

# **Agent-Based Modeling of the Effects of Colony Size and Neonicotinoid Exposure on Bumblebee Behavior within Nests**

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# Acknowledgments



**James Crall**



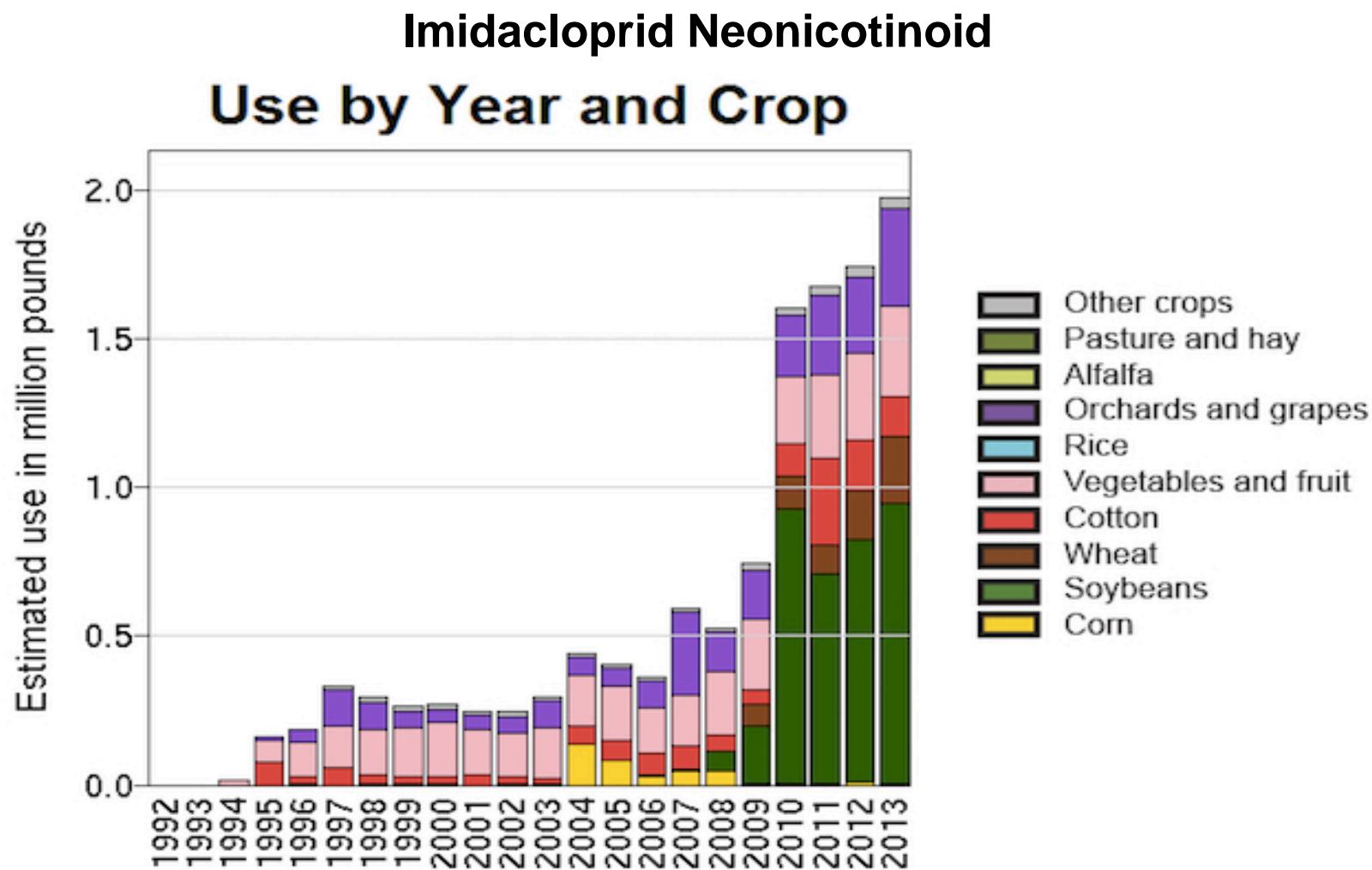
**Biswadip Dey**



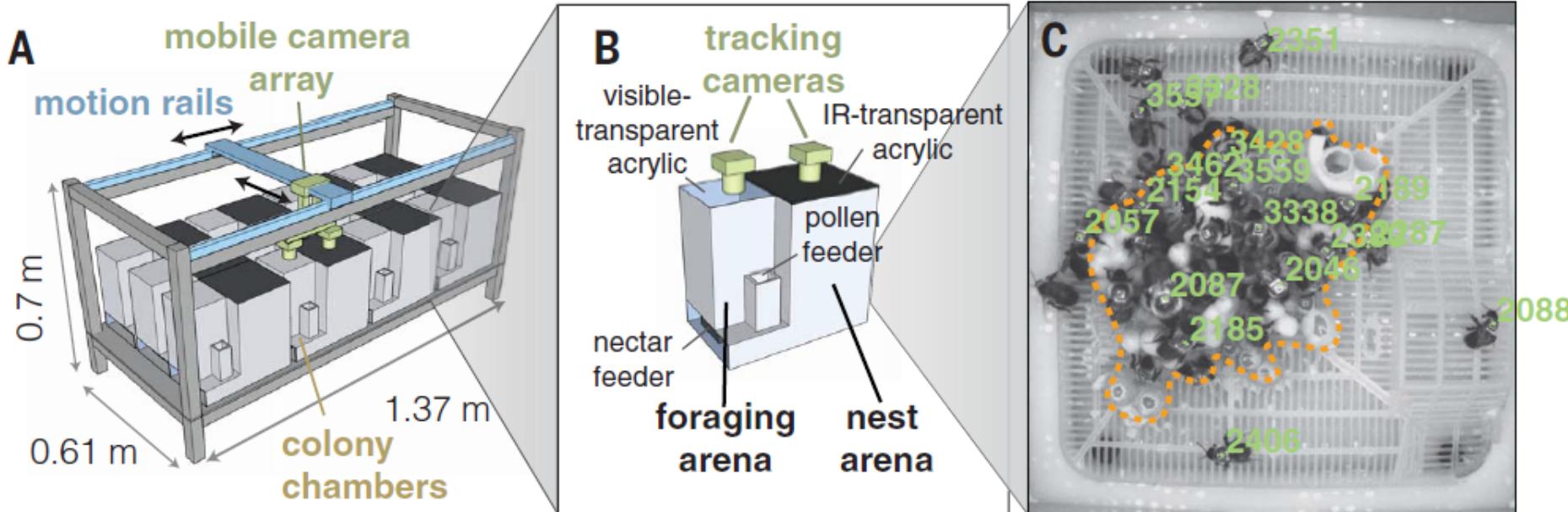
**Benjamin de Bivort**

- ANFV, JC, & BD
  - Statistical and Applied Mathematical Sciences Institute (SAMSI)
