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Original Research

Unusually High Trap Catches of a Snake Egg Parasitoid, *Nicrophorus pustulatus* (Coleoptera: Silphidae) in the Frontenac Axis Population of Gray Ratsnake *Pantherophis spiloides*

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Abstract

Nicrophorus pustulatus was recently identified as a parasitoid of eggs of gray ratsnake (*Pantherophis spiloides*), northern ringneck snake (*Diadophis punctatus*) and eastern fox snake (*Elaphe gloydi*). We sampled *Nicrophorus* spp. near gray ratsnake hibernacula in the Frontenac Axis region, Ontario, using carrion-baited aerial traps set 6 m aboveground. We caught 6 species: *N. tomentosus* (500), *N. sayi* (416), *N. orbicollis* (202), *N. pustulatus* (174), *N. defodiens* (6), and *N. vespilloides* (2). The catches of *N. pustulatus* were highest in traps set near hibernacula (linear regression, R^2 = 0.78, P< 0.003); this relationship was not found with the other species. The greater abundance of *N. pustulatus* near hibernacula may affect nest success of gray ratsnakes.

Key Words: Burying Beetle, Gray Ratsnake, Hibernaculum, *Nicrophorus pustulatus*, Species at Risk.

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INTRODUCTION

Thousand Islands National Park is composed of fragmented mainland and island properties stretching along the St. Lawrence River within eastern Ontario's Frontenac Axis. This area is home to the St. Lawrence/Great Lakes population of gray ratsnake (*Pantherophis spiloides* DumŽril, Bibron and DumŽril), designated as a Species at Risk in 2007 (COSEWIC 2007), due to its limited geographic range in Ontario (Kraus *et al.* 2010). Typically, species of *Nicrophorus* use small- to medium-sized carcasses, often rodents, as a reproductive substrate and food source (Scott 1998).

Recently, *Nicrophorus pustulatus* Herschel has been identified as a possible significant source of egg mortality in oviparous snakes due to egg parasitism in gray ratsnake eggs (Blouin-Demers and Weatherhead 2000; Keller and Heske 2001), evidence that *N. pustulatus* has undergone a host-shift, exploiting the eggs of oviparous reptiles. *Nicrophorus pustulatus* is able to efficiently exploit snake eggs and regulate brood size (Smith *et al.* 2007). *Nicrophorus pustulatus* has also been observed exploiting the eggs of northern ring-necked snakes (*Diadophis punctatus edwardsii* Merrem; LeGros *et al.* 2010) and eastern fox snakes (*Pantherophis vulpinus* Baird and Girard; Robert Willson, 2000, University of Guelph, unpublished data).

In spite of its possible impact on oviparous snake reproductive success, it is not known if this poses a conservation threat (Smith *et al.* 2007). Very little is known about the life history, distribution, or abundance of *N. pustulatus*. In Ontario, *N. pustulatus* has been caught outside the gray ratsnake range, although in low numbers (Smith *et al.* 2007; LeGros and Beresford 2010). *Nicrophorus pustulatus* females have been induced to oviposit and successfully raise late-stage larvae on turtle eggs (Smith *et al.* 2007) and small rodent carcasses in the laboratory (Robertson 1992; Smith *et al.* 2007; Trumbo 1992, 2007), but it is not known if this species uses rodent carcasses in the wild (Robertson 1992; Wilson and Fudge 1984; Wilson *et al.* 1984; Trumbo 1990, 1991), in spite of being attracted to carrion baited traps (LeGros and Beresford 2010)

In this study we report on *Nicrophorus* spp., in particular *N. pustulatus*, abundance in one of the few regions of Ontario where gray rat snakes are known to hibernate. We sampled *N. pustulatus* in Thousand Islands National Park, the only national park in Canada within the range of gray ratsnake, using carrion-baited aerial traps (Ulyshen and Hanula 2007; LeGros and Beresford 2010) set at varying distances from known ratsnake hibernacula. Female gray ratsnakes disperse about 1 km from hibernacula to their nesting sites (Blouin-Demers and Weatherhead 2002). We tested the hypothesis that *N. pustulatus* abundance is high in areas where there are high numbers of gray ratsnake nests. We expected that beetle traps placed near known gray ratsnake hibernacula would catch more *N. pustulatus* than traps set in areas where hibernacula are not known to occur. This is based on the assumption that female ratsnake nests are generally more abundant in the area where hibernacula have been identified – these being indicative of suitable habitat. Other oviparous snakes that occur in this area are eastern milksnake (*Lampropeltis triangulum*), northern ring-necked snake (*Diadophis punctatus*), and smooth green snake (*Opheodrys vernalis*) http://www.ontarionature.org/protect/species/herpetofaunal_atlas.php).

