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Adult blow fly (Diptera: Calliphoridae) activity monitored with baited fly traps in forested and exposed urban landscapes in Nova Scotia

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ABSTRACT

Blow flies (Diptera: Calliphoridae) are usually the first colonizers of a corpse and are, arguably, the most valuable insects used by forensic entomologists to estimate the minimum elapsed time since death or minimum post-mortem interval. An understanding of the regionally specific data on the local Calliphoridae community is important in contextualizing the circumstances of death, the expected presence of colonizers and whether the remains have been relocated. To determine the spring and fall activity of calliphorid species in an urban environment in Nova Scotia, Canada, fly traps baited with fresh liver, were used to monitor adult blow fly activity in Burnside Industrial Park (Dartmouth, NS) in forested and exposed landscapes. Blow fly presence and oviposition activity were documented from 19 April – 4 July and from 19 September – 12 December 2003. Seven species of blow flies were recorded: *Calliphora livida* (Hall), *Calliphora vomitoria* (L.), *Calliphora vicina* (Robineau-Desvoidy), *Phormia regina* (Meigen), *Lucilia sericata* (Meigen), *Lucilia illustris* (Meigen), and *Cynomya cadaverina* (Robineau-Desvoidy). In the spring, *Calliphora livida* was the first species captured and the first to oviposit. The last egg laying record was on 14 November by *Cynomya cadaverina*. In the spring, *Cynomya cadaverina* and *Phormia regina* were only active at forested traps, while in the fall, *Lucilia sericata* was only active at exposed traps. In the fall, blow fly adults continued to be trapped in the exposed habitats into December compared to late October – early November for the forested habitats. The frequency of oviposition and adult presence also showed trends depending on the season and the habitat. Understanding what species are present and their first arrival is important in forensic entomology to indicate what species are likely to be present, and whether it is probable that a body has been relocated. As well, it indicates on which species further research should be focused.

INTRODUCTION

The field of forensic or medico-legal entomology has grown dramatically in the last few decades as its value in death investigations as well as poaching and animal cruelty cases has become more recognized (Rivers and Dahlem 2023). Necrophagous blow fly species (Diptera: Calliphoridae) are typically the first colonizers of a cadaver, being attracted almost immediately after death to oviposit, assuming conditions such as season, temperature, time of day,

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and accessibility, are appropriate (Payne 1965; Anderson and VanLaerhoven 1996; Simpson and Strongman 2002; Gruner et al. 2007; Anderson 2011; Weidner et al. 2016). The predictable development of insects through their immature life stages is used to estimate their minimum age, which infers a minimum post-mortem interval (Byrd and Tomberlin 2020). Insects collected from a cadaver can also be used to infer location of wound sites, whether the body has been disturbed or relocated after death, and length of time of neglect in the case of myiasis in humans or animals (Anderson 2015; Brundage and Byrd 2016; Anderson 2020a; Byrd and Tomberlin 2020).

The species of blow flies that colonize a carcass in any given area are impacted by both biotic and abiotic parameters, including species composition, geographical area, habitat, altitude, and season (Anderson 2020b). Thus, it is vital to have local data on species abundance, diversity, and habitat preference over time before medico-legal entomological analyses can be performed in death or cruelty investigations. Carrion insects are seasonal; species abundance can fluctuate among seasons within geographical regions (Hall 1948; Schroeder et al. 2003; Sharanowski 2004; Sabanoğlu and Sert 2010; Benbow et al. 2013; Parry et al. 2016; Anderson 2020b; Lutz et al. 2022). For example, Benbow et al. (2013) found significant seasonal differences in species composition of necrophagous insects across different stages of decomposition in temperate Ohio, USA. Additionally, in New Jersey, USA, *Lucilia coeruleiviridis* (Macquart) was found to be the dominant species in both spring and summer, although *Phormia regina* (Meigen) was dominant in fall and *Calliphora vicina* (R.-D) was dominant in winter (Weidner et al. 2015). An understanding of the phenology of species in a given area can be useful in determining the season of deposition of a cadaver and has even been used in ancient remains. For example, puparia of *Protophormia terraenovae* (R.-D.) found associated with Pleistocene mammalian remains in Belgium were used to determine if animals died in winter or spring (Germonpre and LeClercq 1994).