- JC
  - Rockefeller Foundation
  - Winslow Foundation
- BdB
  - NSF (IOS-1557913)
  - Alfred P. Sloan Foundation
  - Klingenstein-Simons Fellowship
  - Smith Family Foundation

# Neonicotinoid pesticides are very prevalent and purported to be safe to bees



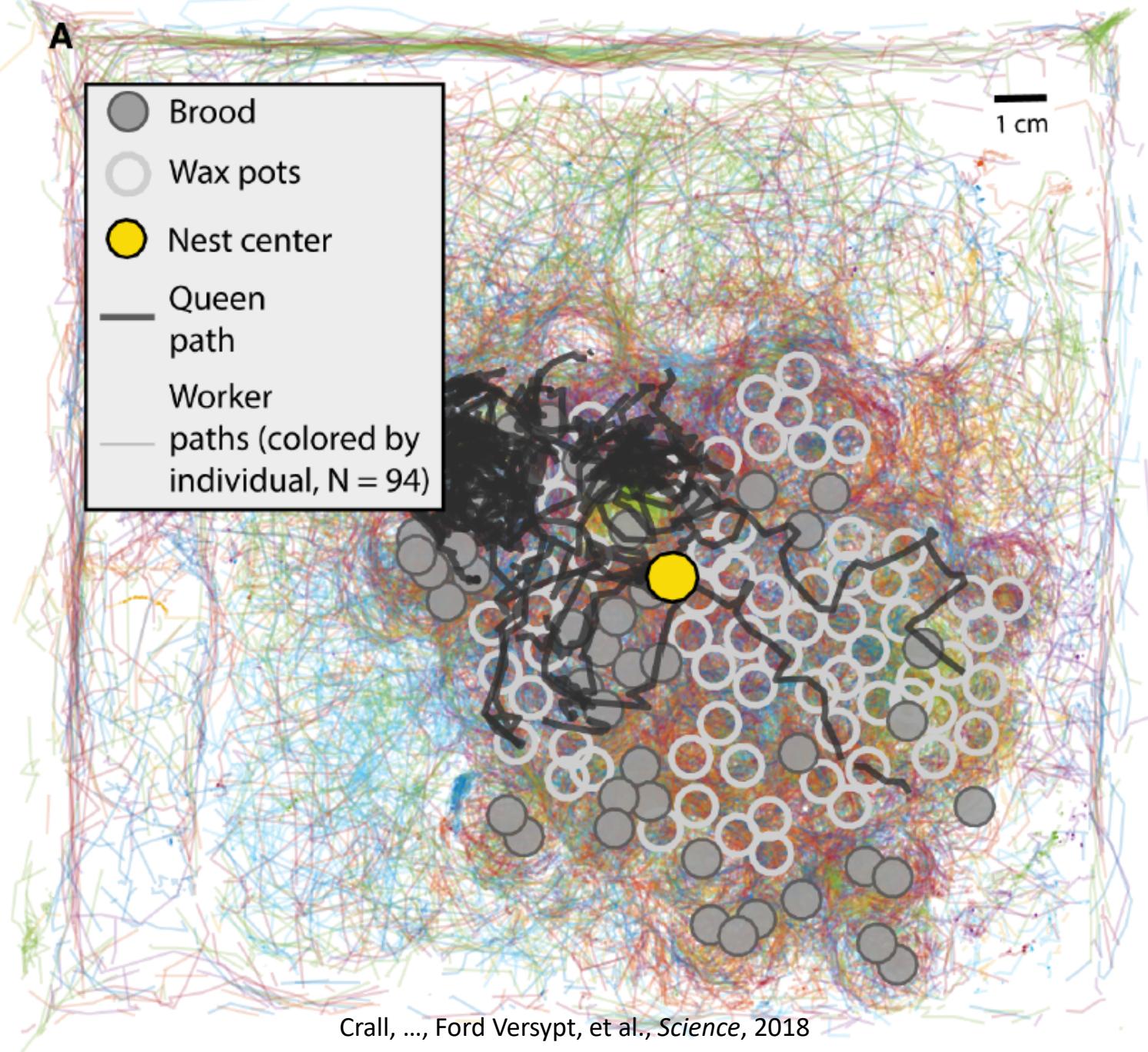
# Bumblebee behaviors can be tracked digitally within their nests



