How pigeons may smell their way home

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Homing pigeon. Credit: Five Furlongs

Homing pigeons, like other birds, are extraordinary navigators, but how they manage to find their way back to their lofts is still debated. To navigate, birds require a 'map' (to tell them home is south, for example) and a 'compass' (to tell them where south is), with the sun and the Earth's magnetic field being the preferred compass systems. A new paper provides evidence that the information pigeons use as a map is in fact available in the atmosphere: odours and winds allow them to find their way home. The results are now published in *Biogeosciences*, an open access journal of the European Geosciences Union (EGU).

Experiments over the past 40 years have shown that homing pigeons get disoriented when their sense of smell is impaired or when they don't

have access to natural winds at their home site. But many researchers were not convinced that wind-borne odours could provide the map pigeons need to navigate. Now, Hans Wallraff of the Max Planck Institute for Ornithology in Seewiesen, Germany, has shown that the atmosphere does contain the necessary information to help pigeons find their way home.

In previous research, Wallraff collected air samples at over 90 sites within a 200 km radius around a former pigeon loft near Würzburg in southern Germany. The samples revealed that the ratios among certain 'volatile organic compounds' (chemicals that can be a source of scents and odours) in the atmosphere increase or decrease along specific directions. "For instance, the percentage of compound A in the sum A+B or A+B+C+D increases the farther one moves from north to south," Wallraff explains.

These changes in compound ratios translate into changes in perceived smell. But a pigeon that has never left its loft does not know in what directions what changes occur – unless it has been exposed to winds at its home site.

At home, a bird is thought to associate certain smells with particular wind directions. "If the percentage of compound A increases with southerly winds, a pigeon living in a loft in Würzburg learns this wind-correlated increase. If released at a site some 100 km south of home, the bird smells that the ratio of compound A is above what it is on average at its loft and flies north," Wallraff explains. To use an analogy, a person in Munich could smell an Alpine breeze when there is wind blowing from the south. When displaced closer to the mountains, they would detect a strong Alpine scent and remember that, at home, that smell is associated with southerly winds: the person would know that, roughly, they needed to travel north to find home.

But this explanation of how pigeons might use wind-borne odours to find their loft was just a hypothesis: Wallraff still needed to prove that the atmosphere does indeed contain the basis of the map system pigeons need to navigate. In the new *Biogeosciences* paper, he develops a model showing that 'virtual pigeons' with only knowledge of winds and odours at home, can find their way back to their lofts by using real atmospheric data.

"My virtual pigeons served as tools to select those volatile compounds whose spatial distributions, combined with variations dependent on wind direction, were most suitable for homeward navigation," explains Wallraff.

The model uses an iterative approach to imitate animal evolution by introducing random mutations in the virtual pigeons, making them most sensitive to those volatile compounds that are most effective for navigation. By selecting the best mutations in the course of thousands of generations, the model creates virtual pigeons capable of finding their bearings as well as real pigeons, showing that even inexperienced birds could use atmospheric information for navigation. The findings present a missing piece in the puzzle of homing pigeon navigation, confirming that winds and odours can indeed work as a map system.

"Work with real pigeons was the beginning of the story. In this research, I wanted to find out whether and in what way the chemical atmosphere fulfils the demands for avian navigation. Eventually, to identify the chemical compounds birds actually use for home-finding, we will need real birds again. But this is far in the future."

More information: Wallraff, H. G.: Ratios among atmospheric trace gases together with winds imply exploitable information for bird navigation: a model elucidating experimental results, *Biogeosciences*, 10, 6929-6943, DOI: 10.5194/bg-10-6929-2013, 2013.

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