BIOLOGIJA
2026. Vol. 72. No. 2. P. 121–128

ISSN 1392-0146 eISSN 2029-0578
DOI: https://doi.org/10.6001/biologija.2026.72.2.2

Dynamics of detection and utilisation of large mammal carcasses by scavengers

Daivaras Rybakovas*,

Artūras Kibiša

Faculty of Forest Sciences and Ecology,
Agriculture Academy,
Vytautas Magnus University,
Kaunas, Lithuania

Carrion is a short-lived but nutrient-rich resource in terrestrial ecosystems. After an animal dies, its body becomes a carcass that can be utilised by scavengers, detritivores, and other microorganisms. Carrion represents a spatially heterogeneous resource, creating localised hotspots of biological and chemical activity, which become particularly pronounced in the case of large vertebrates. Although numerous studies worldwide have investigated carrion use and consumption, considerable gaps remain in understanding carcass detection, utilisation and their ecological impacts. No such studies have previously been conducted in Lithuania. Therefore, the aim of this study was to investigate the utilisation of large mammal carcasses by scavengers in Varnaitinė Forest located in Jurbarkas district. Four study sites were selected within the forest where carcasses were placed approximately twice per month and monitored using camera traps. We recorded scavenger species composition, carcass detection time, visitation duration, and time to complete consumption. The results showed that red foxes, raccoon dogs, and ravens were the dominant scavengers in Varnaitinė Forest. In more open habitats, ravens most frequently detected carcasses first. The mean carcass detection time was 30 hours, while the average time to complete consumption was 81 hours. These findings suggest that in temperate forest ecosystems, carrion functions as a short-lived but ecologically significant source of food and energy.

Keywords: carrion, scavengers, carcass detection, utilisation dynamics

INTRODUCTION

After an animal dies, its body becomes a carcass that can be utilised by scavengers, detritivores, and microorganisms, ultimately contributing nutrients to the soil (Barton et al., 2013). A substantial portion of carrion-derived nutrients is consumed by animals and redistributed across the landscape (Melis et al., 2007). Most scavengers feed on animals that have died due to malnutrition, disease, exposure, parasites, or accidents (DeVault et al., 2003).

* Corresponding author. Email: daivarasrybakovas@gmail.com

Carrion is a highly ephemeral resource. Due to rapid decomposition, terrestrial vertebrate predators generally have access to more live prey than carcasses at any given time (DeVault et al., 2003). Understanding the ecological role of scavengers in terrestrial ecosystems requires knowledge of carrion availability (Houston, 1979). Many large animals likely die in accessible locations, becoming directly available to vertebrate scavengers (DeVault et al., 2003). However, without information on carrion availability, scavenger activity, and the ecological significance of carcasses, many aspects of this trophic pathway remain poorly understood (Houston, 1979).

Previous studies have shown that the composition of organisms visiting carrion changes dynamically across different stages of decomposition. For this reason, succession theory has been widely applied to estimate the time of death in both animal and human remains (Moura et al., 2005).

Numerous studies worldwide have examined various aspects of carrion ecology, including scavenger visitation patterns, decomposition rates, and ecosystem impacts. However, no such studies have been conducted in Lithuania. Therefore, this study aims to identify the species that first detect large mammal carcasses and the speed carrion is utilised in a temperate forest ecosystem in Lithuania.

MATERIALS AND METHODS

The study was conducted from 2023 to 2024 in Varnaitinė Forest located in Jurbarkas district, western Lithuania. Four study sites representing different habitat types were selected within the forest and Reolink Go Plus camera traps (Reolink Innovation Limited, China) were installed at each site (Fig. 1).

Carcasses were placed at the study sites approximately twice per month. In total, 189 carcasses were deployed: 60 roe deer (*Capreolus capreolus*) carcasses and 129 piles of viscera from roe deer or red deer (*Cervus elaphus*). Of the 60 whole roe deer carcasses, 40 were left intact and 20 were incised to expose the internal organs. Whole roe deer used in the study were road-killed individuals collected throughout the study period. Roe deer and red deer viscera were obtained in collaboration with hunters during the respective hunting seasons. Fewer red deer viscera were available compared to roe deer viscera.

At each site, we recorded scavenger species visiting the carcasses, time to first detection, duration of visits, and time to complete

Fig. 1. Location of the four study sites in Varnaitinė Forest, western Lithuania

consumption. Detection time was calculated as the interval between carcass placement and the first recorded visit by any scavenger. Carcass persistence time was defined as the interval between carcass placement and its complete disappearance. Additionally, carcass utilisation time was calculated as the interval between first detection and complete consumption.