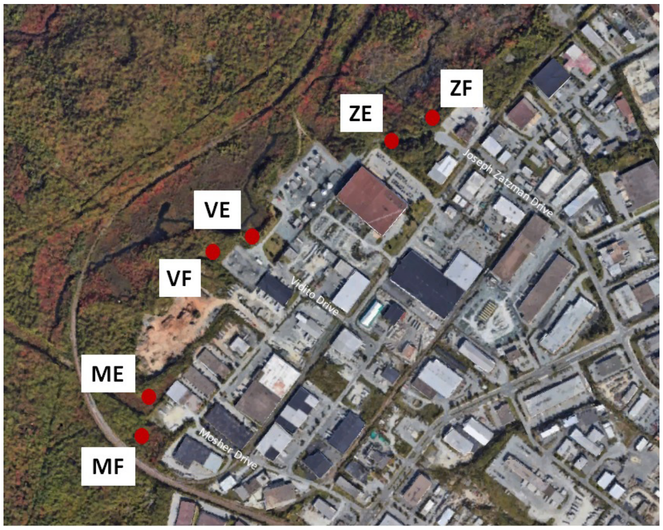
Different methods have been used to survey blow flies including baited traps, sticky traps, and direct collection from carcasses, with the best method dependent on the research question involved (Weidner et al. 2017). Sticky traps are difficult to use, as a great deal of time and patience is required to remove specimens carefully enough to allow for identification (Sanford 2017; Weidner et al. 2017). Carcasses are also challenging to work with, as they are expensive, and experiments require large numbers of animals. This raises ethical concerns, particularly if the animals are killed for research purposes. (Sanford 2017; Weidner et al. 2017). Baited traps are convenient to use and have been used to monitor insects for decades (Beirne 1963; Baz et al. 2010; Martin-Vega and Baz 2013; Infante et al. 2018; Taleb and Djedouani 2022). Baited traps depend almost entirely on olfactory cues which may result in some bias as visual cues are absent, but blow flies primarily orient to carrion using the chemical cues or volatile organic compounds released after death so a meat-based bait is likely to be the most realistic attractant (LeBlanc and Logan 2010). A variety of bait types have been utilized in previous studies including pork muscle, beef, chicken, or pork liver, wet cat food, commercial baits, and small whole carcasses (Anderson 2000; Hwang and Turner 2005; Brundage et al. 2011; Farinha et al. 2014; Lutz et al. 2018; Williams and Villet 2019; Boudreau et al. 2021; Taleb and Djedouani 2022). Beef liver has been shown to be an effective bait and studies have shown that beef liver-baited traps were equally as attractive to carrion species of blow flies as carcasses (Weidner et al. 2017). However, a study in New Brunswick showed that although bait traps were an excellent tool to elucidate the communities of blow flies in specific regions, caution should be exercised in court as there can be differences in assemblages between carcasses and bait traps (LeBlanc et al. 2021).

The objectives of the present study were to document the spring commencement and fall termination of blow fly activity and oviposition in forested and exposed landscapes in an urban area of Nova Scotia as very little research has been conducted on blow flies in this geographic region.

MATERIALS AND METHODS

A baited fly trap study was conducted at an urban site in spring, from 19 April to 4 July 2003, and then repeated in the fall, from 24 September to 12 December 2003. The site was owned by Nova Scotia Power and was located adjacent to the Burnside Industrial Park, Dartmouth, NS, which is part of the Halifax Regional Municipality (pop. ~300,000). Six baited fly traps were placed at this site: three in exposed areas in the middle of fields with no tall vegetation nearby, providing full access to sunlight all day, and the other three within forested areas composed of a mix of deciduous and coniferous trees with a thick canopy above providing shade for the entire day (Figure 1). At each plot, an exposed trap was set and separated by at least 50 m from its counterpart in the forested area. The three plots were given the initials M, V and Z, after the names of their closest roads. F represents a forested placement and E an exposed placement.

Figure 1. Location of traps. Three plots, M, V and Z, were used with two traps at each plot, one exposed (E) and one in forest (F), as shown. The reds dots represent traps. The M and V sites are approximately 400 m apart, and V and Z approximately 500 m apart.



The conventional baited fly trap (modified McPhail trap) is a cylindrical cage with a cone placed inside it, with the cone's wide end attached to the bottom opening of the cage and its narrow end leading into the cage (Beirne 1963; Martin 1977; Erzinçlicğlu 1996). The bait is placed underneath the cage directly in the middle of the inverted cone, creating a confined space which manipulates the flies to move upwards when leaving the bait. A door is located on the top of the trap to provide access to the captured insects.

Modifying the conventional design of the baited fly trap, large coffee tins (1 kg) were used as the cages, with three rectangular holes cut into the bottom sides of each tin to provide entrances for the flies (Figure 2). The metal from the rectangular holes was then bent inwards to support a 15 cm (6") inverted plastic funnel. The translucent plastic lids provided with the coffee tins were used to seal the top of the traps, but also functioned as a door to provide easy access to the captured flies and provided light through the cone to encourage the flies to fly up through the funnel into the trap. Vaseline was also applied around the funnels' narrow opening to keep the flies from walking out of the traps. The tins were mounted on 5x5 cm (2"x2") wooden posts 1 m from the ground and the entire trap was spray painted green except for the translucent lids. The bait was approximately 50 gms of beef liver contained in a Petri dish sitting on the bottom of the tin can, directly under the large opening of the funnel.

