



Community composition of carrion-breeding blowflies (Diptera: Calliphoridae) along an urban gradient in south-eastern Australia

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ABSTRACT

Urbanisation is a process that results in rapid modification of the natural environment, dramatically altering community structure. Blowflies (Diptera: Calliphoridae) are common inhabitants of the urban ecosystem, although little is understood about their distributions or habitat preferences within the urban environment. Blowflies require carrion for development, and as carrion is an ephemeral resource, the effect of urbanisation on these flies may be expected to differ from insects that utilise more uniformly distributed resources. In this study, blowflies were captured at various locations along an urban gradient in the region of Sydney, Australia, during summer and winter. Four habitat categories were sampled: bush, farm, suburban and urban. Using analysis of similarities (ANOSIM), calliphorid assemblages differed between all habitats, except urban and suburban. Species associations with environmental variables were also analysed using canonical correspondence analysis (CCA). Calliphorid abundances were lower in the winter trapping period, compared with the summer trapping period. *Chrysomya* was the most abundant genus during summer, whilst *Calliphora* was the most abundant genus during the winter. Some species also displayed temporal changes in their habitat preferences and synanthropic behaviour. Other species were only present in the urban habitats during winter, suggesting that they rely on urban refuges at this time of year. The ecological effects of urbanisation were clearly observed in the present study, since three distinct calliphorid assemblages were found at three different levels of urbanisation within the urban gradient. This study provides information on blowfly responses to urbanisation of use to forensic and ecological entomologists.

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1. Introduction

Urbanisation is a process that results in the reduction in the amount and quality of natural habitat and is largely believed to have an adverse effect on natural biodiversity. Studies investigating the effects of urbanisation on animal diversity have focussed largely on vertebrates, especially birds (Miller, Wiens, Hobbs, & Theobald, 2003). Carabid beetles are perhaps the most studied invertebrate taxon in connection with urbanisation (Hartley, Koivula, Spence, Pelletier, & Ball, 2007; Niemelä & Kotze, 2009; Niemelä et al., 2002), although butterflies have also been investigated (Blair & Launer, 1997). Carrion-breeding blowflies (Diptera: Calliphoridae) are common inhabitants of the urban ecosystem, however the influence of urbanisation on these organisms is believed to be limited (Hwang & Turner, 2005).

Urbanisation results in habitat homogenisation and often the introduction of exotic species (McKinney, 2006). There is no doubt

that urban areas consist of diverse invertebrate fauna. However, the contribution of native species versus exotic species to urban diversity needs to be investigated in order to aid biodiversity conservation efforts. The effect of urbanisation on species richness appears to be taxon specific (see Feath, Bang, & Saari, 2011). For example, carabid beetle richness has been shown to decrease with increasing urbanisation, with some species showing affinities for particular levels of urbanisation (e.g. suburban rural zones; Niemelä & Kotze, 2009; Niemelä et al., 2002), whilst ant richness shows the opposite trend (Lessard & Buddle, 2005). Unlike other invertebrates that have been more rigorously studied, many blowflies require a temporally and spatially random ephemeral resource (carrion) to complete development, and thus may display different patterns in response to urbanisation compared with insects that feed and/or reproduce on more constant and uniformly distributed food sources. Effective biodiversity conservation planning requires detailed knowledge of such ecological communities found within and outside urbanised areas.

Blowflies display remarkable species–habitat associations and it is likely that these habitat associations vary geographically. For instance, *Lucilia sericata* is commonly associated with pastures in England (Smith & Wall, 1997), whilst in Finland it has been

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Table 1
Environmental composition of each trapping location.

Habitat	Location	Forest (%)	Field (%)	Park (%)	Built (%)	Pop. den.	Co-ordinates	
Bush	B1	97	0	0	3	54	S33°43'	E150°34'
	B2	83	10	0	7	948	S33°58'	E150°55'
	B3	90	7	0	3	162	S34°10'	E150°58'
Farm	F1	49	50	0	1	17	S34°12'	E150°42'
	F2	6	89	0	2	17	S34°01'	E150°39'
	F3	31	67	0	0	23	S33°37'	E150°46'
Suburban	S1	0	2	0	98	529	S33°47'	E150°40'
	S2	16	28	2	54	316	S34°06'	E150°47'
	S3	6	3	0	67	709	S34°00'	E151°05'
Urban	U1	0	0	7	93	7703	S33°53'	E151°12'
	U2	0	0	2	51	5167	S33°51'	E151°10'
	U3	0	0	25	59	5965	S33°52'	E151°12'

Population densities are persons per km.

recorded as being most abundant in urban habitats (Nuorteva, 1963). In Australia, some species inhabit forested areas (e.g. *Calliphora ochracea*; Palmer, 1980), whilst others prefer pasture (e.g. *Lucilia cuprina*; Palmer, 1980). The response of calliphorid communities to urbanisation in Australia is unknown.

