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RESEARCH ARTICLE

SEASONALITY, ABUNDANCE, AND CARRION PREFERENCE OF CARRION BEETLES (STAPHYLINIDAE: SILPHINAE) FROM A SMALL-SCALE SURVEY IN STEELE CREEK PARK, NORTHEASTERN TENNESSEE

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ABSTRACT

Carrion beetles (Staphylinidae: Silphinae) are an essential component of terrestrial ecosystems, facilitating decomposition and nutrient cycling, particularly with vertebrate carcasses. Activity periods of carrion beetle species are known to vary seasonally, and some species have been suggested to vary in the types of carrion they prefer to utilize. Here, we examined the seasonality and abundance of carrion beetles in northeastern Tennessee during a survey over thirteen weeks (trapping every other week totaling seven periods) within a power line right-of-way in Steele Creek Park, Sullivan County, Tennessee. Additionally, the differences between two different bait samples (mouse and snake) were compared. Seven species of carrion beetles were captured during the survey, with *Necrophila americana* (L.) being the most abundant. Although the survey was limited compared to others, the abundance and seasonality of the assemblage broadly aligned with other studies in the region. The snake bait captured nearly twice as many beetles as the mouse bait, though the difference was not statistically significant. Furthermore, no single species showed a significant difference between the baits, suggesting that there is limited bait preference among the species studied. We conclude that carrion beetles have relatively predictable seasonal patterns within the region that drive their presence and abundance, but that species may have no preference for different carrion taxa.

Keywords: carcass, Coleoptera, insect survey, necrophagy, phenology, southern Appalachia.

INTRODUCTION

Carrion beetles (Staphylinidae: Silphinae) consist of nearly 200 species in two taxonomic groups across the globe (Sikes et al., 2024; Weidner & Merritt, 2026), and the fauna of North America is relatively well-known compared to other beetle taxa (Weidner & Merritt, 2026). They are relatively large, conspicuous beetles, many mostly black with orange or red coloration (Sikes et al., 2002; Evans, 2014; Weidner & Merritt, 2026). Due to their reproductive strategy of utilizing carrion, and the unique parental care exhibited by *Nicrophorus* species, carrion beetles have been the subject of many scientific investigations (Sikes et al., 2024; Weidner & Merritt, 2026). The group is also important in forensic investigations to determine post-mortem intervals when present (Dekeirsschieter et al., 2011; Cruise et al., 2018). Ecologically, carrion beetles provide necessary ecosystem functions by facilitating decomposition and nutrient cycling, mainly with vertebrate carcasses, an ephemeral resource with a high degree of competition between vertebrate and invertebrate scavengers (Dekeirsschieter et al., 2011; Abernethy et al., 2017; Fusco et al., 2017; Büchner et al., 2024). As such, it is important that we better understand their seasonality and abundance, as well as carrion preference, to contextualize the patterns relevant to these topics.

Carrion beetle communities vary seasonally in their activity and abundance, which is a significant factor allowing for reduced competition for resources via temporal partitioning (Anderson, 1982; Büchner et al., 2024). Of the species likely to occur in Steele Creek Park, *Oiceoptoma inaequale* (Fabricius) and *O. noveboracense* (Forster) are among the earliest to become active, usually in early spring (Reed, 1958; Anderson & Peck, 1985). *Oiceoptoma inaequale* also tends to be less common in areas where *O. noveboracense* is common (Anderson, 1982). *Necrophila americana* (L.) and *Necrodes surinamensis* (Fabricius) tend to be active throughout much of spring, summer, and early fall (Reed, 1958; Ratcliffe, 1972; Anderson & Peck, 1985). *Nicrophorus* species mostly utilize small carcasses for reproduction, so greater competition exists between them (Potticary et al., 2024). Several *Nicrophorus* species are reproductively active early in the season (Anderson, 1982). However, *Nicrophorus tomentosus* Weber typically emerges later in the season than congenerics (Anderson, 1982; Owings & Picard, 2015). This species does not overwinter as an adult like other *Nicrophorus* species, but instead overwinters as a prepupa, and pupates the following spring (Anderson, 1982; Anderson & Peck, 1985). Habitat use, food type, and food size preference are other important aspects contributing to resource partitioning (Anderson, 1982; Burke et al., 2020).