Figure 2. An example of one of the baited fly traps designed to monitor the commencement and termination of blow fly activity and oviposition in both forested and open habitats in an urban environment. All were painted green for consistency.

The traps were checked twice every week (every three to four days) following Boudreau et al. (2021), as this time period represents the early stage of animal decomposition. Checks occurred between 9:00 and 13:00h. To capture adults inside the trap, a clear plastic bag was placed over the top and then the lid was removed to allow the flies to fly into the bag. Adults were killed by placing the bags in a freezer and stored there until they could be identified. Next the funnel was removed to access the meat. The entire Petri dish with the meat was removed and examined for oviposition. If eggs or larvae were found, they were transported back to the lab to be reared to maturity; if none were found, the Petri dish was discarded. The trap was then reset with a fresh piece of beef liver in a fresh Petri dish. Collections of eggs and larvae were reared on beef liver placed on paper towel over hardwood chips inside a 473 mL (16 oz.) clear plastic beer cup. The top of the cup was covered with paper towel secured with two elastic bands to keep the maggots inside the cup while still allowing for oxygen exchange. Cups were checked daily for fly emergence and to see if additional liver was required. Emerged adults were bagged and placed in a freezer. To facilitate rapid development of the larvae, the rearing room was kept at a temperature of around 20°C, which was documented by an automated, digital temperature recorder (HOBO PRO, Onset Computer Corp, PO Box 3450, Pocasset, MA, USA) placed in the room. All adults collected (reared and field collected) were identified using the keys from Erzinçlicğlu (1996), McAlpine et al. (1987), and Hall (1948). Identifications were confirmed by Bruce E. Cooper, Agriculture and Agri-Food Canada. Representative specimens were sent to the Natural History Museum in Halifax. Only presence and absence of species at each trap and time were recorded.

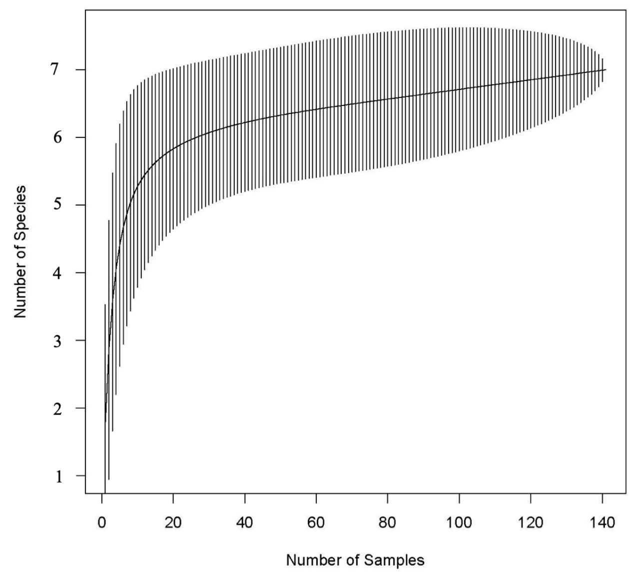
Minimum, maximum, and mean temperatures were downloaded from Environment Canada weather data for Shearwater A Station, Halifax, Nova Scotia, approximately 11.6 km from the research site (Government of Canada 2023). Trapped and reared collections were pooled into a single presence/absence dataset. The data were analyzed in R v. 4.0.3 (R Core Team 2020), and the *picante* package v. 1.8.2 (Kembel et al. 2010). A sample-based rarefaction curve was used to assess sampling effort. Alpha-diversity was assessed as the species number in each habitat, season, or type of plot. To compare community compositions in fall and spring, a non-metric multi-dimensional scaling (NMDS) plot was generated using the *vegan* package v. 2.5-7 (Dixon 2003).

RESULTS

Seven species of blow fly were collected overall: *Calliphora livida* (Hall), *Calliphora vomitoria* (L.), *Calliphora vicina*, *Lucilia illustris* (Meigen), *Lucilia sericata* (Meigen), *Cynomya cadaverina* (R.-D.), and *Phormia regina*. The sample-based rarefaction curve approached, but did not reach, asymptote (Figure 3). Comparisons of α-diversity between habitats, between seasons, and between plots yielded no apparent differences (Figure 4). An NMDS plot, however, revealed some potential distinction between species composition in spring and in fall (Figure 5: stress value = 0.07).