Blowflies are forensically important due to their ability to rapidly colonise a corpse (Byrd & Castner, 2010), however, little is understood about their distributions within urbanised areas, despite many of the criminal cases requiring forensic entomological analysis occurring in cities. Similarly, these insects play an important role as pollinators within the urban context (Ssymank, Kearns, Pape, & Thompson, 2008) and they pose an important sanitary risk by acting as vectors for pathogens and are agents of myiasis in humans and other animals (Byrd & Castner, 2010).

Studying ecological patterns in urban environments is a relatively new focus of ecology; however its study is a fundamental component of conservation biology (Grimm, Grove, Pickett, & Redman, 2000; Jenkins, 2003; Miller & Hobbs, 2002). The urban gradient approach is a popular method used to investigate how different intensities of human disturbance affect ecological processes (McDonnell & Pickett, 1990). Urban gradient analysis utilises an array of sites located across areas exposed to various intensities of human disturbance. Since urban areas usually consist of highly developed centres, surrounded by diminishing urban development, they can be thought of as an environmental gradient (McDonnell & Pickett, 1990). The spatial extent and magnitude of environmental change along an urban gradient is far greater than ecologists are typically able to study within natural gradients, and therefore provide a unique opportunity to quantify human impacts on the environment.

Besides these spatial variations, temporal variations in blowfly species abundances and activities are also known to occur (Davies, 1999; Fuller, 1934; Norris, 1966; O'Flynn, 1983; Smith & Wall, 1997). These fluctuations are complex due to the interaction between biological rhythms (reproductive cycle), resource availability and climatic cycles (seasonality and photoperiod). Furthermore, spatial distributions may be expected to undergo temporal variation, due to the different characteristics and resources available in habitats situated along an urban gradient. Presently, no data on the temporal variation of calliphorids in the Sydney metropolitan region are available.

The current study therefore investigated the spatial variation in blowfly populations along an urban gradient in the greater Sydney metropolitan and surrounding regions. Blowfly communities were compared at locations associated with different grades of urbanisation, and the degree to which community composition can be explained by local habitat characteristics was examined. This study also provided an opportunity to investigate temporal

variation in relative abundances and distributions of blowfly species. It is hypothesised that calliphorid communities will consist of a diminishing proportion of endemic species and an increasing proportion of synanthropic species as the habitats become more urbanised. By associating changes in habitat structure with species abundances, this work will enhance our understanding of how human modification of the natural environment affects the diversity of ecological communities.

2. Methods

2.1. Trapping locations

Urban gradients need to capture different levels of urbanisation if they are to provide ecologically useful information. An assumption of gradient analysis is that the environment changes in a predictable manner as distance from the origin changes. In most cities, there is usually no simple linear decrease in the level of urbanisation from the city centre to rural areas (McIntyre, Knowles-Yáñez, & Hope, 2000). An indirect form of gradient analysis is therefore required, where study locations are not aligned linearly, but instead, chosen based on factors which capture the various degrees of urbanisation (Marzluff, Bowman, & Donnelly, 2001; Medley, McDonnell, & Pickett, 1995).

The greater Sydney area was subjectively characterised into four grades of urbanisation, similar to those of Hwang and Turner (2005), referred to hereafter as 'habitats': bush (B), farm (F), suburban (S) and urban (U). Within each habitat, three trapping sites were located and separated by at least two kilometres. Satellite imagery (obtained from <http://www.googleearth.com>) was used to measure the relative areas of forest cover and human land use within a 1 km radius of each trap (Table 1). Four measurement categories were used in total and defined as follows:

- (1) Forest: native vegetation.
- (2) Field: fields typical of a rural region.
- (3) Park: largely treeless areas that are intensively managed, e.g. sports fields and parklands.
- (4) Built: any space covered by man-made structures, such as buildings and roads.

Population densities were obtained for the statistical local area within which each trap was located by referring to the Australian Standard Geographical Classification (Ewing, 2009). Projected population densities for 2009 were used (Table 1).

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