Carrion beetles can be found on any vertebrate carcass. However, some coleopterists in the first half of the twentieth century (e.g., Smith, 1910) reported that some species showed a preference for certain vertebrate carcasses, such as ectotherms or endotherms (Shubeck, 1976a). Shubeck (1976a) summed up these claims, which appeared in widely available North American beetle guides (i.e., Jaques, 1951; Dillon & Dillon, 1961) at the time. Following previous guidebooks, White (1983) stated, “Different species are attracted to different kinds of animals; some to mammals, some to birds, some to snakes, some to fish.” Shubeck (1976a) noted that the assumption that some carrion beetles show a bias towards certain carrion taxa was apparently based on observations and not experimental results. Additionally, any perceived carrion preference in beetles could also be a function of the seasonality of different carrion taxa, especially in certain habitats during certain times of the year (e.g., wetland habitats during amphibian breeding periods [Abernethy et al., 2017]). In many modern carrion beetle surveys, the choice of bait seems to be based on what is readily available or what has been used in previous surveys (e.g., Ulyshen & Hanula, 2004; Katovich et al., 2005; Beirne, 2012; Fusco et al., 2017).

Shubeck (1976a) attempted to test these claims using fish (ectothermic) and chicken (endothermic) baits in New Jersey and found only *Nicrophorus orbicollis* Say showed a significant difference between the two baits, with more captured with fish bait. He hypothesized that since it was the only nocturnal species analyzed, the fish must emit odors that are more easily detectable at night by nocturnal carrion beetles (Shubeck, 1976a). Coyle & Larsen (1998) examined the effectiveness of four bait types in Iowa using fish, chicken, beef liver, and piglet, concluding that chicken was the most effective bait, attracting a diverse assemblage of carrion beetles, but with beef liver attracting nearly twice as many individuals, and fish attracting the same number of species. Some future surveys chose chicken bait based on these conclusions (e.g., Wolf & Gibbs, 2004).

The purpose of this study was to document the diversity and seasonality of carrion beetles in Steele Creek Park, northeastern Tennessee, and to revisit the claims of early researchers that some species are attracted to certain carrion taxa more than others. We hypothesized that carrion beetles would show similar abundance and seasonal patterns as found in previous studies in the region and that species would show no preference for carrion taxa.

Materials and Methods

Study site

The carrion beetle survey took place at a power line right-of-way in Steele Creek Park in northeastern Tennessee (Fig. 1). The park is a 9.259 km^2 municipal park in Sullivan County, near the Virginia border (Jessee et al., 2022). It falls within the Ridge and Valley physiographic province and is characterized by forested steep, shale knobs (405 to 670 meters above sea level). It is surrounded by residential and commercial development (Klahs, 2014; Jessee et al., 2022). The power line right-of-way runs in a northwest-southeast direction perpendicular to the knobs (Fig. 1). It was cleared of all trees in 2022 by Bristol Tennessee Essential Services and herbicide was applied to the cleared area in 2024 (S. Craddock, BTES, personal communication). Prior to the clearing of the trees, it was similar in appearance to the adjacent forested area of mature, second-growth, hardwood forest, excluding the area immediately surrounding the power line towers at the knob peaks, which have been cleared of trees for several years. The clearing is now characterized by several early successional native and non-native herbaceous and woody plants, namely Japanese stiltgrass (*Microstegium vimineum* [Trinius]: Poaceae), northern spicebush (*Lindera benzoin* [L.]: Lauraceae), princess tree (*Paulownia tomentosa* [Thunberg]: Paulowniaceae) saplings, brambles (*Rubus* sp.: Rosaceae), and thistles (Asteraceae), as well as several other early succession trees.