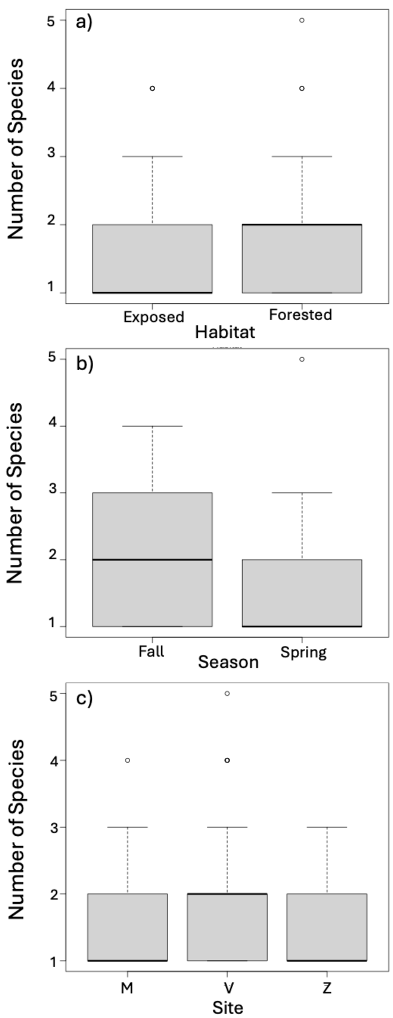
The dates that species were collected (both as adults and eggs) in both exposed and forested treatments, together with the weather data for the trapping period and the number of traps colonized on each date are shown for spring in Figure 6 and fall in Figure 7. The most common species collected during the spring were *Calliphora livida, Lucilia illustris,* and *Lucilia sericata* and in fall were *Calliphora livida, Calliphora vicina* and *Cynomya cadaverina*. Frequency of collection indicated that, on many occasions, the females laid eggs, which were reared and identified, but the adults were not captured, indicating escape. Therefore, considering both adult trapping and egg rearing together gives a better picture of species presence and preferences. As no blow flies were collected in the earliest collection in the spring, nor the last collection days in the fall, we believe that the data indicate the earliest and latest presence of blow fly activity over the year.

Figure 3. Sample-based rarefaction curve for Diptera: Calliphoridae species caught in and reared from beef liver-baited coffee can traps at three urban plots in Dartmouth, Nova Scotia, Canada, in spring and fall of 2003. The rarefaction was based on 1000 permutations randomly generated from trap-catch data samples. The shaded area represents the 95% confidence interval.



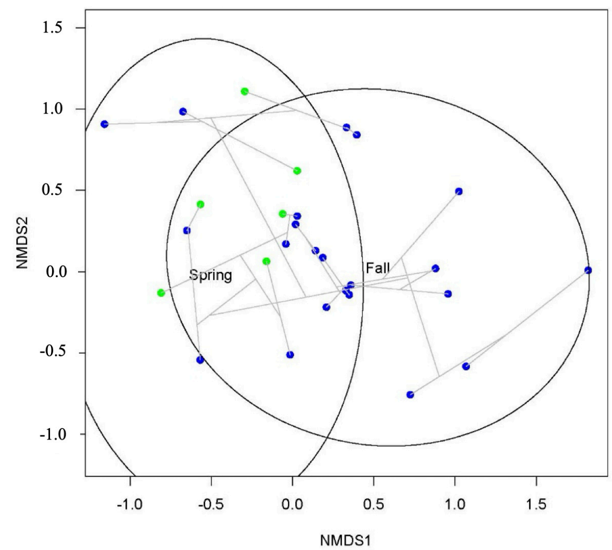
Calliphora livida was caught first in spring in forested areas (22 April), and then in exposed areas a week later, and continued to be regularly collected at both exposed and forested areas in both spring and fall. *Calliphora vicina* was not collected until late spring (8 June) but was one of the latest species still collected in fall (5 December) well after the first hard freeze on 9 November (when temperatures dropped below 2°C for more than four hours). It was collected at both exposed and forested areas, but almost entirely from eggs rather than adults, indicating a large number of adult escapes. *Lucilia* spp. were the latest to be collected in spring (2 June) and the first to cease activity in fall (14 October) with an outlier in a single trap on 7 November (*Lucilia sericata). Lucilia sericata* was collected almost entirely in exposed areas, although *Lucilia illustris* was collected at both exposed and forested areas. *Cynomya cadaverina* was collected exclusively and *Calliphora vicina* almost exclusively at forested