An experimental component was also conducted to evaluate differences in scavenger behaviour depending on carcass presentation type. Utilisation time was compared among intact carcasses, incised carcasses, and viscera-only treatments.

Camera trap data were processed using Microsoft Excel, and statistical analyses were performed using Tibco Statistica software.

RESULTS

Scavenger species composition

During the entire study period, a total of 2,881 visits to carcasses were recorded across all sites. In total, 13 animal species were documented visiting carcasses. The recorded mammal species included red fox (*Vulpes vulpes*), raccoon dog (*Nyctereutes procyonoides*), domestic dog (*Canis lupus familiaris*), wild boar (*Sus scrofa*), pine marten (*Martes martes*), and grey wolf (*Canis lupus*) (Fig. 2).

The following bird species were also observed at carcasses: common raven (*Corvus corax*), common buzzard (*Buteo buteo*), hooded crow (*Corvus cornix*), Eurasian jay (*Garrulus glandarius*), white-tailed eagle (*Haliaeetus albicilla*), one unidentified prey bird species, and a flock of unidentified small bird species.

Red foxes (29%), raccoon dogs (23%), and ravens (22%) were the most frequent visitors to carcasses (Fig. 3). The remaining species accounted for 3% to 7% of total visits. White-tailed eagles, grey wolves, and unidentified bird species were grouped as 'other species' and together represented only 1% of all visits, having been recorded only few times during the study period.

Fig. 2. Scavenger species observed at carcasses during the study

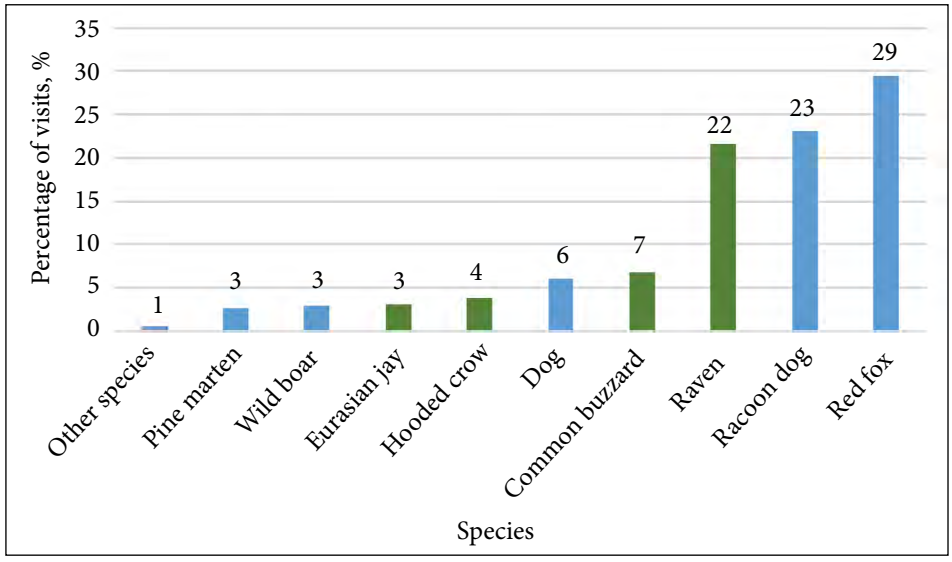

Fig. 3. Percentage of scavenger visits by species recorded at carcasses during the study period. Mammals and birds are indicated by different colours

Species composition was similar across the four study sites. Red foxes, raccoon dogs, and ravens were consistently the most frequent scavengers at carcasses at all locations.

Seasonal analysis of scavenger visits revealed that red foxes, raccoon dogs, and ravens were the most frequent visitors to carcasses throughout all seasons (Table). However, visitation frequencies varied seasonally: foxes were most common in spring and winter, whereas raccoon dogs dominated in summer and autumn. Raven visitation remained relatively consistent across seasons with only a slight (2%) increase observed in spring.

Raccoon dogs were most active during summer and autumn, while fox activity showed only minor seasonal variation, with a 2% higher visitation rate in spring and winter compared to summer and autumn. Among other species, Eurasian jays, pine martens, hooded crows, and grey wolves exhibited higher activity in winter than in other seasons. Domestic dogs and common buzzards most frequently visited carcasses in spring. White-tailed eagles were recorded several times in spring; however, due to the low number of observations, they accounted for less than 1% of total visits. Wild boars were most active at carcasses during summer.

