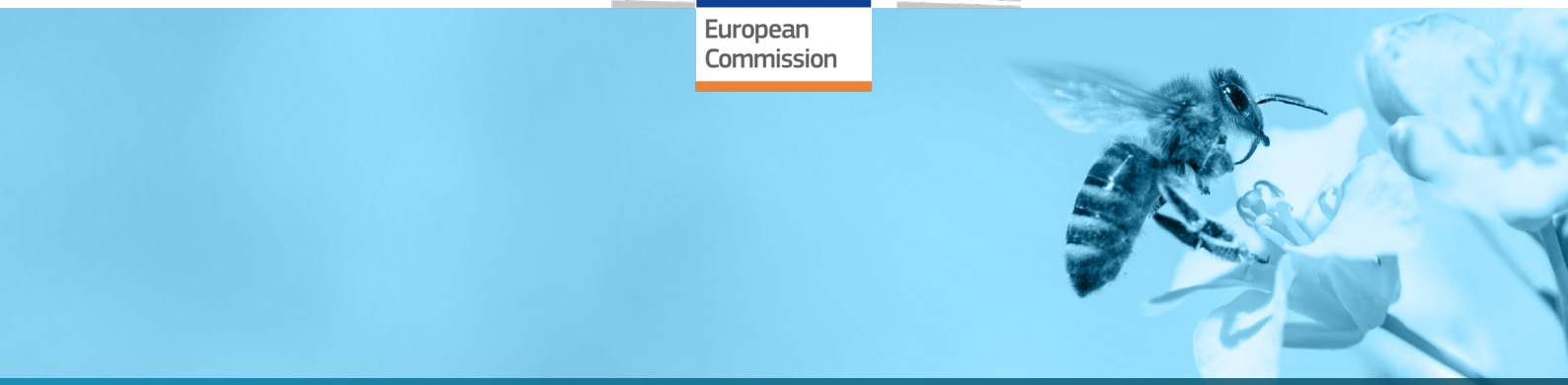

SCIENCE FOR ENVIRONMENT POLICY

A single exposure to urban air pollution may impair honeybees' olfactory learning and memory

18th May 2020 /
Issue 542

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Source:
Leonard, R., Pettit, T., Irga, P., McArthur, C. and Hochuli, D. (2019). Acute exposure to urban air pollution impairs olfactory learning and memory in honeybees. Ecotoxicology. 28(9): 1056–1062.

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A honeybee is the most significant and economically important managed pollinator species worldwide; honeybees and thousands of wild pollinator species provide a pollination service to agriculture with an estimated value of $190 billion (USD) (€175.90) annually. However, exposure to contaminants, such as pesticides, can affect honeybee foraging behaviour and fitness. This study looks at the potential impact of urban air pollution on bee health.

Honeybees use their sense of smell to locate, recognise and remember flowers. A component of diesel exhaust fumes — nitrogen oxides (NOx) — can reduce some airborne plant smells, leaving honeybees unable to recognise plants. Carbon dioxide from exhaust fumes can directly affect olfactory (sense of smell) learning and memory in honeybees, shown in part by the reduced extension rate of the proboscis (bee's tongue).

According to the European Green Deal communication[1], sustainable mobility is a priority within the EU, with long-term goals of a 90% reduction in carbon emissions from transport by 2050. In 2013 the EC adopted a Clean Air Policy Package[2] which set air quality objectives for 2020 and 2030, and accompanying legislative measures. The EC's Clean Air for All[3] communication, 2018, established measures to ensure that existing targets are met in the short term, as well as new air quality objectives for the decade up to 2030. The package also includes measures to help cut air pollution, with a focus on improving air quality in cities and supporting research and innovation.

Research on the effects of human-generated air pollution is vital as, by 2030, United Nations projections[4] show an increase in urban population of 1.35 billion. More than 5.87 million km2 of land has a positive probability of being converted to urban areas by 2030, and 20% of this (1.2 million km2) has a high probability of urban land cover expansion, according to probabilistic forecasts of global expansion[5]. Increased urban farming will probably mean that urban honeybees will encounter more contaminants.

European Commission

SCIENCE FOR ENVIRONMENT POLICY

A single exposure to urban air pollution may impair honeybees' olfactory learning and memory (continued)

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To cite this article/service:
"Science for Environment Policy":
European Commission DG Environment News Alert Service, edited by SCU, The University of the West of England, Bristol..

To investigate whether urban air pollution had an impact on honeybees' olfactory learning and memory, the researchers exposed them to diesel air pollution and noted its effect on proboscis extension — an important part of foraging behaviour. Worker honeybees, Apis Mellifera, were collected into a perforated container, then exposed to four different concentration levels of diesel air pollution.

Diesel fuel candles were burnt to create three different levels of air pollution — low, medium and high. The fourth concentration was ambient air, which acted as a control. The level of pollution exposure for each of these treatments was found by using an exposure chamber containing five minutes-worth of emissions from the candles. Instruments calculated the gases present for each of the air treatments: NO2, CO2, total volatile organic compounds (TVOC) (compounds that are gases at a low temperature) and total suspended particles (TSP).

The exposed honeybees were then conditioned — or trained— to associate a floral lavender scent with a sugar solution reward. The honeybees were understood to recognise the stimulus (scent) when they displayed the conditioned response — the extension of its proboscis beyond their mouthparts. Following this stage, short and long-term memory formation of the conditioned response to the lavender smell was tested by exposing the bees to the same smell after 1, 24 and 48 hours. This time, no sugar reward was offered, but the bees' proboscis extension was recorded if it occurred in response to the smell.

The number of honeybees that successfully learnt floral odours after direct air pollution was significantly lower than those unexposed bees. However, there was no significant difference between the three pollution levels, pointing to a threshold effect of air pollution on honeybees' olfactory learning and memory. Short- and long-term memory odour was significantly impaired in bees exposed to the three pollution levels, compared with bees exposed to ambient air pollution levels.

The study demonstrates that even after acute (i.e. short-term) exposure to air pollution, a bee's ability to learn and remember floral smells is negatively affected. Honeybees in cities are more likely to experience chronic air pollution exposure. As such, potential impacts on honeybee learning and memory may be amplified. The researchers suggest that air pollution may contribute to a decline in honeybee colony fitness together with factors such as pesticides, mites and disease.

1. European Green Deal communication: https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf

2. European Commission (2013). Clean Air Policy Package:https://ec.europa.eu/environment/air/clean_air/index.htm

3. European Commission (2018). Clean Air for All: https://eur-lex.europa.eu/legal-content/FR/TXT/?qid=1526552009832&uri=COM:2018:330:FIN

4. United Nations (2012). World Urbanization Prospects, the 2011 Revision (United Nations, New York): https://www.un.org/en/development/desa/population/publications/pdf/urbanization/WUP2011_Report.pdf

5. Seto K.C., Güneralp B. and Hutyra, L.R. (2012) Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. PNAS. 109 (40): 16083–16088.