Figure 4. Box and whisker plots of numbers of Diptera: Calliphoridae species caught in and reared from beef liver-baited coffee can traps in Dartmouth, Nova Scotia, Canada, in a) exposed and forested habitat types, b) fall (24 September to 12 December 2003) and spring (19 April to 4 July 2003), and c) at three different plots. M, V and Z represent the names of each plot. Boxes show interquartile ranges (i.e. 25th to 75th percentiles) with dark lines representing median values. Whiskers show the range of values found within 1.5 times the interquartile range; points depict outliers.



areas in spring, yet both were collected in both exposed and forested areas throughout the fall, with *Cynomya cadaverina* being one of the last species still active in early December. *Phormia regina* was collected in only one trap during the spring trapping on 4 July, but collected a little more frequently in fall, albeit still rarely collected, whilst *Calliphora vomitoria* was collected only once as eggs in a single fall trap. Between 2 and 5 December, temperatures

Figure 5. Non-metric multi-dimensional scaling (NMDS) plot of Diptera: Calliphoridae species caught in and reared from beef liver-baited coffee can traps in two habitats in Dartmouth, Nova Scotia, Canada, in fall (24 September to 12 December 2003) and spring (19 April to 4 July 2003). Each point represents a sample within each season: spring (green), and fall (blue), with ovals showing 95% confidence intervals (stress value = 0.07).

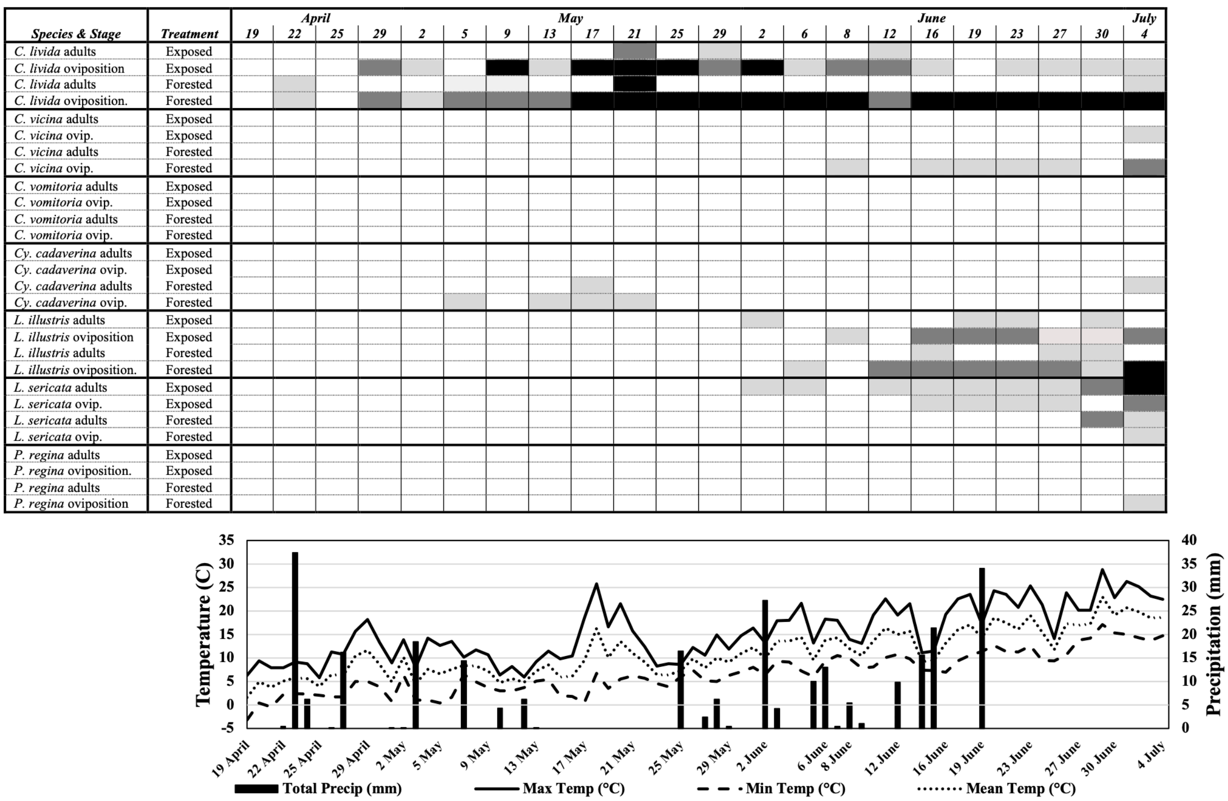


dropped considerably, with highs of -6°C and lows of -11.5°C (Figure 7) which effectively ended insect activity.