Carrion beetle survey

Carrion beetles were surveyed every other week for seven-day periods from 20 May to 19 August 2025, resulting in seven trapping periods (Table 1; Fig. 2b). Two carrion beetle traps, one on each side of the power line right-of-way, were located at a low area (530 meters above sea level) on a northwest slope (Fig. 1). The traps were placed 35 meters apart. Traps were an above-ground design (sitting on the ground as opposed to pitfall-style traps) similar to the traps designed by Shubeck (1976b), and the beetles had to actively climb into the trap to get to the bait. One adult mouse (large size adult feeder mice, *Mus musculus* [L.]) and a similar-sized section of snake (*Pantherophis* sp.) (both between 27 to 40 grams) were used as baits each trapping period and placed inside a mesh-covered plastic cup inside the trap. The insects did not have direct access to the baits and were trapped live. The mouse and snake baits were chosen to represent endothermic and ectothermic carrion following the previous reports of carrion preference (see Shubeck [1976a] and references therein; White, 1983), and both species are active throughout the survey period (May – August). Mouse and snake baits were on opposite sides of the power line right-of-way each trapping period, then alternated each period. Adult beetles were collected from the traps and counted on the third and seventh day of the trapping periods, then totaled for each of the seven periods and each bait type (seven samples for each bait type) (Table 1). Vouchers of all species are housed in the research collections of The Nature Center at Steele Creek Park.