Table. **Seasonal distribution (%) of scavenger visits by species**

Species	Winter, %	Spring, %	Summer, %	Autumn, %
Racoon dog	17	21	31	32
Eurasian jay	5	4	0	1
Dog	5	7	6	6
Pine marten	6	1	2	0
Raven	21	23	21	21
Red fox	30	30	28	28
Wild boar	3	2	6	2
Common buzzard	7	8	4	5
Hooded crow	5	4	2	3
Wolf	1	0	0	0

We also analysed which species were the first to detect carcasses. Across all study sites combined, ravens most frequently detected carcasses first (47%), followed by red foxes (29%) and raccoon dogs (14%) (Fig. 4). All other species did not exceed 3% of first detections.

At study sites 2, 3, and 4, the pattern was consistent, with ravens most frequently detecting carcasses first. In contrast, at site 1, red foxes were the primary initial detectors. At this site, foxes accounted for 52% of first detections, followed by raccoon dogs (23%), whereas ravens represented only 10%.

Seasonal effects on first detection were also analysed. In spring, autumn, and winter, ravens were most often the first to detect carcasses. In contrast, during summer, raccoon dogs and foxes were the dominant first detectors, each accounting for 38% of summer detections, while ravens comprised only 8% of first detections during this season.

Carcass detection and consumption patterns

We analysed the time interval between carcass placement and first detection. Detection time ranged from less than 1 h to 133 h after placement. The mean detection time was 30 h, and the median detection time was 19 h.

Mean detection times were similar at sites 2 and 4, averaging 40 h and 42 h, respectively. However, median detection times differed between these sites: 29 h at site 2 and 41 h at site 4. The fastest detection occurred at site 3, where carcasses were detected on average within 12 h (median = 4 h). At site 1, the mean detection time was 28 h, with a median of 19 h.

Detection time differed significantly among study sites (Kruskal–Wallis test: $H(3) = 18.7$, $p < 0.05$) (Fig. 5). The shortest mean detection time was recorded at site 3, while the longest was observed at sites 2 and 4.

We also analysed the time interval from carcass placement to complete consumption. This duration ranged from eight to 459 h. The mean time to complete consumption was 81 h, with a median of 68 h. The longest mean consumption time was recorded at site 2 (91 h), while the shortest was observed at site 3 (64 h). The highest median consumption time occurred at site 4 (89 h), and the lowest at site 3 (52 h). The interval from placement to complete consumption did not differ significantly among study sites (Kruskal–Wallis test: $H(3) = 4.40$, $p = 0.22$).

Additionally, we calculated the interval between first detection and complete consumption (utilisation time). Utilisation time ranged from