DISCUSSION

The present study indicates the blow fly species which are most likely to be attracted to carrion in the urban Halifax area in spring and fall, and their times of first arrival in spring and their last activity in fall. Seven species of blow fly were collected: *Calliphora livida*, *Calliphora vicina, Cynomya cadaverina, Lucilia illustris* and *Lucilia sericata*, with *Phormia regina* being rarely collected and *Calliphora vomitoria* being collected only once. In a baited trap study in New Brunswick, only five species (*Calliphora livida, Calliphora vicina, Lucilia illustris, Lucilia sericata* and *Phormia regina*) were collected frequently, with numbers varying between urban, forest, and semi-urban areas, although a total of 14 species were collected overall (Boudreau et al. 2021). In a baited trap survey across Canada, only a small number of adults were collected (30), with the majority being *Phormia regina* (Langer et al. 2019), which may relate to season, although so few were collected, it is hard to draw conclusions.

Figure 6. Spring collection of adult and immature blow fly species collected at exposed and forested baited fly traps set up in Dartmouth, Nova Scotia with accompanying temperature and precipitation data from the Environment Canada Weather Station at Shearwater A (Government of Canada, 2023), showing minimum, maximum and mean temperatures in degrees Celsius, for the duration of the spring survey. Black box shading indicates dates where species were found in all three traps, dark grey at two and light grey at one.



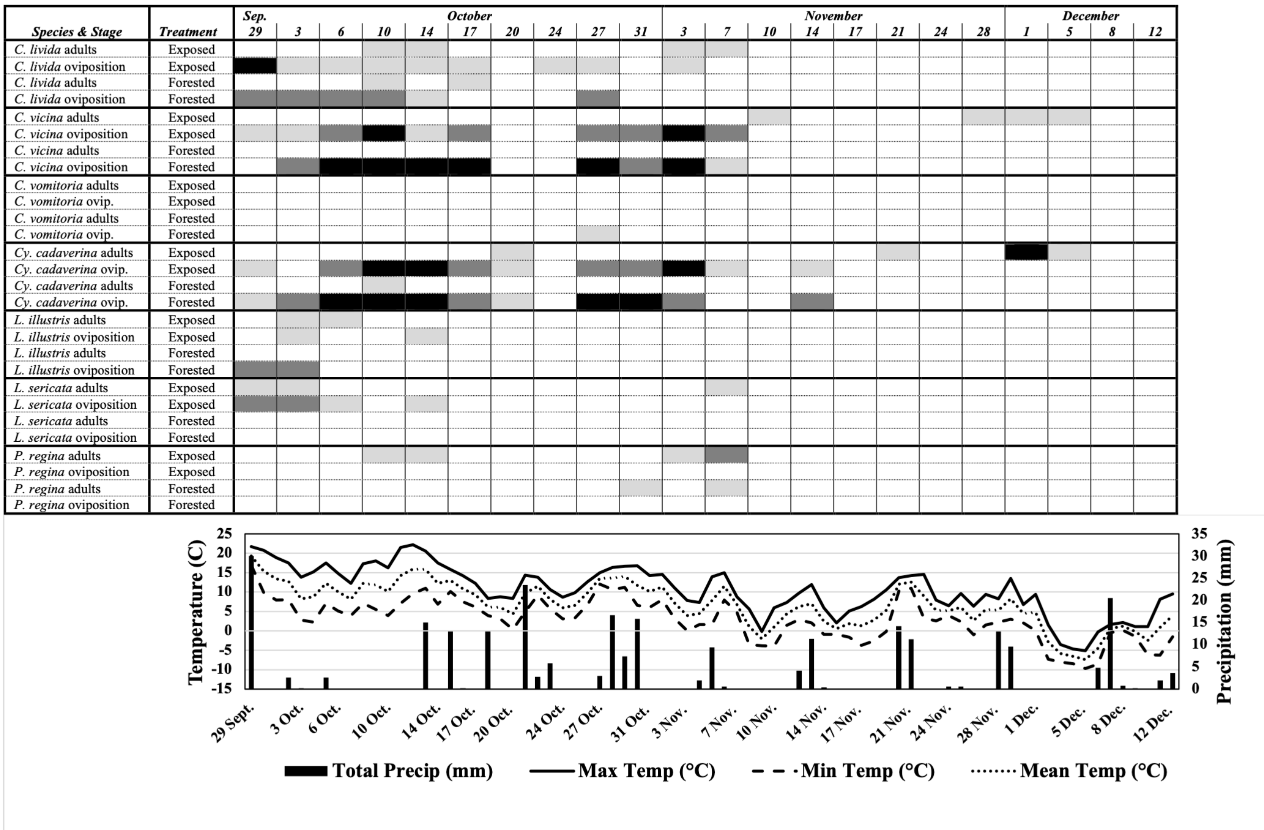
The sample-based rarefaction curve approached an asymptote (Figure 3), suggesting that greater sampling effort could have recorded a few more rare species. Species could be rare because there were few individuals present, because they were not active, because they did not enter the traps, or because they entered the traps but escaped without laying eggs. We are confident that most species of forensic importance were catalogued in this survey, as most of the species collected here were also collected from carcasses in other studies in Nova Scotia (LeBlanc and Strongman 2002; Simpson and Strongman 2002; Langer et al. 2019).