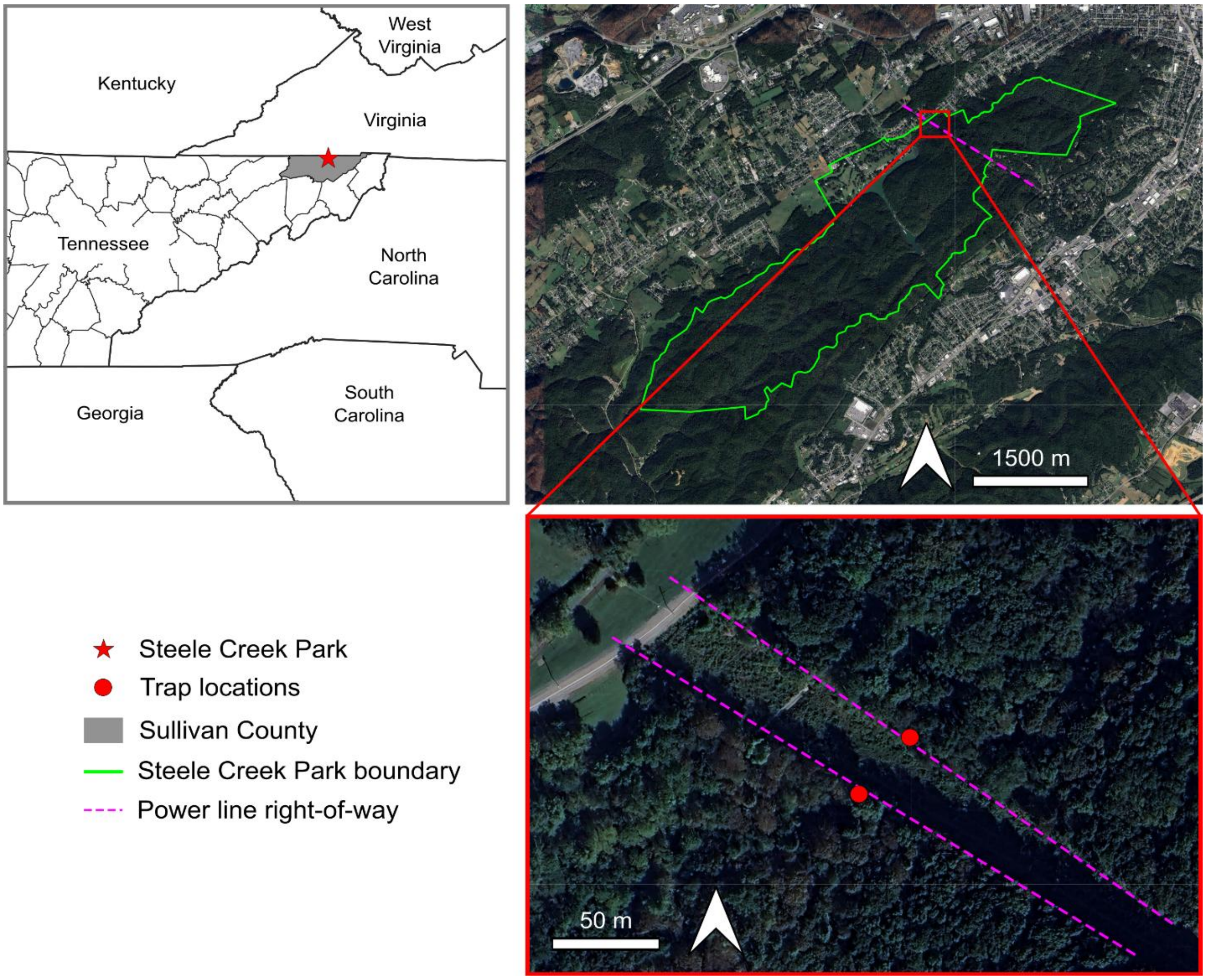

Figure 1. Location of Steele Creek Park in northeastern Tennessee and the location of the two trap locations within the power line right-of-way.

Statistical analysis

All analyses were performed in PAST (Paleontological Statistics, version 4.03) (Hammer et al., 2001). The two different bait classes (mouse vs. snake) were tested for statistical differences in total carrion beetle abundance and abundances of each species using the Mann-Whitney *U*-test, excluding *Necrodes surinamensis* and *Nicrophorus pustulatus* due to their overall low numbers. This test was chosen due to the non-normal distribution of the majority of the data. Shannon diversity (*H*'), a common measure of community heterogeneity (Magurran, 1988), of the two bait samples were tested for statistical difference using the diversity permutation test. Shannon diversity (*H*') was also determined for the two periods, early (20 May to 4 July) and late (8 July to

19 August), and tested for statistical difference using the diversity permutation test. Species evenness, the distribution of species abundances within a community (Buzas and Hayek, 1996), was determined for the two bait samples, as well as the early and late periods. The phenology of each beetle species throughout the survey and the percent species abundance for each trapping period were graphed (Fig. 2).

Table 1. Abundance of each carrion beetle (Staphylinidae: Silphinae) species recorded in this survey for each of the two bait types (recorded as mouse/snake) during each trapping period. *Necrophila americana* (*N.a.*), *Oiceoptoma noveboracense* (*O.n.*), *Oiceoptoma inaequale* (*O.i.*), *Necrodes surinamensis* (*N.s*), *Nicrophorus tomentosus* (*N.t.*), *Nicrophorus orbicollis* (*N.o.*), *Nicrophorus pustulatus* (*N.p.*), Shannon diversity (*H'*), species evenness (Evenness).

Trapping period	*N.a.*	*O.n.*	*O.i.*	*N.s.*	*N.t.*	*N.o.*	*N.p.*	Total	*H'*	Evenness
20-27 May	17/15	2/4	13/7	-	-	5/0	-	37/26		
3-10 June	11/1	8/10	11/1	-	-	1/0	-	31/12		
17-24 June	12/76	5/34	1/6	-	1/18	0/1	-	19/135		
1-8 July	58/41	0/2	-	0/1	6/12	4/2	0/3	68/61		
15-22 July	12/88	-	-	-	0/3	0/3	0/1	12/95		
29 July-5 August	24/6	-	-	-	1/0	3/1	-	28/7		
12-19 August	1/40	-	-	-	0/4	0/4	-	1/48		
Total	135/267	15/50	25/14	0/1	8/37	13/11	0/4	196/384	1.0267/ 1.0291	0.5583/ 0.3998

Results

Diversity, abundance, and seasonality

Seven species of carrion beetles, resulting in 580 individuals, were captured during the survey (Tables 1 and 2). *Necrophila americana* was the most abundant species (n = 402). All other species were captured in relatively low numbers, especially *Nicrophorus pustulatus* Herschel (n = 4) and *Necrodes surinamensis* (n = 1) (Tables 1 and 2). Other necrophilous beetles captured, but beyond the scope of this paper, were Histeridae, non-silphine Staphylinidae, Leiodidae, Scarabaeidae, Dermestidae, and Nitidulidae.

