Science AAAS

Multiple stressors, neonicotinoid insecticides and bee declines

Joachim R. de Miranda[1], Francesco Nazzi[2]

[1]Department of Ecology, Swedish University of Agricultural Sciences, SE-75007 Uppsala, Sweden. joachim.de.miranda@slu.se

[2]Dipartimento di Scienze AgroAlimentari, Ambientali e Animali, Università degli Studi di Udine, via delle Scienze 206, 33100 Udine, Italy. francesco.nazzi@uniud.it

The paper by Woodcock et al. (*1*), recently published on Science, is the latest in a long series trying to assess if neonicotinoid insecticides are harmful to bees under realistic field conditions. It follows a number of studies carried out under more controlled conditions which clearly showed that compounds from this family of insecticides have several sublethal effects on bees, affecting navigation, immunity and reproduction (*2-4*). In fact, despite the bigger scale of the present study, its conclusions do not seem to be different from those attained previously, in that negative effects were noted on some bees, under certain conditions, whereas other bees, under the same conditions, did not seem to suffer adverse effects (*5*).

This study will therefore most likely be coopted to bolster partisan agendas on both sides of the neonicotinoid debate: that these chemicals are inherently dangerous to pollinators and should be banned, or that the real-world consequences for pollinators of neonicotinoid use in agriculture remain unproven and are (therefore) insufficient to off-set its incremental benefits relative to alternative pest control methods. Both claims are grounded in reasoned arguments and a resolution requires a decision of how much damage society is willing to accept, and to what benefit. Neonicotinoids are highly effective at killing insects and it is disingenuous to pretend that just pollinating insects are somehow exempted, even when this cannot be demonstrated conclusively in certain experiments. Similarly, it is equally disingenuous to pretend that neonicotinoids are the only (anthropogenic) factor affecting bees.

The topic is an important one indeed because, in recent years, bees have been diminishing in both abundance and diversity in many countries in the northern hemisphere and neonicontinoid insecticides could be a further factor driving these losses, in combination with parasites, pathogens, habitat loss, landscape homogenization and climate change (*6*), all linked together in a complex network of dynamic interactions (*7*).

The multifactorial nature of bee declines has now been recognized but our capacity to tackle the problem seems to be still limited. For example, a recent literature survey of insect studies in which different classes of stressors were manipulated in a full-factorial manner, produced only 133 studies covering 24 stressor pairs, fewer than ten included three-stressor combinations, and none included more than three stressors (*8*). Another critical factor is our limited understanding of what constitutes bee health. It is relatively simple to show that pesticide exposure affects bee physiology, behavior, gene expression *etc.*, but so do many other, non-anthropogenic factors. Changes in these systems, whose function is to respond to environmental challenges, is as much a sign of a healthy organism as is a lack of response -where this could reasonably be expected- is a sign of an unhealthy organism. It is therefore not so much the changes themselves, but their context, size and duration that is key to determining whether and how a particular challenge is damaging.

Good science is about making predictions and testing these against observations. However, predictions extending beyond their immediate context, leading to the transformative solutions that society demands will always be constrained by our (lack of) understanding of the homeostatic mechanisms mediating the intricate interactions of an organism with its environment.

References:

1. B.A. Woodcock, et al., Country-specific effects of neonicotinoid pesticides on honey bees and wild bees. *Science* **356**, 1393-1395 (2017).
2. M. Henry, et al. A Common Pesticide Decreases Foraging Success and Survival in Honey Bees. *Science* **336**, 348-350 (2012).
3. P.R. Whitehorn, S. O'Connor, F.L. Wackers, D. Goulson, Neonicotinoid Pesticide Reduces Bumble Bee Colony Growth and Queen Production. *Science* **336**, 351-352 (2012).
4. Di Prisco G., et al., Neonicotinoid clothianidin adversely affects insect immunity and promotes replication of a viral pathogen in honey bees. *PNAS* **201314923** (2013). doi:10.1073/pnas.1314923110
5. M. Rundlöf, et al., Seed coating with a neonicotinoid insecticide negatively affects wild bees. *Nature* **521**, 77-80 (2015).
6. D. Goulson, E. Nicholls, C. Botías, E.L. Rotheray, Bee declines driven by combined stress from parasites, pesticides, and lack of flowers. *Science* **1255957** (2015). doi:10.1126/science.1255957
7. F. Nazzi, F. Pennacchio, Disentangling multiple interactions in the hive ecosystem. *Trends Parasitol.* **30**, 556-561 (2014).
8. S. Kaunisto, L.V. Ferguson, B.J. Sinclair, Can we predict the effects of multiple stressors on insects in a changing climate? *Curr. Opin. Insect Sci.* **17**, 55-61 (2016).