MATERIAL AND METHODS

Adult *Nicrophorus* beetles were sampled weekly, from mid-May to mid-August 2014 in the Hill Island (44º21'N, 75º57'W) and Mallorytown (44º28'N, 75º51'W) properties of Thousands Islands National Park, Ontario, Canada, and also at a private property in Brockville, Ontario, Canada (44º35'N, 75º41'W) (Figure 1). Sample sites were within a large contiguous forested region of mixed woods plains ecozone, dominated by shagbark hickory (*Carya ovata*), sugar maple (*Acer saccharum*), northern red oak (*Quercus rubra*), and Eastern white pine (*Pinus strobus*). The 3 study sites were chosen to be located at varying distances from known and previously identified gray ratsnake hibernacula found during a radio-telemetry study on home range size and hibernaculum location initiated by Thousand Islands National Park in 2002 (Francis 2005). Nine traps were deployed for approximately 3 months across 3 sites: 3 traps at Hill Island, 4 traps at Mallorytown, and 2 traps at Brockville. The distance (km) from each trap to the nearest hibernacula was Hill Island: 0.054, 0.055, 0.165; Mallorytown: 2.081, 2.104, 2.195, 3.189; Brockville: 12.187, 12.241 (Figure 1). The Brockville study site was located outside of the gray ratsnake range. All study sites had mature trees and shaded understories with sparse herbaceous and shrub cover. Each trap was suspended 6 m aboveground and fastened in place with a rope over a tree branch (LeGros and Beresford 2010).

Beetle traps were constructed from 2 L clear carbonated soda bottles. Beetles fell down the bottle funnel into a 0.5 L bottle filled with 250 mL of propylene glycol (non-toxic plumbing antifreeze) to kill and preserve specimens (Thomas 2008). Each trap was baited with a fresh raw chicken drumstick suspended from a wire attached to the top of the trap. When samples were collected weekly, preservation fluid and bait was replaced. Specimens were removed and transferred to vials containing 80% denatured ethanol. The *Nicrophorus* species were identified and sexed using the keys in Anderson and Peck (1985). All by-catches were discarded.

There were 81 samples collected in total. Some traps were replaced shortly after being deployed due to wind damage; others were left in place for > 7 d due to access difficulties. Because of this, trap catches were expressed as number caught per 7 trapping-day period. Therefore, all sample periods were corrected to a 7-d equivalent sampling period, expressed as catch per week at each sampling site. Traps that were damaged or ruined were excluded from our analysis. We regressed the number of each *Nicrophorus* species caught to distance from known hibernacula. Trap catch data (n + 1) and distance were $\log_e$ transformed to normalize the data. Linear correlations were conducted using Statistica 7 (StatSoft). The linear regression P values were Bonferroni-corrected (Sokal and Rohlf 1997) as alpha 0.05/6 = 0.0083, 6 being the number of species caught. Figure 1was created using ArcMap 10.2.2.

RESULTS AND DISCUSSION

In total, we caught 1,300 *Nicrophorus* from 6 species. The most abundant was *N. tomentosus* (500), followed by *N. sayi* (416), *N. orbicollis* (202), *N. pustulatus (*174), *N. defodiens* (6), and *N. vespilloides* (2). *Nicrophorus pustulatus*, the species of interest, made up 13.3% of the total catch.