Necrophila americana (n = 402) was the most abundant species during each trapping period, except the second period (3 June to 10 June). *Oiceoptoma inaequale* (n = 39) and *O. noveboracense* (n = 65) were almost exclusively captured during the first three trapping periods (20 May to 24 June) with none captured after 8 July. *Nicrophorus tomentosus* (n = 45) was captured regularly in relatively low numbers beginning on the third trapping period (17 June to 24 June). *Nicrophorus orbicollis* (n = 24) was consistently captured in low numbers nearly all trapping periods. *Nicrophorus pustulatus* (n = 4) was captured in very low numbers during two trapping periods (1 July to 22 July). One individual of *Necrodes surinamensis* was captured during the period of 1 July to 8 July (Table 1; Fig. 2).

The diversity of the early (*H'* = 1.3036) and late (*H'* = 0.5177) periods differed extensively (Table 2), which was statistically significant ($p = 0.0001$). Species evenness of the two periods also differed extensively, with the early period (0.6137) having a higher evenness than the late period (0.2797) (Table 2).

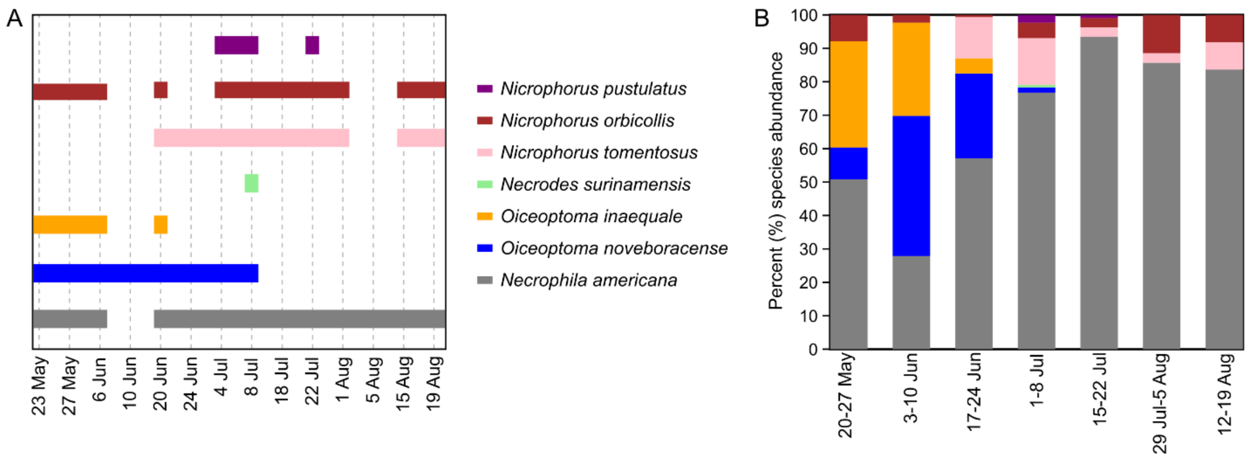

Figure 2. Phenology of each species throughout the survey period (2025) using data from each collection day (A) and percent species abundance for each trapping period (B).

