

TEMPORAL SURVEY OF A CARRION BEETLE (COLEOPTERA: SILPHIDAE) COMMUNITY IN INDIANA

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ABSTRACT. Carrion beetles (Coleoptera: Silphidae) play an important role in vertebrate decomposition as they utilize carcasses to carry out their life cycles. These beetles represent novel models for behavioral ecology, and can act as important forensic indicators in death investigations. However, population and community dynamics of silphids in Indiana are currently outdated. The aim of this study is to update surveys of a single silphid community with high temporal resolution in order to explore diversity and abundance patterns over time. Beetles were collected from Purdue University multiple times (N = 13) over a period of seven months in order to assess population dynamics at a single site. A total of 1607 specimens constituting seven different species were collected. Species abundance over time and space changed dramatically, and only one species (*Nicrophorus tomentosus* Weber) was present in nearly all collections (eleven out of thirteen, June–October 2014). It was demonstrated that the community dynamics of silphids at a single site in Indiana aligns with previous studies in the state. Additionally, the community structure of this family appears to change drastically over time in the summer months.

Keywords: Silphidae, carrion, forensic entomology, *Nicrophorus tomentosus*

INTRODUCTION

After death, a vertebrate carcass assumes the role of a quality, yet highly ephemeral, nutrient resource that is utilized by insects and other organisms (Benbow et al. 2015). Though blow flies (Diptera: Calliphoridae) represent the most heavily scrutinized carrion-breeders by ecologists and forensic scientists (Amendt et al. 2004), beetles can also play a critical role in the decomposition process (Dekeirsschieter et al. 2013b). In particular, carrion beetles (Coleoptera: Silphidae) utilize carcasses to carry out their life cycles and represent novel models for behavioral ecology (Ratcliffe 1996).

Silphids are widespread in North America, with recorded observations in Arkansas (Holloway & Schnell 1997), Colorado (Smith et al. 2000), Indiana (Shubeck et al. 1977; Perez et al. 2014), Iowa (Coyle & Larsen 1998), Louisiana (Watson & Carlton 2005), Michigan (Werner & Raffa 2003), Missouri (Shubeck & Schlepplik 1984), Nebraska (Ratcliffe 1996), New Jersey (Shubeck 1983), Texas (Mullins et al. 2013), and Virginia (Beirne 2013). Two subfamilies (Nicrophorinae and Silphinae) comprise this family (Anderson & Peck 1985), and can be differentiated by both morphology (i.e., body

shape) and resource utilization. Nicrophorine beetles (“Burying Beetles”) not only directly consume the carcass (necrophagy), but also bury it for their offspring, thereby preventing intruders from “stealing” the carcass (Trumbo 1990). In particular, nicrophorines (e.g., *Nicrophorus investigator* Zetterstedt) preferentially bury small (16–48 g) vertebrate carcasses (Smith & Heese 1995; Smith & Merrick 2001), thereby providing a protected, consistent resource on which to rear offspring. Larvae of this species are altricial, requiring one or both parents (biparental brood care) to feed them for the extent of their immature life stages. Meanwhile, silphine beetles (e.g., *Necrophila americana* Linnaeus) consume larger carcasses for feeding and will prey on other scavengers (necrophily), but do not bury carcasses or exhibit any parental care.

Members of the subfamily Nicrophorinae have been the focus of intense ecological research in the last century, as they exhibit a suite of remarkable reproductive behaviors, including communal breeding in response to competition with flies (Scott 1994), carcass modification (Pukowski 1933), and biparental care (Scott 1998). Nicrophorines also possess specialized chemosensory adaptations to efficiently locate a carcass (Dekeirsschieter et al. 2013a) and emit volatiles to kill microorganisms on the carcass (Haberer et al. 2014). In addition,

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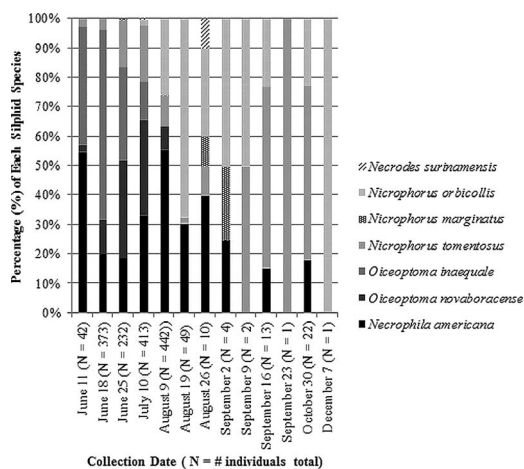


Figure 1.—Stacked bar plot showing the percentage of each silphid species ($N = 7$) of the total silphid abundance at Purdue University over 13 collection periods.

nicrophorines exhibit complex ecological and evolutionary associations with phoretic mites in which the beetle acts as a vehicle to transport up to hundreds of mites to ephemeral resources, including carcasses. The mites, in turn, may consume eggs or larvae of competitors (Springett 1968; Wilson 1983; Schwarz & Müller 1992).