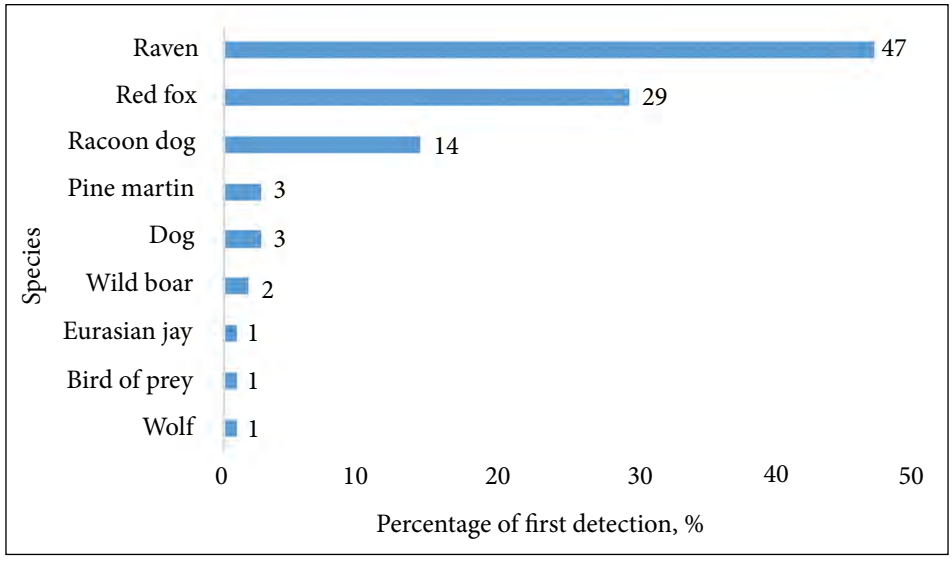

Fig. 4. Percentage of first detection of carcass by species

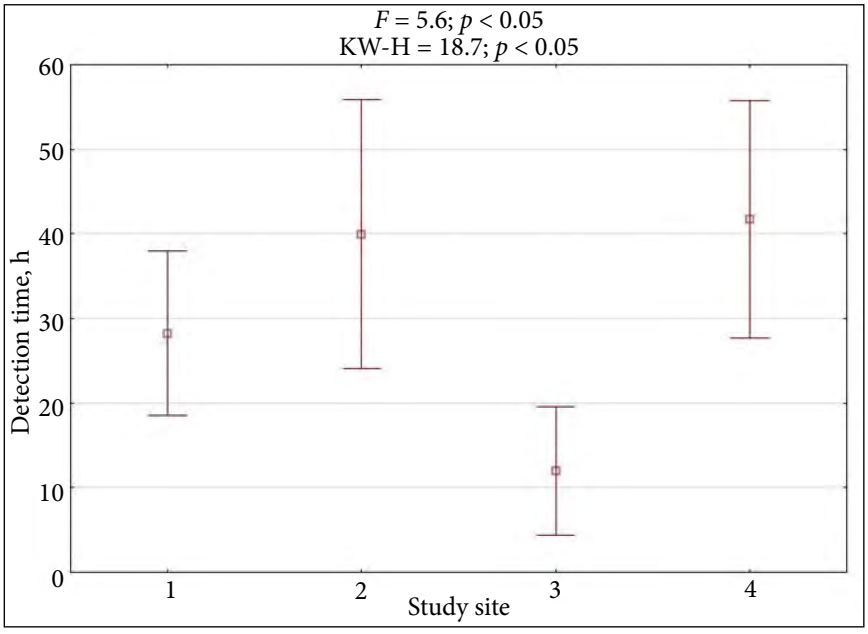

Fig. 5. Carcass detection time (h) across study sites

one to 435 h, with a mean of 51 h and a median of 41 h. The longest mean utilisation time was recorded at site 1 (60 h), whereas the shortest was observed at site 4 (40 h). At sites 2 and 3, mean utilisation times were 51 and 52 hours, respectively. The highest median utilisation time was recorded at site 1 (44 h), and the lowest at site 4 (39 h). No significant differences were found in utilisation time among study sites (Kruskal–Wallis test: $H(3) = 2.03$, $p = 0.566$).

DISCUSSION

The results of this study showed that red foxes, raccoon dogs, and ravens were the most frequent visitors to carcasses, whereas other species were recorded less often. Seasonal patterns were generally similar, with the same dominant species present throughout the year. Fox visitation rates remained relatively stable across seasons, likely reflecting their year-round activity and opportunistic foraging behaviour. In contrast, raccoon dog activity was lower in winter and spring. This pattern may be explained by their seasonal physiological adaptations: raccoon dogs can enter periods of reduced activity during cold winters, although they may resume activity during milder conditions.

White-tailed eagles were recorded at carcasses several times in spring. This may be related to spring migration or opportunistic use of carrion, as the diet of white-tailed eagles primarily consists of fish and waterbirds, with carrion forming only a minor component (Rašomavičius, 2021).

Ravens most frequently detected carcasses first. This finding is consistent with previous observations indicating that corvids locate carrion primarily using visual cues rather than olfaction (Ivanauskas, 1956). Birds are also well adapted to scavenging due to the low energetic costs of soaring flight. Soaring requires less energy than terrestrial locomotion (Schmidt-Nielsen, 1972), allowing birds to search large areas more efficiently than mammalian or reptilian scavengers (Houston, 1979). However, at study site 1, foxes were more often the initial detectors than ravens. This pattern may be associated with habitat characteristics, as the site 1 was located deeper within the forest and contained fewer open areas, potentially limiting visual detection by aerial scavengers.

Carcass detection time differed significantly among study sites. Carcasses were detected most rapidly at site 3 and most slowly at sites 2 and 4. These differences may be related to

habitat structure and the proportion of open areas, which influence the ability of visually oriented scavengers to detect food resources. Site 3 contained more open habitat patches, which likely facilitated faster carcass detection.

The mean time from carcass placement to complete consumption was 81 h, or approximately three days, with an overall range from less than one day to 19 days. Compared with studies conducted in other regions, carcass persistence in this study falls within a similar range, although it is slightly shorter than that reported in some warmer climates. In southeastern Spain, herbivore carcasses persisted for approximately 3–8 days (Moleón et al., 2017). Similarly, at the Savannah River Site in the United States, most carcasses were detected and removed during the night, with an average persistence of 5–6 days (DeVault, Rhodes, 2002). In that study, visual exposure, carcass size, and habitat type did not significantly influence detection probability; however, higher temperatures increased carcass discovery rates.

