under the University of Central Oklahoma IACUC authorization #7008, #7009.

2.3. Experiments

Three experimental series were conducted from October 2012 through March 2014. Three carcasses were placed for each of the experiments. Each carcass was individually numbered for experimental reference. Carcasses were kept on ice during transport and temporary storage, and were placed at field sites within 24 h of being obtained. In each experiment, a carcass was placed within an animal proof wire cage (1.5 m × 1 m × 0.5 m), which consisted of a metal frame covered with a thin wire mesh [5,13], to serve as a control. For each experiment, a second carcass was placed undisturbed directly on the ground and left exposed. A third carcass, was modified to allow for the implantation of radio transmitters (Wildlife Materials, Inc. SOPI) into medullary cavities of long bones in order to find their location if moved from the deposition site.

2.4. Data collection and analysis

The study site was monitored continuously throughout the experiment period by both electronic surveillance and regular site visits. Carcasses were monitored with battery powered motion triggered trail/game cameras (Moultrie GameSpy I-85) with infrared flashes [5,12,15], and a Digital Video Recorder (DVR) system with cameras that captured video 24 h a day [4,12,13]. All of the cameras were moved as needed to ensure that carcasses remained in view and that quality video and photo data was collected.

The site was visited every other day at the beginning of each experiment, with the frequency tapering off to weekly visits as the movement and usage of the carcass diminished or stopped completely. At each visit the carcasses were photographed and any changes in the condition of the carcasses were noted. Changes in orientation and movement of elements from the previous visit were also recorded.

Activity tables were created, based on video data of scavenger visit times for all experiments, which charted species, visit time, and sunrise and sunset. Skeletal elements were examined for taphonomic indicators of scavenger activity. Temperature and humidity data were collected using Tinytag© Plus 2 data loggers. The data loggers recorded temperature and relative humidity measurements at 15 min intervals throughout a 24 h period. Average daily temperature was calculated from the interval temperature data and used to calculate accumulated degree days (ADD) for all experiments [16]. ADD measures the amount of heat loading on the carcass during the decomposition process by using the sum of average daily temperatures from the time of death until discovery. This allows for standardization and cross comparability between regional and seasonal studies. Total body score (TBS) was also calculated using the scoring system established by Megyesi et al. [16]. TBS is a standardized measure of taphonomic progression that is assessed by scoring the body in three regions: the limbs, trunk, and head and neck. Each region is assigned a number on a scale of fresh to dry bone, and then each score is combined for a total score ranging from 3 (completely fresh) to 35 (dry skeletonization).

Collected data was used to evaluate temporal distinctions and patterns in scavenging behavior. These included discernable patterns in carrion visit time, carcass usage, and subsequent remains' displacement. Actions such as grooming in proximity to the carcass after feeding were included in total visit duration. Patterns were evaluated for their ecological significance and usefulness in informing forensic death investigations and searches for remains.

3. Results

Virginia opossums were the most common scavenger seen visiting the carcasses with 188 distinct events captured on digital video or photograph, which is 70% of the total mammalian scavenger visits. Visits were defined by an animal coming into view of the camera, partaking in a scavenging related activity at the carcass, such as feeding or cleaning, and then leaving the view of the cameras. The overwhelming frequency of opossum visits stands in stark contrast to the visit frequency of other mammalian scavengers observed throughout the experiment period. Bobcats (*Lynx rufus*) were observed on digital video or photograph feeding at carcasses only 31 times (11% of total visits) and coyotes (*Canis latrans*) 51 times (19% of total visits). Opossums were observed scavenging at 6 of the available carcasses, coyotes at 7, and bobcats at only 2. The two carcasses which were not scavenged by opossums were removed from the area by coyotes within a few days of placement and were available the least amount of time.

Average opossum visit duration was highest in the first experiment with 15.34 min per feeding event. It was lowest in the third experiment at 4.6 min per visit, where average daily temperature was highest. While this implied some relationship between activity and temperature, it was not of statistical significance.

Opossums scavenged at predictable times of the day and were almost exclusively nocturnal except for a single visit that was recorded at sunrise. This pattern persisted over the course of all seasons. Opossums were observed scavenging during all seasons of the experiment, and showed no distinct seasonal preference (Fig. 1).

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