The population dynamics of common silphids have been previously investigated in other regions, including *Nicrophorus americanus* Olivier in Arkansas (Holloway & Schnell 1997), Indiana (Shubeck et al. 1977), and particularly populations of *N. investigator* in Colorado (Smith & Heese 1995; Smith et al. 2000; Smith & Merrick 2001). Silphid population sizes tend to be significantly correlated with small mammal biomass (Holloway & Schnell 1997; Smith & Merrick 2001). The purpose of this study was to re-assess a community of silphids that had been surveyed many years prior at Purdue University (West Lafayette, IN) (Shubeck et al. 1977). Results of this study are compared to what was previously found at the Purdue site, as well as results from a nearby site seeded with 53 pig (*Sus scrofa* Linnaeus) carcasses in Rensselaer, IN (Perez et al. 2014).

MATERIALS AND METHODS

Silphids were sampled from the FERC (Forensic Entomology Research Center) at Purdue University from June to December 2014. Beetles were collected passively via pitfall traps

consisting of a plastic 6-quart (5.7 L) storage box filled with approximately 5 cm of pet-friendly RV & marine antifreeze (Super Tech®) and baited with approximately 500 g aged chicken liver and blood in a 710 mL plastic food storage container. This apparatus was buried flush with the surface of the ground and covered with chicken wire to exclude scavengers, and covered with an aluminum roof approximately two inches above ground to protect the trap from rain. Three pitfall traps were placed at approximately 15 m intervals and were checked every week in June and July 2014, and every two to three weeks thereafter for a total of 13 collections.

At each collection, antifreeze containing trapped insects was filtered through a 20 cm diameter 88 mesh strainer and stored in 95% ethanol. Traps were reset with aged chicken liver bait, and filled with clean antifreeze. Silphids were identified to species via morphological taxonomy (Anderson & Peck 1985; Mullins et al. 2013), counted, and stored at -20°C . Temperature data (average, maximum, and minimum ($^{\circ}\text{C}$)), for each site was posteriorly collected from archived historical weather data (www.wunderground.com). Specimens are vouchered at the Purdue Entomology Research Collection.

Statistics were performed in R using standard packages (R Core Team 2015), as well as the vegan package for biodiversity statistics (abundance, species richness, Simpson's index of diversity, and Jaccard's similarity coefficient) (Oksanen et al. 2015).

RESULTS

A total of 1607 silphids were collected from June to December 2014 (Fig. 1). Seven silphid species were collected (*Necrodes surinamensis* (Fabricius), *Necrophila americana* (Linnaeus), *Oiceoptoma novaboracense* (Forster), *Oiceoptoma inaequale* (Fabricius), *Nicrophorus marginatus* (Fabricius), *Nicrophorus orbicollis* (Say), and *Nicrophorus tomentosus* (Weber).

The summer months of June – August exhibited the greatest abundance of silphids ($N = 543$), as well as the highest average species richness ($R = 5.28$). Simpson's Index of Diversity ($I-D$) was greatest for late June/early July ($I-D = 0.751$), and late August ($I-D = 0.720$) when temperatures averaged 22.2°C ($9.4 - 30.6^{\circ}\text{C}$) and 24.4°C ($15.6 - 31.7^{\circ}\text{C}$), respectively. These dates also clustered together using Jaccard's