Bait comparison

The mouse bait recorded a total of 196 (mean = 28, SD = 21.4) carrion beetles, and the snake recorded 384 (mean = 54.9, SD = 46.7) carrion beetles across all seven trapping periods (Table 1). This was not a statistically significant difference ($U = 17.5$, $z = 0.8315$, $p = 0.4057$). Although more individuals were captured with snake bait for a few species (Table 1), no statistically significant difference was found regarding each individual species (Fig. 3). The mouse and snake baits had a near equal diversity, $H' = 1.0267$ and $H' = 1.0291$ respectively (Table 1), with the difference not being statistically significant ($p = 0.9799$). Species evenness was highest with the mouse bait (0.5583) (Table 1).

Table 2. Carrion beetle (Staphylinidae: Silphinae) species recorded in this survey during early (20 May to 4 July 2025) and late (8 July to 19 August 2025) sampling periods. Species are in order of total capture.

	Early	**Late**
Necrophila americana	150	252
Oiceoptoma noveboracense	64	1
Nicrophorus tomentosus	28	17
Oiceoptoma inaequale	39	0
Nicrophorus orbicollis	10	14
Nicrophorus pustulatus	1	3
Necrodes surinamensis	0	1
Total	292	288
Shannon Diversity (H')	1.3036	0.5177
Species Evenness	0.6137	0.2797

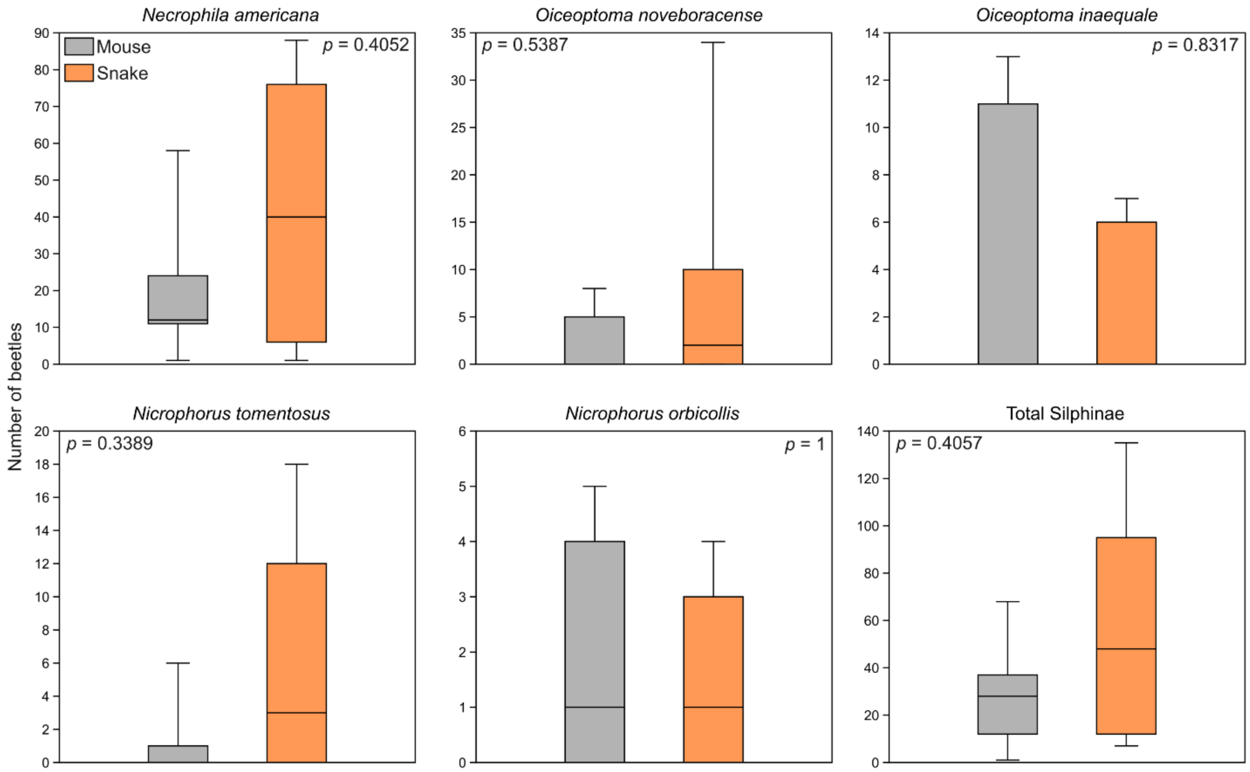

Figure 3. Box and whisker plots showing the distribution of data from each bait type (mouse and snake) across all seven trapping periods for each species and total carrion beetles. *Necrodes surinamensis* and *Nicrophorus pustulatus* were excluded due to their low sample size. Differences were not statistically significant.

