Changing blow fly (Diptera: Calliphoridae) populations in Orlando, Florida, United States

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Insects fulfill a large array of ecological roles including pollination, pathogen transmission, and decomposition. Necrophagous insects, specifically blow flies (Diptera: Calliphoridae), are an important part of terrestrial decomposition because of their ability to locate and colonize carcasses. This dependence on carrion for completion of their life cycles allows carrion trapping to give insight into population compositions and changes in those compositions should they occur.

Previous studies in Florida (Gruner et al. 2007; Swiger et al. 2014) have shown a consistent group of carrion-attending blow flies that includes *Lucilia sericata* Meigen, *Lucilia coeruleiviridis* Macquart, *Phormia regina* Meigen, *Cochliomyia macellaria* Fabricius, *Chrysomya rufifacies* Macquart, and *Chrysomya megacephala* Fabricius. The 2 *Lucilia* species, *P. regina,* and *C. macellaria* are ubiquitous North American flies. However, *C. rufifacies* and *C. megacephala* are tropical, non-native blow flies introduced to the United States in the early 1980's. The first *Chrysomya* species introduced into the continental United States was *C. rufifacies* reported from Texas in 1981 (Gagné et al. 1982). The introduction of *C. megacephala* to the continental United States occurred in both California and Texas in 1989 (Wells 1991). By 1992 both *C. rufifacies* and *C. megacephala* were documented as being "...abundantly present and well entrenched..." in Florida (Baumgartner 1993, page 338). However, no studies have been conducted in the Orlando, Florida, region to observe whether these 2 non-native species have had an impact on overall blow fly distributions.

Thus, this research was conducted with 2 main objectives: to gain an understanding of the blow fly populations in urban Orlando, Florida, and to document any potential shifts in blow fly species prevalence since the previous survey conducted in 2002 to 2004 (Gruner et al. 2007).

The study was carried out in Orlando, Orange County, Florida, from Jun to Sep 2009 and Apr to Oct 2010 at 4 different locations around the city (28.48764 °N, 81.26329 °W; 28.57303 °N, 81.41284 °W; 28.63535 °N, 81.42215 °W; 28.57411 °N, 81.40785 °W). Fly specimens were collected during the summer months using assorted fresh and frozen (up to 4 wks) animal carrion. The carrion, all roadkill, ranged from small rodents to a large dog. Carcasses were placed in shaded areas with little direct sunlight. Ambient air temperatures were recorded on-site and compared with wireless internet field connections, with all comparison temperatures being within 1 °C of each other. Successive specimen gathering from the same animal carcass continued up to 3 d after the initial collection. In 2009, adult fly specimens were collected using an aerial net. The aerial net was swept in figure-eight motions 5 to 60 cm above the carcass. The captured specimens were transferred into a vial of 95% alcohol. In 2010, adult fly specimens were collected using a modified Bishopp cone trap (Hall 1948). The screened conical trap was 23 cm off the ground. It had a 66 cm base and 15 cm top that ended in a 15 cm collecting jar. The specimens were placed at −18 °C for 5 ± 2 mins and funneled into a vial of 95% alcohol. Adult specimens were identified morphologically (Whitworth 2006). Because sampling intervals varied across dates, numbers collected are expressed as numbers per sample date.

Table 1 and Figure 1 present summaries of species and numbers collected in 2009 and 2010. Peak activity varied by species, but overall, the blow flies collected were most abundant Jul to Sep (2009) and Jun to Sep (2010). Only 5 species of calliphorids were recovered: *C. rufifacies*, *C.*

Table 1. Calliphorid species collected in 2009 (Jun 11 2009 to Sep 12 2009) and 2010 (Apr 4 2010 to Oct 11 2010) in Orlando, Florida, from exposed carrion. Data include totals from all dates, and totals reflecting sampling effort expressed as totals per sampling day.