No apparent differences in species composition were found between habitats, seasons, or plots (Figure 4). The NMDS plot (Figure 5) suggested that there might be some potential distinction in species composition between spring and fall collections. Some species may have been absent or rarely detected because there was no summer trapping. Further analysis of indicator species would help to determine how practical such a distinction might be.

In this study, blow flies were much more frequently collected, and species diversity was highest, in early fall in comparison with spring. *Calliphora livida* was the dominant species in both spring and fall surveys. In other studies in Nova Scotia, *Calliphora* spp. were also dominant in fall, albeit *Calliphora vicina, Calliphora vomitoria* and *Calliphora terraenovae* Macquart (LeBlanc and Strongman 2002), and were rarely recorded in summer trials (Simpson and Strongman 2002).

Calliphora livida was the most frequently collected blow fly species in both spring and fall and was the first calliphorid species to colonize. It was also commonly collected in another study in New Brunswick, less than 200 km from the present site (Boudreau et al. 2021). In Manitoba, it was one of the more commonly collected blow flies from baited traps across Winnipeg, and was collected throughout the spring, summer, and fall (Anderson and

Figure 7. Fall Collection of adult and immature blow fly species collected at exposed and forested baited fly traps set up in Dartmouth, Nova Scotia with accompanying temperature and precipitation data from the Environment Canada Weather Station at Shearwater A (Government of Canada, 2023), showing minimum, maximum and mean temperatures in degrees Celsius, for the duration of the fall survey. Black box shading indicates dates where species were found in all three traps, dark grey at two and light grey at one.



Galloway 2023). In Illinois *Calliphora livida* was both the first species collected in spring and the last species collected in fall on carrion, being absent from June to September before again being collected in late fall (Johnson 1975). This species was collected in baited traps in spring in New Jersey, although interestingly, as seen in this study, they were more commonly reared from eggs oviposited on the bait (17.3% of total collected) than were captured as adults (0.3% of total collected), and were not collected from piglet carcasses (Weidner et al. 2017). The low numbers of adults collected in comparison with oviposition again suggests that some adult blow flies were evading capture.

One of the most basic tenets of forensic entomology is that insect activity and development is temperature dependent (Tarone and Benoit 2020), therefore, flight and oviposition are greatly impacted by ambient temperature. In a temperate climate such as that seen in much of North America, this also means that insect activity is limited by season, as most insects are not active in the colder conditions of winter and overwintering insects emerge from diapause in spring when conditions become warmer.

Of most interest to us was the beginning and end of activity for forensically important species. The first species collected in spring was *Calliphora livida* on 22 April. Prior to that date, minimum temperatures had been below freezing with highs between 9.8°C and 10.2°C from 19 to 22 April (Figure 6). The first trapping event, therefore, represents the first time that minimum temperatures were above 0°C, although temperatures between 19 to 22 April were still very low with means below 7.2°C and highs from 9.8 to 14.4°C. The last species to be collected in the fall, on 5 December, were *Calliphora vicina* and *Cynomya cadaverina,* although no eggs were oviposited by any species after 14 November. Although a hard frost did occur in early November, temperatures did rise to highs above 15°C on two days (Figure 7). Adult Calliphoridae activity usually ceases below 10-12°C (Williams 1984; Erzinçlicğlu 1996), but several authors have noted that many calliphorids are active below this temperature, (Donovan et al. 2006; Weidner et al. 2017; Lutz et al. 2022).

Calliphora spp. are considered to be more cold-adapted than other calliphorids (Faucherre et al. 1999; Hodecek and Jakubec 2022). *Calliphora vicina* is common in cooler regions and cooler times of year (Watson and Carlton 2005; Mohr and Tomberlin 2014) with much lower developmental thresholds than other calliphorids (Davies and Ratcliffe 1994; Donovan et al. 2006). In contrast, both *Lucilia illustris* and *Lucilia sericata* were much later in colonizing, not arriving until the start of June, despite warm conditions in mid-May. *Lucilia* spp. are generally considered more warm-adapted than *Calliphora* spp. (Faucherre et al. 1999; Lutz et al. 2022), hence more likely to be found in summer, as found here.

