SHORT COMMUNICATION

Densities of feral honey bee colonies utilising tree hollows in central Perth, Western Australia

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INTRODUCTION

The European honey bee (*Apis mellifera*) has been present in Australia for over a century (Hopkins 1911) and there is now a well-established honey bee industry which generates large revenues and provides jobs for many people across the country (Rodriquez 2003).

One of the many challenges facing apiculturists is the management of swarms (Jacobs et al. 2017). Losing a colony to swarming reduces apiary productivity and releases a feral colony to the landscape. A feral colony is simply one that exists in the absence of management. The term feral applies to any escape livestock that, like these honey bees, persist in the environment without husbandry.

Indeed, feral colonies have been well documented to occur in natural areas (Oldroyd et al. 1994; Oldroyd et al. 1996; Cunningham et al. 2022; Hinson et al. 2015). A major concern is that feral colonies are often not monitored resulting in uncertainty about densities and therefore impacts of feral colonies.

One detrimental impact of feral colonies is that they often occupy spaces which would otherwise be suitable for native Australian wildlife. This has been demonstrated for regent parrots (Oldroyd et al. 1994), sugar gliders (Wood et al. 1998), Carnaby's Cockatoos (Saunders et al. 2014), and Leadbeater's Possums (Lindenmayer et al. 2009). Such findings have led to efforts to provide alternative nest boxes for native wildlife, including using PVC materials instead of timber which are shown to reduce the risk of occupancy by feral honey bees (Berris and Barth 2020). These conservation efforts are promising, however, the lack of monitoring of feral honey bee colonies is alarming considering the already known impacts that the colonies are having on native wildlife.

Additional negative implications of feral honey bee colonies on native biodiversity include increasing the spread of weeds by pollinating their flowers (Goulsen et al 2004; Simplson et al. 2015), floral resource competition with native pollinators (Geslin et al. 2017; Prendergast and Ollerton 2023), and reducing the fecundity of native bees (Paini et al. 2005).

Furthermore, there is an increasing amount of literature on the impacts of honey bees on native bees, some of which indicates negative effects of competition on native bee abundance, reproductive output, and species richness (Prendergast et al. 2023). This is often exaggerated when feral honey bee colonies are considered, as opposed to managed hives, with feral colonies often surviving longer periods of time, being more aggressive, and being more mobile than managed colonies (Prendergast et al. 2023).

More work is needed to pinpoint the precise impacts on native bees with a focus on how competition with honey bees may effect species ecology. However, to leave feral colonies unmonitored, and under-studied, is leaving native biodiversity vulnerable to the impacts, both those already documented and those yet to be discovered.

This short note is to communicate the feral honey bee colonies found during a systematic survey of central Perth and to provide a minimum colony density estimate for the city.

METHODS

The centre of Perth, Western Australia, was surveyed for feral honey bee colonies using tree cavities. A study area of 5.85 km^2 was demarcated which included the Central Business District (CBD), East Perth, and West Perth. The city consists of many high-rise buildings, roads, several pedestrianised streets, and multiple parks. The study area is encompassed by the Swan River to the east and south. To the southwest is Kings Park Botanical Gardens, whilst to the north and west is a mix of high- and low-density buildings.

Publicly accessible roads and parks within the study area boundary (Figure 1) were walked by the researcher in December 2022 and early January 2023.