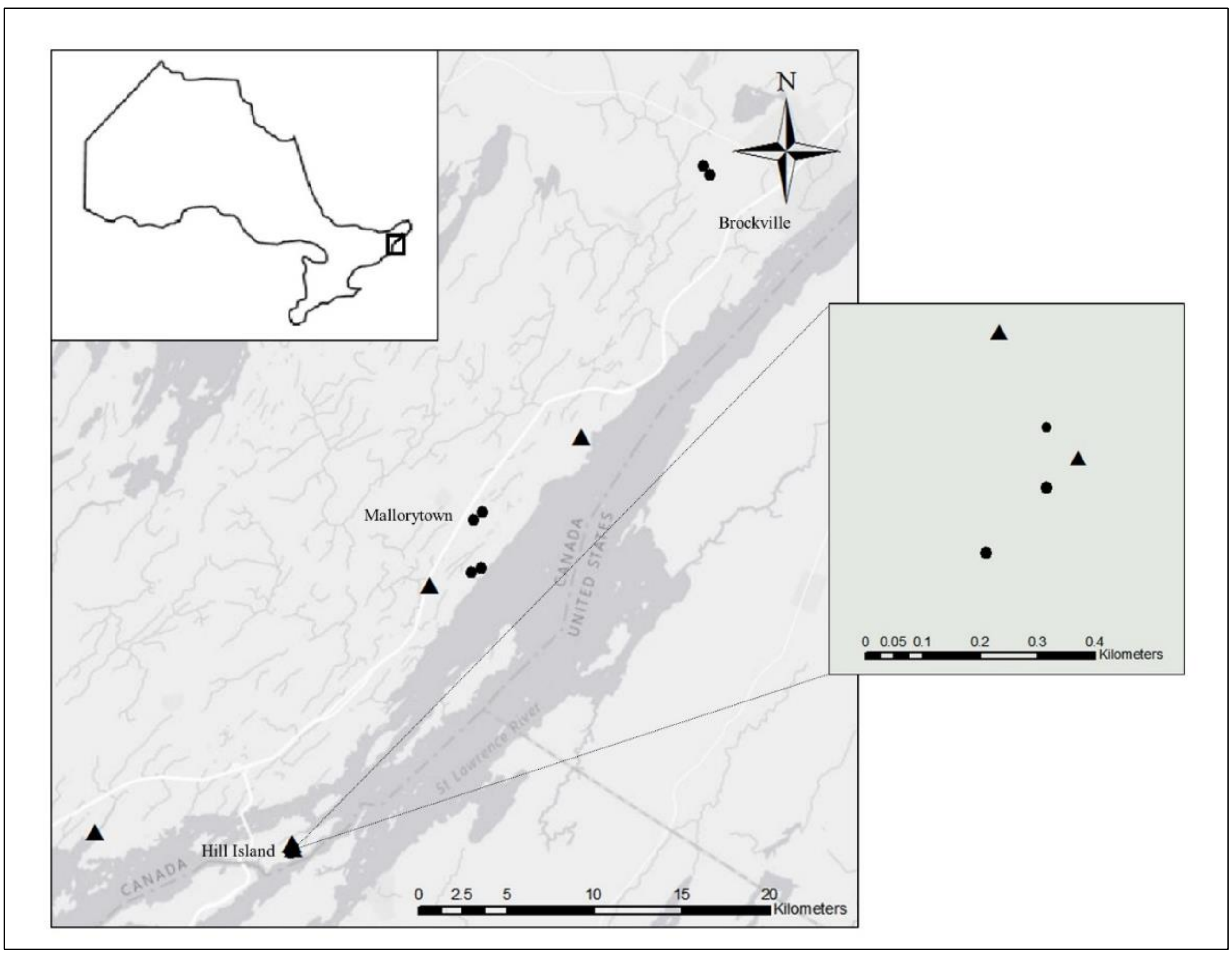

Figure 1. Location of known gray ratsnake hibernacula (closed black triangles) and individual trapping locations (closed black circles), the open black rectangle indicates the location of the study site in Ontario. The enlarged map shows gray ratsnake hibernacula and individual trapping locations on Hill Island.

Trap catches of *N. pustulatus* were highest in traps set near known gray ratsnake hibernacula (Figure 2). Catches of other *Nicrophorus* species did not follow this pattern. This supports our hypothesis that *N. pustulatus* is abundant in areas where gray ratsnakes are known to nest. This could have important implications for the conservation of this species in the Frontenac Axis region. Our catch of 174 N. pustulatus out of 1,300 *Nicrophorus* spp. (13.4 %) was an unexpectedly high proportion compared to previous reports, e.g., 2.2% (Shubeck 1969), 0.47% (Anderson 1981), 8.4% (Shubeck 1983), 4.3% (Shubeck and Schleppnik 1984), 0.36% (Lingafelter 1995), 0.29% (Backlund and Marrone 1997), 0.002% (Trumbo and Thomas 1998), 0.6% (Bedick *et al.* 1999), and 0.3% (LeGros and Beresford 2010), but note 11.7% (Ulyshen *et al.* 2007), and 36% (Dyer and Price 2013). *Nicrophrous pustulatus* was common in our traps, in spite of being reputedly rare (Shubeck 1970; Anderson 1982; Robertson 1992; Wolf and Gibbs 2004). This perception that *N. pustulatus* is rare or uncommon may be explained as an artifact of sampling method – baited aerial traps suspended several metres aboveground (e.g., Ulyshen *et al.*. 2007; LeGros and Beresford 2010; Dyer and Price 2013) appear to catch far more specimens than traps set near the ground. It is not known where the bias lies relative to actual abundance, whether ground catches are artificially low or whether aerial catches are artificially high.