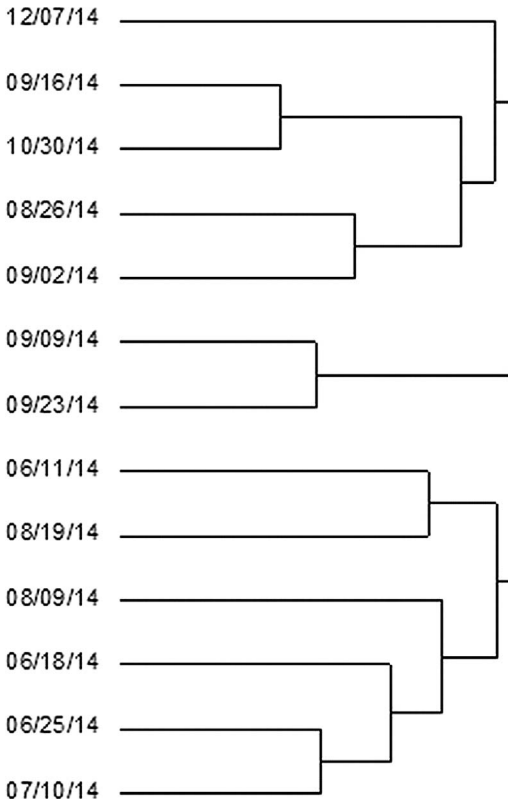


Figure 2.—Dendrogram representing Purdue University site collection dates clustered by number of shared species.

Index (clustering between sites based on shared species), whereas dates of low abundance and low diversity also clustered together (Fig. 2). Silphid abundances were as follows: *Np. americana* (N = 551, June – October), followed by *O. inaequale* (N = 386, June – August), *O. novaboracense* (N = 293, June – August), *N. tomentosus* (N = 199, June – October), *N. orbicollis* (N = 171, August – December), *N. marginatus* (N = 5, June, August – September), and *Ne. surinamensis* (N = 2, July, August).

DISCUSSION

Silphid species sampled in this study corresponded to those reported previously by Shubeck et al. (1977), except for the absence of *Nicrophorus pustulatus* (Herschel) in our survey. Shubeck et al. (1977) observed *O. novaboracense* as the most prominent species (N = 2033, April – July), followed by *O. inaequale* (N = 756, April – July), *Np. americana* (N = 572, April – July), *N. orbicollis* (N = 318, August – September),

N. tomentosus (N = 201, June – July), *Ne. surinamensis* (N = 25, June – July), and *N. pustulatus* (N = 13, June – September). Though rank order differs slightly, both Shubeck et al. (1977) and the current study show that the subfamily Silphinae predominates this region in early to mid-summer, and is replaced temporally by the Nicrophorinae from mid-summer to fall. Silphid diversity in the current study also aligns with observations made from 53 pig carcasses at Rensselaer, IN (Perez et al. 2014), the only discrepancy was that *O. inaequale*, was observed in our study but not in theirs.

The American Carrion Beetle, *Np. americana*, was the most predominant species collected (N = 551), and was present from mid-June to early October. This ground-dwelling silphid, with its preferences for an open-field habitat (Shubeck 1983), arrives at carcasses in late spring to early summer (Anderson 1982), and may arrive early in decomposition (Tabor et al. 2004). Collections of *Np. americana* have been made with carrion-baited pitfall traps (Coyle & Larsen 1998; Shubeck 1983; Werner & Raffa 2003), carcasses (Tabor et al. 2004), and isopropanol-baited pitfall traps (Reut et al. 2010). Two *Oiceoptoma* species (*O. inaequale* and *O. novaboracense*) comprised the second and third most abundant silphid sampled, but were only present from June to August. This genus appears 2–3 days after carcass deposition and can remain on or near remains until advanced decay (Tabor et al. 2004). Patterns of *Oiceoptoma* spp. sampled here align with those seen for *O. inaequale* and *O. novaboracense* in New Jersey, as they are most active in the early part of the summer and decline in abundance thereafter (Shubeck 1983). Though *N. tomentosus* was not the most abundant silphid overall, it was the most prevalent species in its subfamily, appearing at 11 of the 13 collections. This species has been speculated to be the “most active” species in this genus, as it may exhibit a broad flight range when searching for a carcass (Shubeck 1983). According to these collection data, *N. tomentosus* emerges in mid-late June and reaches peak abundance in August and September, a pattern that aligns with Anderson (1982).

Overall, this study demonstrated that silphid beetle communities exhibit consistent interannual diversity and abundance patterns for this site. Additional molecular analyses of silphid communities and individual species in the Midwest would greatly improve upon this

work and would shed light on the population genetic structure of carrion beetles. A community-based molecular approach to track changes in allele frequencies over time could give insight into why population dynamic patterns do not vary over time.

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