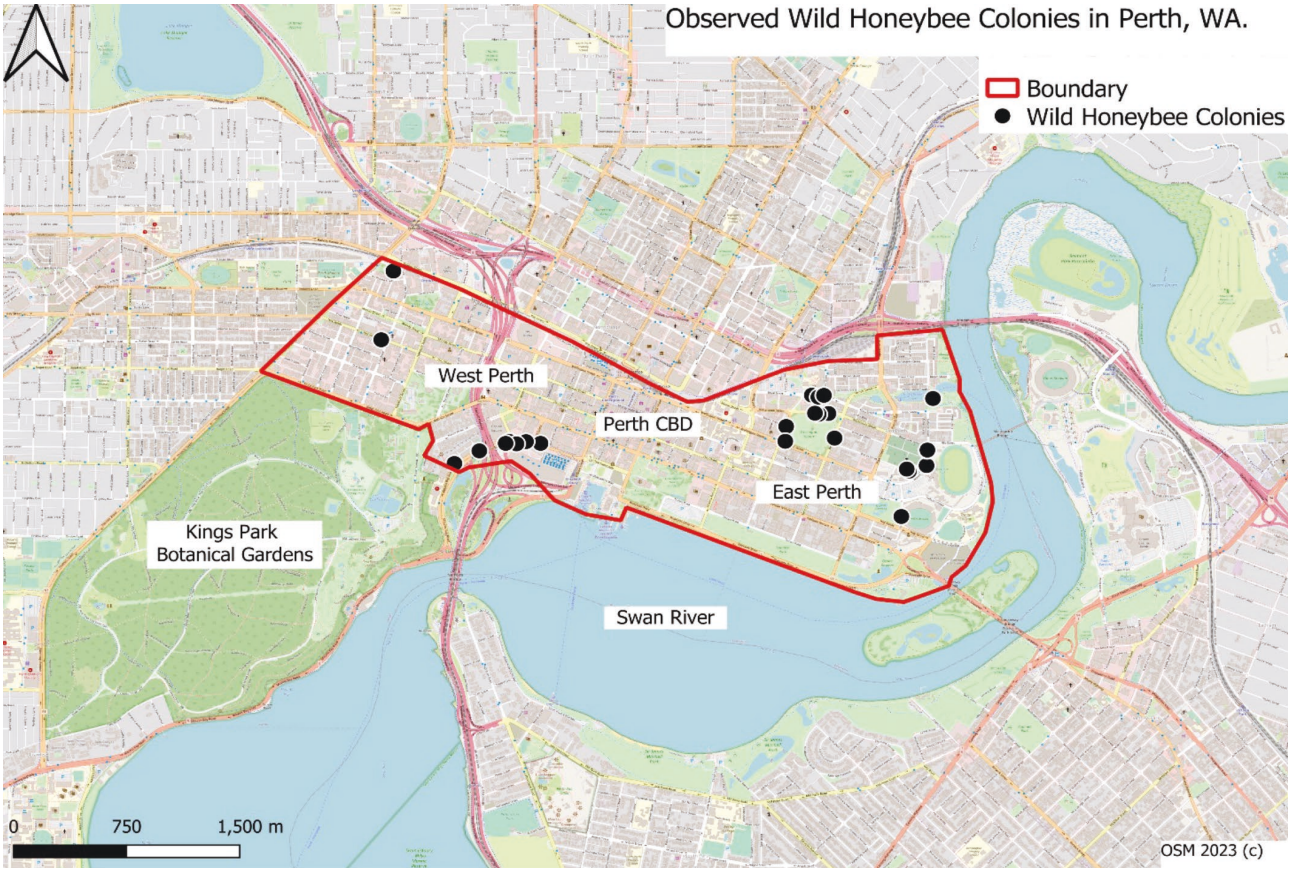

FIGURE 1 Observed feral honey bee colonies in Perth, Western Australia. The figure indicates feral honey bee colonies in tree hollows recorded during this survey with a black circle. The study area is indicated by the bold red boundary within which roads and parks were surveyed.

Each tree found was carefully checked and inspected for scars, cavities, holes, and hollows. If found, these were then observed for up to 30 minutes. The recorder watched until the 30 minutes was expired or if honey bees were observed entering or exiting the hole. Observations were made on warm and sunny days commensurate with honey bee activity.

The locations of each observed feral colony were recorded and categorised as either a park or a street. The categorisation was based on if the tree observed was on a road or if it was within the boundary of a park.

A feral honey bee colony density estimate was calculated by dividing the number of colonies observed by the area surveyed. The area used for this measurement is the area of the parks and roads surveyed. Shapefiles of the road network (Main Roads Western Australia 2024) and parks (City of Perth 2024) were downloaded and used to calculate this area. 602 roads equating to approximately 76.61 km were surveyed and the approximate width of a standard urban two-land road (7.4 m) was used to calculate an area of 0.56 km^2. A total of 24 parks in the study area were surveyed and these measured an area of approximately 0.83 km^2. As such, a total area of approximately 1.39 km^2 was surveyed for feral honey bee colonies using tree hollows.

RESULTS

Twenty-six colonies were found inside the study area at eight different locations (Table 1 and Figure 1). The surveyed area has an estimated density of 18.57 colonies per km^2.

DISCUSSION

I find that feral honey bee colonies exist at a density of 18.57 colonies per km^2 across the surveyed area of central Perth, Western Australia. My findings are higher than existing colony density estimates in the literature for cities. For instance, they sit above the reported density of 6.5 colonies per km^2 in Paris (Ropars et al. 2019). Our study does not include the expansive forested Kings Park Botanical Gardens whereas the study in France did include Bois de Boulogne and Bois de Vincennes. As such, I interpret that my results could be at the higher end of density estimates for a metropolitan city. Furthermore, my findings indicate that the feral honey bee colony densities could be even higher if the study was expanded to the nearby botanical gardens which is extensively forested.