Discussion

Diversity, abundance, and seasonality

Results from the carrion beetle survey revealed the presence of all species expected. It is unsurprising that *Necrophila americana* was the most abundant carrion beetle captured in this survey. *Necrophila americana* is often very abundant in many places, primarily forested areas, within its range (e.g., Coyle & Larsen, 1998; Ulyshen & Hanula, 2004; Beirne, 2012; Dyer & Price, 2013; Owings & Picard, 2015). Likewise, carrion beetle surveys in the Ridge and Valley of southwestern Virginia (Beirne, 2012) and southeastern Tennessee (Lumpkin, 1971) have yielded similar results, with *N. americana* being the most abundant. In Virginia, *N. americana* tends to be more predominant in the Ridge and Valley (Beirne, 2012), and the same trend likely extends into Tennessee (Lumpkin, 1971). The abundances of the other carrion beetle species captured in this survey also showed similar trends to studies in the southern Ridge and Valley of Virginia and Tennessee (Lumpkin, 1971; Beirne, 2012).

Nicrophorus marginatus (Fabricius) is the most widely distributed member of its genus in North America, ranging across most of the United States, southern Canada, and northern Mexico, but is uncommon to absent in most of the southeastern United States (Ratcliffe, 1996; Sikes et al., 2002; Ulyshen & Hanula, 2004). *Nicrophorus marginatus* has been recorded within the southern Ridge and Valley (Lumpkin, 1971; Tabor et al., 2005; Beirne, 2012), but was not recorded in this survey, nor has it been collected or observed in Steele Creek Park prior. Tabor et al. (2005) noted its presence in Montgomery County, Virginia. Beirne (2012) found it made up over eight percent of carrion beetles in Pulaski County, Virginia (open field location), but it was not recorded in Bath County, Virginia (forest edge location). Lumpkin (1971) recorded just one individual of the species at survey sites below 610 meters above sea level, and more individuals at higher elevations. It seems that the species could be locally abundant in a few areas of the southern Appalachian region where appropriate habitat exists but absent from others. However, it was not expected in this survey due to its open habitat preference (Anderson & Peck, 1985; Lingafelter, 1995; Ratcliffe, 1996; Dyer & Price, 2013). *Nicrophorus defodiens* Mannerheim and *N. sayi* Laporte are both known from nearby areas to Steele Creek Park but are almost exclusively found in higher elevations of the southern Blue Ridge (Lumpkin, 1971; Trumbo, 1990; Beirne, 2012; Evans, 2014), thus were also not expected in this survey.

Due to the small scale of this survey, discerning patterns of seasonal activity were limited. However, a few broad patterns were evident. The seasonal activity of each species showed broadly similar trends to studies in the southern Ridge and Valley of Virginia and Tennessee (Reed, 1958; Lumpkin, 1971; Beirne, 2012) as well as other studies in nearby states (Ulyshen & Hanula, 2004; Dyer & Price, 2013; Owings & Picard, 2015). Both *Oiceoptoma* species were active only in the earlier trapping periods in this survey (Fig. 2), which corresponds to other studies in the region (Reed, 1958; Ulyshen & Hanula, 2004; Beirne, 2012). The last captures of *O. inaequale* and *O. noveboracense* in this survey were 20 June and 8 July respectively (Fig. 2a). Although the data is limited, *O. inaequale* seemed to peak in abundance earlier than *O. noveboracense*, resembling the seasonal activity found in other studies (Shubeck et al., 1977; Beirne, 2012; Owings & Picard, 2015). Both species are typically the first carrion beetles to become active (Reed, 1958; Anderson, 1982; Ulyshen & Hanula, 2004) and were likely active for several weeks prior to the start of this survey.