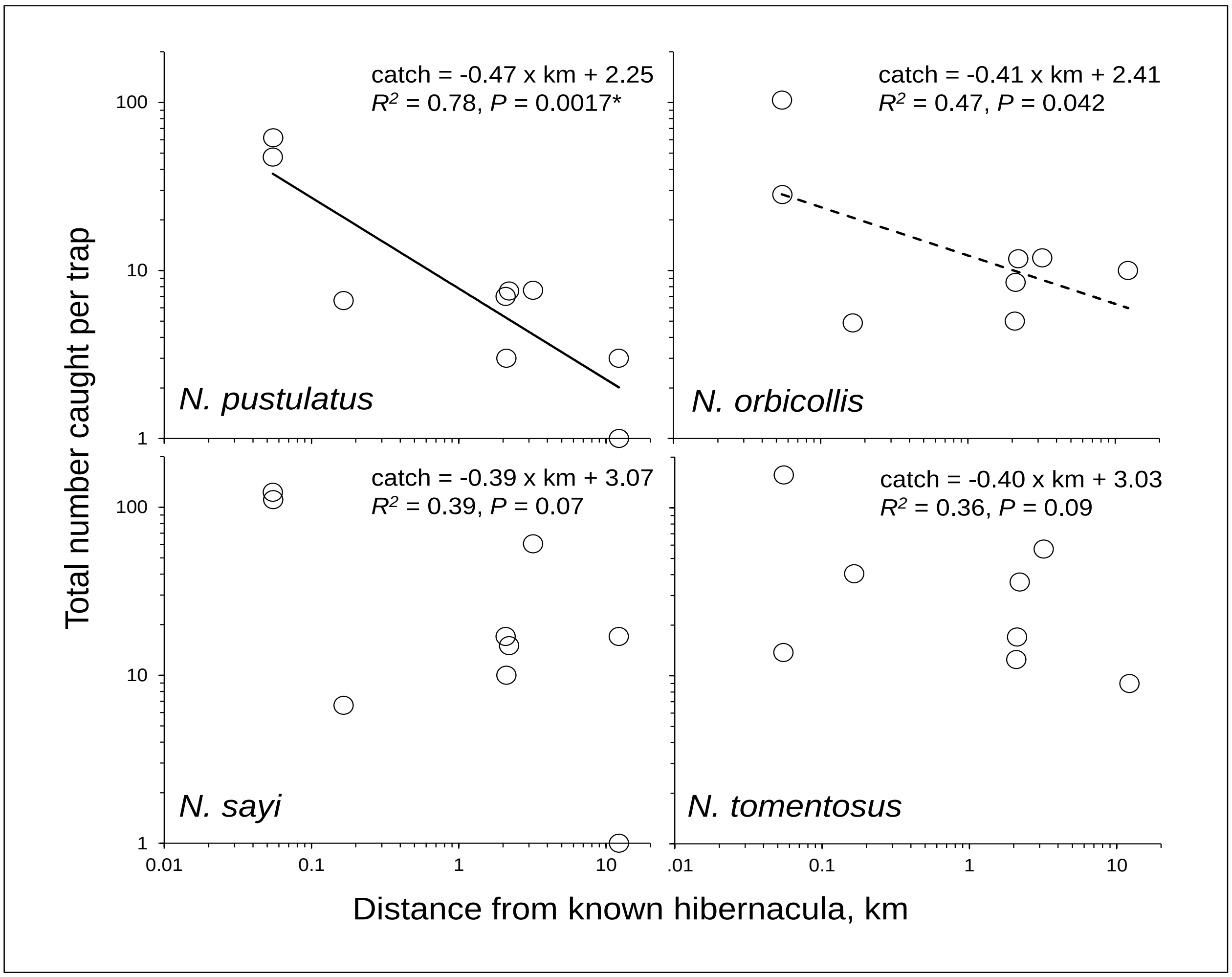

Figure 2. Regressions of distance of traps from gray ratsnake hibernaculum and number of *Nicrophorus* spp. beetles caught per trap for the 4 most abundant species: *N. pustulatus, N. orbicollis, N. sayi*, and *N. tomentosus*. * indicates this was significant at the 5% level (Bonferroni corrected alpha = 0.0083, see Methods).

It is possible that unknown hibernacula locations occur within the entire study area, and therefore could alter the true distance from trapping location to hibernaculum. The actual locations of the gray ratsnake nests in Thousand Islands National Park are not known. However, one of our underlying assumptions is that the location of known hibernacula is indicative of the relative abundance of both nesting sites and other hibernacula in a region.

Nicrophorus pustulatus beetles may have the potential to cause significant egg mortality in individual gray ratsnake nests (Blouin-Demers and Weatherhead 2000). Gray ratsnakes are communally nesting species, with up to 8 females laying eggs in 1 nest (Blouin-Demers and Weatherhead 2000). The high biomass associated with communal nesting could increase detection by *N. pustulatus*.

Nicrophorus pustulatus catches occur outside of the range of gray ratsnakes (LeGros and Beresford 2010), and have been found on other oviparous snakes (LeGros *et al*. 2010; Willson 2000). It is not known how often *N. pustulatus* attacks gray ratsnake eggs, or the extent to which this beetle can exploit other species. The effect of *N. pustulatus* on the populations of oviparous snakes is also unknown. Indeed, it is not been determined how trap catches at different heights relate to actual beetle abundance. Our high catches near known hibernacula indicate that more work is needed to determine if the abundance patterns of *N. pustulatus* that we observed might interfere with conservation efforts.

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