The lack of large woodland areas in our study also helps to explain our lower density estimates when compared to the 50–150 colonies per km^2 recorded in

TABLE 1 Feral Honey bee colonies observed in the central Perth study area, Western Australia.

Location	Category	Colonies
East Perth Cemetery	Park	5
Queens Gardens	Park	1
Totterdell Park	Park	1
Victoria Gardens	Park	2
Wellington Square	Park	6
Hay Street (West Perth)	Street	1
Mounts Bay Road	Street	7
Royal Street	Street	3
Total		**26**

Australian forests (Cunningham et al. 2022; Oldroyd et al. 1997). As such, I consider that the higher number of colonies observed in some of the parks in this study, such as Wellington Square with six colonies and the East Perth Cemetery with five colonies, are likely realistic for areas with more trees, and, likely, a result of more tree cavities being available to be occupied. Furthermore, two streets where I recorded high numbers of feral colonies, Mounts Bay Road with seven colonies and Royal Street with three colonies, were lined with mature tree species, suggesting, that it is the presence of the larger trees, rather than the land categorization, influencing higher densities.

The density reported in this study is concerning for native cavity dwelling species. The feral colonies in these locations are reducing the amount of suitable habitat for native species which has already been demonstrated for birds (Oldroyd et al. 1994; Saunders et al. 2014; Berris and Barth, 2022) and mammals (Wood and Wallis 1998; Lindenmayer et al. 2009).

The presence of the feral colonies is also alarming because of the documented competition with native pollinators for floral resources (Paini and Roberts 2005; Pendergast et al. 2021; Pendergast and Ollerton 2022). The combination of limited native habitat in the city and the competition from feral honey bees may be impacting the already teetering balance our native species must endure to persist.

An important consideration is that the density estimate provided is a minimum estimate for the area considered and that feral honey bee colonies may have been overlooked during this study. For instance, I do not consider feral honey bee colonies in private gardens or on buildings and it is relatively well documented that urban feral honey bee colonies are often found in human made structures such as in residential dwellings and water meter boxes (Baum et al. 2011).

Furthermore, feral colonies can persist high up in trees and whilst every effort was taken to carefully check all the trees, it is possible that small or hidden colonies were not detected. Despite this, our findings highlight the importance of monitoring for feral colonies in our landscapes to better understand their persistence and allow examination of the impacts they may be having on native species.

I highlight the importance of better managing the swarming process to ensure that managed beehives are not releasing swarms into our landscape which already has a density of feral honey bee colonies with the potential to detrimentally impact our native species and habitats. One practical measure to control swarms from managed beehives would be to improve the detection of queen cells (Buttstedt et al. 2018). It is already widely accepted that continuous monitoring for developing queen cells is one of the best methods which allows beekeepers to predict, manage, and mitigate for swarming.

I summarise that central Perth, Western Australia, has a relatively high feral honey bee colony density compared to that of other metropolitan cities and that the few park area and streets with mature trees are supporting high densities. It is crucial to continue monitoring feral colonies to better understand the influences on other species.

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REFERENCES

Baum, K.A., Kolodziej, E.Y., Tchakerian, M.D., Birt, A.G., Sherman, M., and Coulson, R.N. (2011). Spatial distribution of Africanized honey bees in an urban landscape. *Landscape and Urban Planning* **100**(1–2): 153–162. doi: 10.1016/j.landurbplan.2010.12.005

Berris, K.K., and Barth, M. (2020). PVC nest boxes are less at risk of occupancy by feral honey bees than timber nest boxes and natural hollows. *Ecological Management and Restoration* **21**(2): 155–157. doi: 10.1111/emr.12414

Buttstedt, A., Mureşan, C.I., Lilie, H., Hause, G., Ihling, C.H., Schulze, S.-H., Pietzsch, M., and Moritz, R.F. (2018). How honeybees defy gravity with royal jelly to raise queens. *Current Biology* **28**(7): 1095–1100. doi: 10.1016/j.cub.2018.02.022.

City of Perth (2024). Parks. https://catalogue.data.wa.gov.au/dataset/perth-parks [accessed 22 January 2024].