Necrophila americana was active throughout the survey period with peak activity in late June through July. *Nicrophorus orbicollis* was also active throughout the survey but was captured in relatively low numbers each trapping period, so no peak in activity is apparent. *Nicrophorus tomentosus* was first captured in late June, the typical time of emergence for the species (Anderson & Peck, 1985; Owings & Picard, 2015). The species was found to have two peaks in activity in northeastern Georgia (Ulyshen & Hanula, 2004) and Maryland (Dyer & Price, 2013). It was still active during the final trapping period and may have had another peak in activity if trapping continued. *Necrodes surinamensis* and *Nicrophorus pustulatus* were captured in too few numbers to determine activity periods, but both species are known to be active throughout the summer (Ratcliffe, 1972; Shubeck et al., 1977; Ulyshen & Hanula, 2004; Dyer & Price, 2013). Lumpkin (1971) captured most *Necrodes surinamensis* in June and July in southeastern Tennessee. These two species tend to be captured in low numbers in carrion traps (Anderson, 1982; Robertson, 1992), and both appear to prefer large carcasses in the wild (Ratcliffe, 1972; Anderson, 1982; Trumbo, 1990; Ulyshen et al., 2007). Additionally, *N. pustulatus* appears to forage more often at canopy-level than at ground-level (Ulyshen et al., 2007; Legros & Beresford, 2010; Dyer & Price, 2013; Burke et al. 2020).

There was a significant difference in the diversity of carrion beetles in the early (20 May to 4 July) versus the late (8 July to 19 August) periods of the survey, although nearly the same number of individuals were captured during each (Table 2). The early period included nearly all the *Oiceoptoma* individuals as well as more *Nicrophorus tomentosus*, contributing to the higher diversity and species evenness. Aside from *Necrophila americana*, nearly all species were captured in relatively low numbers during the late period (Table 2). The high abundance of *N.*

americana during the late period heavily influenced the diversity and species evenness indices. This study generally aligns with Shubeck et al. (1977) and Owings & Picard (2015) who found that *Necrophila* and *Oiceoptoma* are predominant earlier in the season and *Nicrophorus* is predominant later in the season.

Bait comparison

This study tested some of the early claims that some carrion beetle species have a preference for ectothermic carrion over endothermic carrion (see Shubeck [1976a] and references therein; White, 1983). Prior to this survey, *Necrodes*, *Necrophila*, and *Oiceoptoma* have all been observed on various large carcasses of mammals, birds, and reptiles in Steele Creek Park (L. D. Jessee, personal observation). Although nearly twice as many carrion beetles were captured in snake-baited traps (Table 1), the difference was not statistically significant. Contrasting with Shubeck (1976a), who found *Nicrophorus orbicollis* to show a significant preference for ectothermic carrion (fish), *N. orbicollis* did not show a significant preference for either bait type in this survey (Fig. 3). However, this survey was limited with fewer traps, fewer individuals captured, and different baits were used.

The diversity of carrion beetles captured with mouse and snake bait were very similar and showed no statistical significance. The species evenness, higher for mouse bait than snake bait, was heavily influenced by *Necrophila americana* being very abundant, especially in the snake bait sample. This survey did not show that mouse or snake bait performed significantly better, although more carrion beetles were captured with snake bait. It is unknown whether the size of the bait, small in this case, had any influence on attracting carrion beetles, but carcass size could potentially influence the abundance of beetles (Anderson, 1982; Schmude, 2013). Although, decomposition stage of the carcass likely has more of an influence than size (Büchner et al., 2024). Also not tested here is whether certain traits of vertebrate taxa (e.g., nutrient, calorie, fat, and moisture content) influence carrion beetle abundance or potentially influence carrion beetle fitness.

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