Year	*Chrysomya rufifacies*	*Chrysomya megacephala*	*Lucilia coeruleiviridis*	*Cochliomyia macellaria*	*Lucilia sericata*
			Total Collected per Sampling Day		
2009	73	98	15	1	3
2010	773	4,547	81	141	5
			Percent of Total Collected		
2009	38%	52%	8%	1%	2%
2010	14%	82%	1%	3%	0%
			Total Collected		
2009	588	1,110	98	12	1
2010	7,510	44,711	484	1,016	49
			Percent of Total Collected per Sampling Day		
2009	33%	61%	5%	1%	0%
2010	14%	83%	1%	2%	0%

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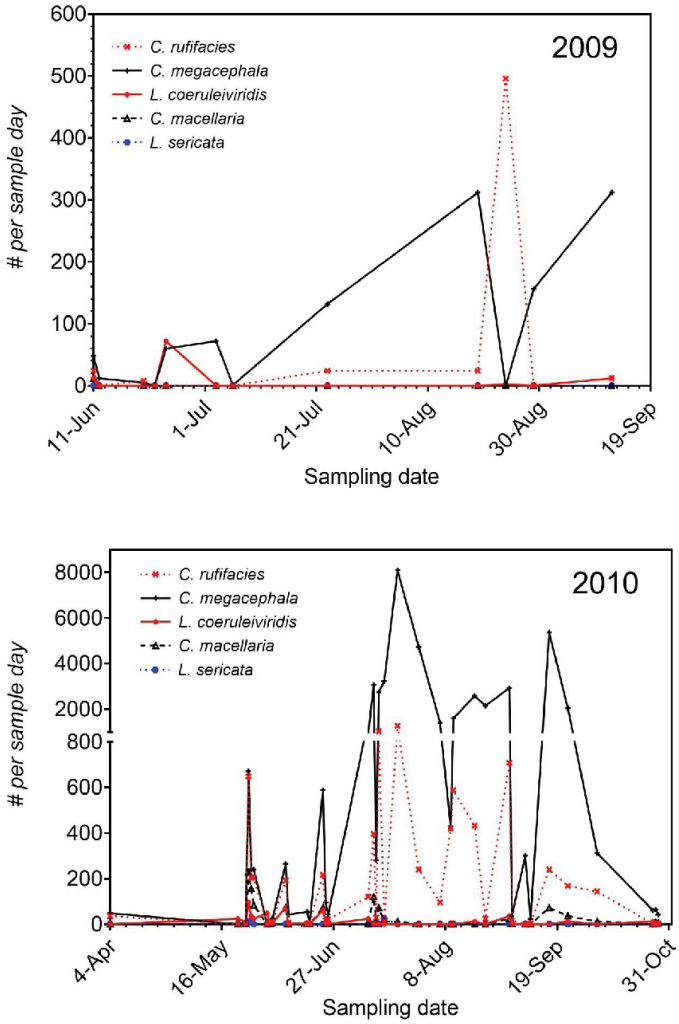

Fig. 1. Summary of species and numbers of blow fly collected in 2009 (by aerial netting) and 2010 (by Bishopp cone trap). Only 5 species of calliphorids were recovered: *Chrysomya rufifacies*, *Chrysomya megacephala*, *Cochliomyia macellaria*, *Lucilia coeruleiviridis*, and *Lucilia sericata*.

megacephala, *C. macellaria*, *L. coeruleiviridis*, and *L. sericata*. Of these, the *Chrysomya* species were by far the most abundant, representing 90% of all blow flies collected in 2009 and 96% of all blow flies in 2010. Specifically, *C. megacephala* was the most abundant species, representing 63% of collections (per sampling day) in 2009 and 83% in 2010.

From 2002 to 2004, 7 species of blow flies were collected from pig carrion near Gainesville, FL: *L. coeruleiviridis*, *C. macellaria*, *C. rufifacies*, *P. regina*, *C. megacephala*, *Calliphora livida* Hall, and *Calliphora vicina* Robineau-Desvoidy (Gruner et al. 2007). *Lucilia coeruleiviridis* was the most abundant species collected, comprising as much as 90% of flies collected in the summer. *Lucilia coeruleiviridis* was also the most abundant species in Orlando, Florida case collections in the early 2000's (Haskell, unpublished data).

Our survey sites were approximately 180 km south of those sampled by Gruner et al. (2007) in 2002 to 2004. In addition to the different location and environmental conditions, 2 other important differences between the studies are that we used carrion from various small animal species while Gruner et al. (2007) used dead pigs. Also, we sampled Jun to Sep (2009) and Apr to Oct (2010), while Gruner et al. (2007) sampled year-round. Despite these differences, our a priori expectation was that we would collect a greater diversity in species as we were trapping using a variety of bait species during the warmest months of the year. In contrast to our expectations and the findings of Gruner et al. (2007), we collected 5 species compared with their 7. Missing from our samples were *P. regina*, *C. livida*, and *C. vicina*, but we collected *L. sericata,* which was not collected by Gruner et al. (2007).