Cynomya cadaverina was collected in spring and fall in this study which is consistent with other studies in North America (Hall 1948; Weidner et al. 2015). It was one of the first colonizers in spring in Saskatchewan (Sharanowski et al. 2008) and was found only in spring in Manitoba (Gill 2005). It has been suggested that this species becomes semi-torpid during the summer months, resting in cooler areas (Schoof et al. 1956). However, in an earlier study in this region of Nova Scotia, it was collected in the summer months (Simpson and Strongman 2002). *Phormia regina* was rarely collected in this study which is supported by earlier work in this region that showed that this species, although very common in both urban and rural areas in summer (Simpson and Strongman 2002), is much less common in fall (LeBlanc and Strongman 2002). In California, *Phormia regina* was found to prefer warm seasons over colder seasons (Brundage et al. 2011) similarly in South Carolina (Tomberlin and Adler 1998). Both of these states have considerably warmer springs than Nova Scotia. In Germany, it is considered to be a summer species (Schroeder et al. 2003), although it was collected in spring and fall, as well as summer in New Jersey (Weidner et al. 2015). Therefore, the low numbers of *Phormia regina* collected here are probably due to temperature and season and not to lower species abundance in this region, as it was one of the more common species collected in New Brunswick in a large trapping study over the entire insect season (Boudreau et al. 2021). This seasonality was also observed by one of us (DBS) in human homicide cases in Nova Scotia (LeBlanc and Strongman 2002).

Lucilia spp. are considered warmer weather species, being most abundant during summer (Matuszewski et al. 2013; Fremdt and Amendt 2014; Weidner et al. 2015; Bernhardt et al. 2018; Byrd and Tomberlin 2020; Hildebrand et al. 2022; Hodecek and Jakubec 2022; Lutz et al. 2022; Maisonhaute and Forbes 2022). *Lucilia sericata* is frequently considered a summer species of blow fly (Schroeder et al. 2003) and this was indicated in this survey, as it was collected later in the spring survey and early in the fall survey.

Although many blow fly species are ubiquitous, some show clear preferences for certain environments (Brundage et al. 2011; Benbow et al. 2013; Babcock et al. 2019; Boudreau et al. 2021). Although, in this study, no statistically significant differences were seen between exposed and forested areas, some trends were noted. *Lucilia sericata* was collected primarily from exposed traps. This species has frequently been shown to prefer warmer seasons (Lutz et al. 2018) and sunny habitats (Smith 1986; Sharanowski et al. 2008; Prado e Castro et al. 2011) and is considered primarily an urban species (Anderson 1995; Simpson and Strongman 2002; Boudreau et al. 2021) although it is sometimes found more commonly in rural areas in Metro Vancouver, British Columbia (Smith et al. 2023).

Cynomya cadaverina was collected infrequently from the forested traps in spring but commonly oviposited at both habitats in fall. (Sharanowski et al. 2008). In an earlier pig carcass experiment in the same region as the present study, *Cynomya cadaverina* was found in both urban and rural sites, and even on buried carcasses (Simpson and Strongman 2002).

The traps were not as efficient in collecting adult blow flies as expected. In some cases, spring oviposition was recorded before adults of that species were collected in the traps. In other cases, eggs were oviposited, but no adults of that species were ever collected. In fall, some oviposition occurred after the last adult of that species had been collected. This indicates that female flies were able to access the bait and successfully oviposit but had been able to evade the trap. Therefore, blow flies were active even though there were no adult collections, suggesting that the baited fly traps were not as efficient as had been desired. This is not uncommon in baited fly trapping experiments (Weidner et al. 2017; Smith et al. 2023). However, as the oviposited species were also included in the analysis, it is believed that the surveys give an accurate representation of species presence and habitat preferences, as the rarefaction curve approached an asymptote. Another limitation that must be considered is in relation to species' oviposition preference and attraction to fresh versus decomposed tissue. Although blow flies are early carrion colonizers, some species do have preferences for fresh carrion over carrion that is a few days old (Lane 1975; Erzinçlicğlu 1996). Traps were cleared twice a week, and baits refreshed each time with fresh beef liver. Fresh bait would likely only capture early colonizing species and not reflect all blow fly species relevant to forensic studies in the area. If baits were changed daily, this might have limited our results to species only attracted to fresh bait. However, the bait was replaced every three to four days and studies on blow fly attraction to remains only vary within 0-76 hours after death (Lane 1975; Denno and Cothran 1976; Lord and Burger 1984; Goddard and Lago 1985; Hall and Doisy 1993). As well, the beef liver will have lost moisture over the trapping time, which might have impacted capture.

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