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The impact of urbanisation on body condition and size in *Bombus hypnorum* and *Bombus lucorum* agg. (Hymenoptera: Apidae) in urban (parkland and brownfield) and rural sites in the west of Scotland

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Urbanisation is increasing globally, resulting in the conversion of natural land to land characterised by impervious urban surfaces (Łopucki & Kitowski, 2017). Urban environmental variables are thought to influence bumblebee physiological traits, which could confer a loss of fitness (Ayers & Rehan, 2021). Numerous studies have investigated the impact of urbanisation on body size, yielding mixed results (Banaszak-Cibicka *et al.*, 2018; Eggenberger *et al.*, 2019; Theodorou *et al.*, 2020). However, body condition is an important metric for both individual and environmental health, which has been understudied in the urban context.

Here I describe a study that compared two bumblebee species from 12 urban sites, nine parks and three brownfield sites in Glasgow, Scotland (hereafter collectively called “urban” sites), and 12 rural sites, around Loch Lomond, about 20 miles to the north of the city. This study revealed that urbanisation had no negative effect on body condition. Urban and rural populations of the two species tested in this study, *Bombus lucorum* agg. and *B. hypnorum*, showed no significant loss of body mass, as indicated by log likelihood tests comparing models with or without urbanisation as a factor (*B. lucorum*: $2\Delta LL = -2.1$, $DF = 1$, $p > 0.05$; *B. hypnorum*: $2\Delta LL = -2.75$, $DF = 1$, $p > 0.05$). Furthermore, in both species, the body size of urban specimens did not differ significantly from that of specimens from rural environments (*B. lucorum*: $2\Delta LL = -2.7$, $DF = 1$, $p > 0.05$; *B. hypnorum*: $2\Delta LL = -2.78$, $DF = 1$, $p > 0.05$), suggesting there was no loss of fitness in the urban populations of the species measured.

The influence of environmental variables measured (temperature, green space area, habitat fragmentation and flower abundance) were not always as expected. There was no evidence of the urban heat island effect in Glasgow, with no significant difference in temperature variation found between the urban and the rural sites. Floral abundance did not appear to differ between urban and rural sites either. The influence of these

environmental variables on bee body size and condition were also unexpected. For example, intertegular distance in *B. lucorum* agg. increased as fragmentation decreased, when the study by Theodorou *et al.* (2020) predicted that larger body sizes would grant a mobility advantage in fragmented landscapes. This led to the conclusion that local and landscape variables have a complex relationship with bumblebee size and condition, and can in turn influence each other.

Although this study reveals positive findings for the influence of urbanisation on bumblebees, it is imperative that the management of urban green spaces ensures that an ample number of floral resources is provided, in order to help bumblebees thrive. The full results of this study are being prepared for publication elsewhere.

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