Cunningham, S.A., Crane, M.J., Evans, M.J., Hingee, K.L., and Lindenmayer, D.B. (2022). Density of invasive western honey bee (*Apis mellifera*) colonies in fragmented woodlands indicates potential for large impacts on native species. *Scientific Reports* **12**(1): 3603. doi: 10.1038/s41598-022-07635-0

Geslin, B., Gauzens, B., Baude, M., Dajoz, I., Fontaine, C., Henry, M., Ropars, L., Rollin, O., Thébault E., and

Vereecken, N.J. (2017). Massively introduced managed species and their consequences for plant–pollinator interactions. *Advances in Ecological Research* **57**: 147–199. doi: 10.1016/bs.aecr.2016.10.007

Goulson, D., and Derwent, L.C. (2004). Synergistic interactions between an exotic honey bee and an exotic weed: pollination of *Lantana camara* in Australia. *Weed Research* **44**(3): 195–202. doi: 10.1111/j.1365-3180.2004.00391.x

Hinson, E.M., Duncan, M., Lim, J., Arundel, J., and Oldroyd, B.P. (2015). The density of feral honey bee (*Apis mellifera*) colonies in South East Australia is greater in undisturbed than in disturbed habitats. *Apidologie* **46**: 403–413. doi: 10.1007/s13592-014-0334-x

Hopkins, I. (1911). *The illustrated Australasian bee manual and complete guide to modern bee culture in the Southern Hemisphere*. Gordon & Gotch, Wellington, New Zealand.

Jacobs, M., Cazier, J.A., Wilkes, J.T., Rogers, R., and Hassler, E.E. (2017). 'Building a business analytics platform for enhancing commercial beekeepers' performance: Descriptive validation of a data framework for widespread adoption by citizen scientists'. Proceedings of the Americas Conference on Information Systems.

Lindenmayer, D.B., Welsh, A., Donnelly, C., Crane, M., Michael, D., Macgregor, C., Mcburney, L., Montague-Drake, R., and Gibbons, P. (2009). Are nest boxes a viable alternative source of cavities for hollow-dependent animals? Long-term monitoring of nest box occupancy, pest use and attrition. *Biological Conservation* **142**(1): 33–42. doi: 10.1016/j.biocon.2008.09.026

Main Roads Western Australia (2024). Road Network. https://catalogue.data.wa.gov.au/dataset/mrwa-road-network [accessed 22 January 2024].

Oldroyd, B.P., Lawler, S.H., and Crozier, R.H. (1994). Do feral honey bees (*Apis mellifera*) and regent parrots (*Polytelis anthopeplus*) compete for nest sites? *Australian Journal of Ecology* **19**(4): 444–450.

Oldroyd, B.P., Thexton, E.G., Lawler, S.H., and Crozier, R. H. (1997). Population demography of Australian feral bees (*Apis mellifera*). *Oecologia* **111**: 381–387.

Paini, D.R., and Roberts, J.D. (2005). Commercial honey bees (*Apis mellifera*) reduce the fecundity of an Australian native bee (*Hylaeus alcyoneus*). *Biological conservation* **123**(1): 103–112. doi: 10.1016/j.biocon.2004.11.001

Prendergast, K.S., and Ollerton, J. (2022). Impacts of the introduced European honey bee on Australian bee-flower network properties in urban bushland remnants and residential gardens. *Austral Ecology* **47**(1): 35–53. doi: 10.1111/aec.13040

Prendergast, K.S., Dixon, K.W., and Bateman, P.W. (2023). The evidence for and against competition between the European honey bee and Australian native bees. *Pacific Conservation Biology* **29**(2): 89–109. doi: 10.1071/PC21064

Prendergast, K.S., Dixon, K.W., and Bateman, P.W. (2021). Interactions between the introduced European honey bee and native bees in urban areas varies by year, habitat type and native bee guild. *Biological Journal of the Linnean Society* **133**(3): 725–743. doi: 10.1093/biolinnean/blab024

Rodriguez, V.B., Riley, C., Shafron, W., and Lindsay, R. (2003). 'Honey bee industry survey'. Rural Industries Research and Development Corporation.

Ropars, L., Dajoz, I., Fontaine, C., Muratet, A., and Geslin, B. (2019). Wild pollinator activity negatively related to honey bee colony densities in urban context. *PloS one* **14**(9): e0222316.

Saunders, D.A., Mawson, P.R., and Dawson, R. (2014). Use of tree hollows by Carnaby's Cockatoo and the fate of large hollow-bearing trees at Coomallo Creek, Western Australia 1969–2013. *Biological Conservation* **177**: 185–193. doi: 10.1016/j.biocon.2014.07.002

Simpson, S.R., Gross, C.L., and Silberbauer, L.X. (2005). Broom and honeybees in Australia: an alien liaison. *Plant Biology* **7**(5): 541–548. doi: 10.1055/s-2005-865855

Wood, M.S., and Wallis, R.L. (1998). Potential competition for nest sites between feral European honey bees (*Apis mellifera*) and common brushtail possums (*Trichosurus vulpecula*). *Australian Mammalogy* **20**(3): 377–381.

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