The results from Varnaitinė Forest demonstrate that even under temperate climatic conditions, carcasses can be utilised relatively rapidly. This suggests that, in addition to temperature, the composition and activity of the local scavenger community may play a crucial role in carcass removal dynamics. Opportunistic mammalian predators and corvids dominated at the study sites and were efficient in both detecting and consuming carrion. Furthermore, the presentation of carcasses – whether intact, incised, or consisting solely of viscera – may have accelerated both detection and consumption processes.

The broad range of carcass persistence (up to 19 days) indicates that carcass utilisation dynamics can be highly variable and influenced by environmental conditions, seasonal factors, and stochastic events. Such variability highlights that carrion functions as a short-lived yet highly dynamic energy pulse within ecosystems, with its incorporation into trophic networks depending on complex interactions between biotic and abiotic factors.

Although carrion represents only a small proportion of total detrital biomass in most ecosystems (Swift et al., 1979; Parmenter, MacMahon, 2009), its ecological role in nutrient cycling and population dynamics is disproportionately large compared to plant detritus. This is primarily due to two key characteristics: first, carrion is nutrient-rich, whereas plant detritus is generally nutrient-poor and contains relatively low concentrations of essential macronutrients such as nitrogen and phosphorus (Swift et al., 1979; Moore et al., 2004). Second, carrion decomposes much more rapidly than plant detritus – potentially up to three times faster (Parmenter, MacMahon, 2009). These features – accelerated temporal dynamics and high nutrient concentration – make carrion a distinctive component of detrital resource pools in terrestrial ecosystems (Barton et al., 2013).

In addition, a study conducted in Minnesota, USA, demonstrated that piles of deer gut attract a variety of animal species and increase their spatial aggregation. Predators at these sites not only fed on carrion but also increased predation on other animals, thereby intensifying predator–prey interactions and altering local food web structure (Candler et al., 2023). Thus, carrion serves not only as a direct food source for scavengers but also as a driver of broader ecological interactions within ecosystems.

CONCLUSIONS

Red foxes, raccoon dogs, and ravens were the most frequent visitors to carcasses in Varnaitinė Forest. Ravens most commonly detected carcasses first. The observed carcass detection and consumption times indicate that in temperate forest ecosystems, carrion functions as a short-lived but ecologically significant source of food and energy.

Received 3 March 2026
Accepted 22 May 2026

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STAMBIŲJŲ ŽINDUOLIŲ GAIŠENŲ APTIKIMAS IR VARTOJIMAS MAITĖDŲ MITYBOJE

Santrauka

Maita yra labai trumpalaikis reiškinys. Gyvūnui mirus, jo kūnas tampa gaišena, kurią gali vartoti maitėdos, detritofagai ir kiti mikroorganizmai. Erdviniu požiūriu maita nėra vienodas išteklius, tai biologinės ir cheminės veiklos židinys, dar labiau išryškėjantis didelių stuburinių gyvūnų atveju. Pasaulyje yra atlikta įvairių tyrimų, susijusių su maita ir jos vartojimu, tačiau dar daug informacijos apie gaišenų suradimą, vartojimą ir įtaką ekosistemoms nėra žinoma. Lietuvoje tokių tyrimų nėra, todėl šiuo tyrimu siekta ištirti stambiųjų žinduolių gaišenų vartojimą maitėdų mityboje Jurbarko r. esančiame Varnaitinės miške. Keturiose šio miško vietose buvo dedama gaišena maždaug du kartus per mėnesį. Tyrimo vietose gyvūnai buvo stebimi pakabintomis vaizdo kameromis: kokie gyvūnai lankosi prie gaišenų, per kiek laiko jas aptinka, kiek laiko išbūna, per kiek laiko gaišena likviduojama. Tyrimo rezultatai rodo, jog Varnaitinės miške prie gaišenų dažniausiai lankėsi lapės, mangutai ir krankliai. Atviresnėse vietose pirmieji gaišenas dažniausiai aptikdavo krankliai. Vidutinis maitos aptikimo laikas – 30 val., vidutinis jos likvidavimo laikas – 81 val. Tyrimo vietose nustatytas maitos aptikimo ir suvartojimo laikas leidžia manyti, kad maita vidutinio klimato miško ekosistemose funkcionuoja kaip trumpalaikis, tačiau ekologiškai reikšmingas maisto ir energijos šaltinis.

Reikšminiai žodžiai: maita, maitėdos, maitos aptikimas, likvidavimo dinamika