The absence of *C. livida* and *C. vicina* is expected as both are most active at cool temperatures, while all the species we collected either favor or better tolerate higher temperatures like those seen during our collection period (24.4–35.6 °C) (Haskell & Williams 2008). As one of the most common species occurring on carrion across North America, the absence of *P. regina* was initially unexpected. However, competition studies (McInnis & Higley 2020) show that *P. regina* was unable to compete successfully with *C. rufifacies* given limited food resources in laboratory experiments. Consequently, the absence of *P. regina* in our samples agrees with the expectation that as environmental conditions (specifically temperature) change to favor tropical species like *C. rufifacies* and *C. megacephala, P. regina* and other blow fly species are subject to competitive displacement.

This same phenomenon of competitive displacement might also be playing out between *C. rufifacies* and *C. megacephala.* With the introduction of *C. rufifacies* to North America and increasing average temperatures, many scientists predicted that *C. rufifacies* would expand its range and would potentially become the most abundant summer blow fly. This prediction has been valid regarding range expansion (Shahid et al. 2000; Rosati & VanLaerhoven 2007; Bugaski & Bailey 2020) and *C. rufifacies* has become the predominant species in many habitats, especially during the late summer months. However, we found that *C. megacephala* was the most abundant species collected, with an especially high percentage of all blow flies collected (over 80%) in 2010. We think the most likely explanation for the abundance of *C. megacephala* is temperature-mediated competitive exclusion. Gruner et al. (2017) showed that *C. megacephala* development rates are much faster at higher temperatures than those reported for *P. regina* or *C. rufifacies.* This is supported by Shiao and Yeh (2008) who reported *C. megacephala* not only had a shorter larval duration but was also able to survive with a lower body weight. So, while *C. rufifacies* expands its range geographically, in central Florida, *C. megacephala* continues to be the dominant species due to its faster development rates under higher temperatures and its ability to produce smaller, viable adults.

From a practical standpoint, information regarding the relative diversity of blow flies is of forensic value, particularly on a regional basis. For example, differences in species distribution on a body can be an indicator of seasonality and of instances where a body may have been moved post-mortem (Haskell & Williams 2008). Biologically, these distribution data help document results of competitive differences between introduced and native blow flies, and how climate change could potentially influence those competitive relationships.

Although changes in species relationships and population dynamics are complex and even unknowable in some cases, these results, as well as previous research, are continuing to document population shifts and the impact these shifts can have on native and non-native blow fly species.

Summary

Blow flies (Diptera: Calliphoridae) were collected from various carrion baits in Orlando, Florida over 2 periods: Jun 2009 to Sep 2009 and Apr 2010 to Oct 2010. In a previous study conducted from 2002 to 2004 the dominant blow fly in Orlando, Florida, was *Lucilia coeruleiviridis* Macquart (Gruner et al. 2007). This collection documents a shift to *Chrysomya megacephala* Fabricius, as the most dominant blow fly

species found in Orlando, Florida in 2009 to 2010. These field results have potential forensic implications, particularly in the analysis of cold cases.

Key Words: diversity; competition; competitive displacement; introduced species

Sumario

Se recolectaron moscas calliforidas (Diptera: Calliphoridae) de varios cebos de carroña en Orlando, Florida durante 2 períodos: de junio del 2009 a septiembre del 2009 y de abril del 2010 a octubre del 2010. En un estudio anterior realizado entre el 2002 y 2004, la mosca dominante en Orlando, Florida, era *Lucilia coeruleiviridis* Macquart (Gruner et al. 2007). Esta colección documenta un cambio a *Chrysomya megacephala* Fabricius, como la especie de mosca calliforida más dominante encontrada en Orlando, Florida entre 2009 y 2010. Estos resultados de campo tienen implicaciones forenses potenciales, particularmente en el análisis de casos sin resolver.

Palabras Clave: diversidad; competencia; desplazamiento competitivo; especies introducidas

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