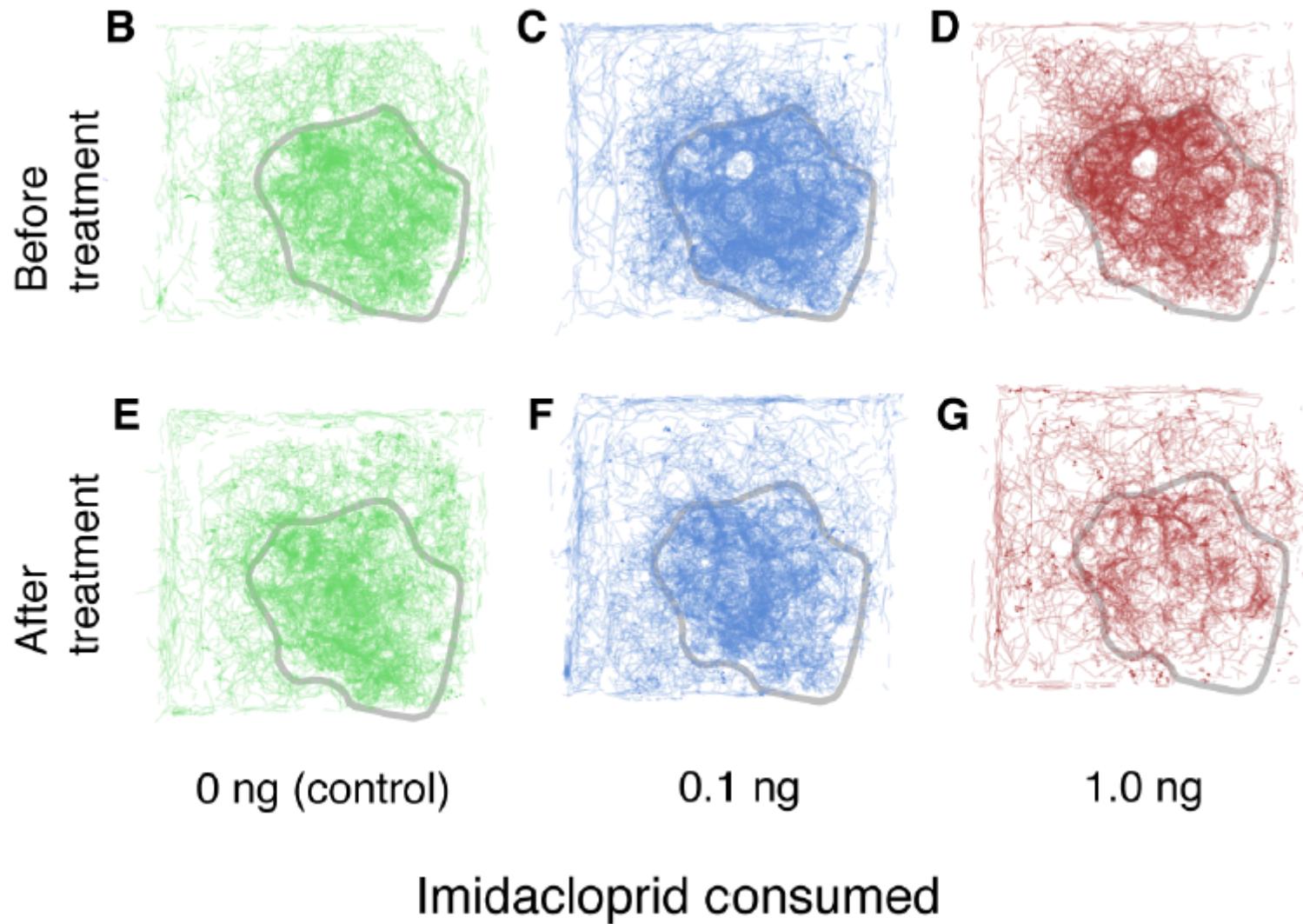


**A**

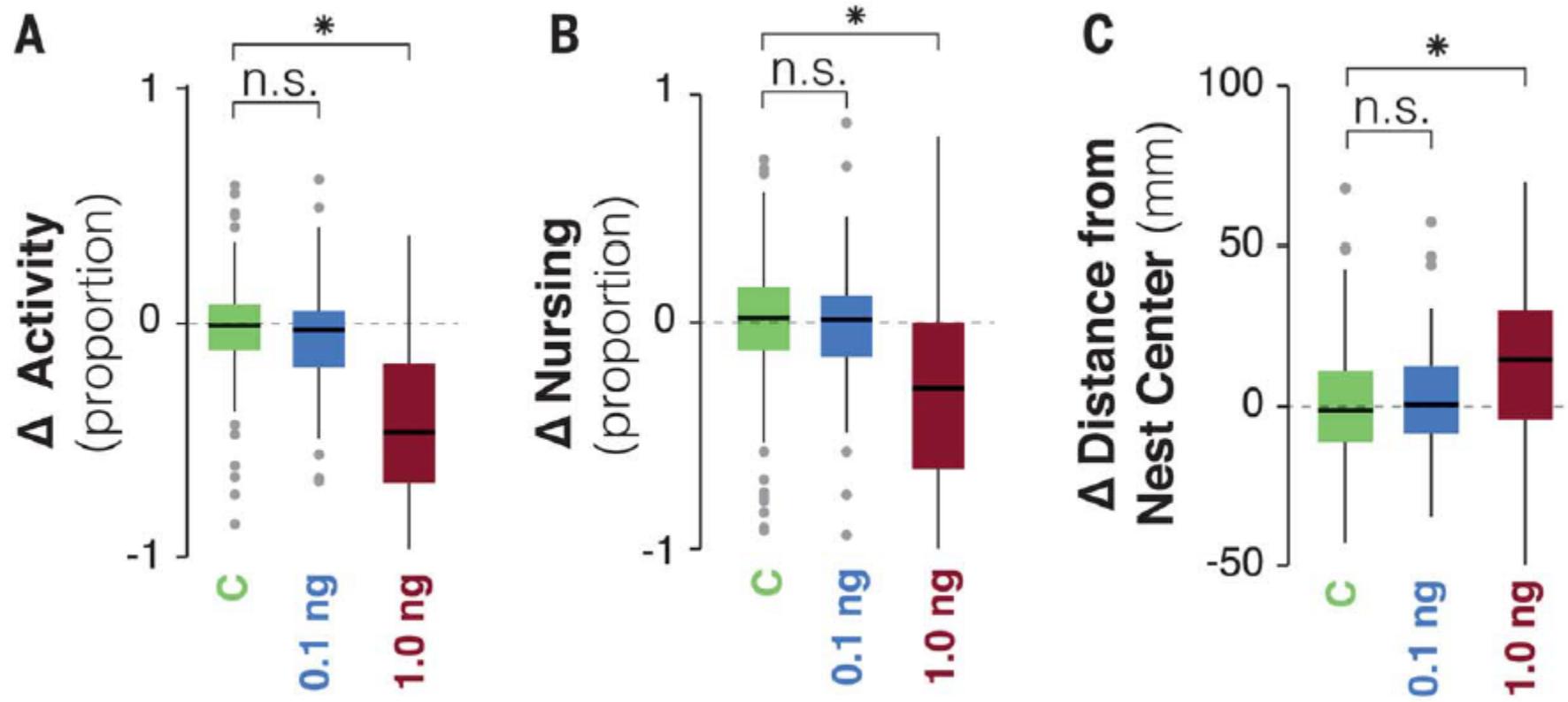
- Brood
- Wax pots
- Nest center
- Queen path
- Worker paths (colored by individual, N = 94)



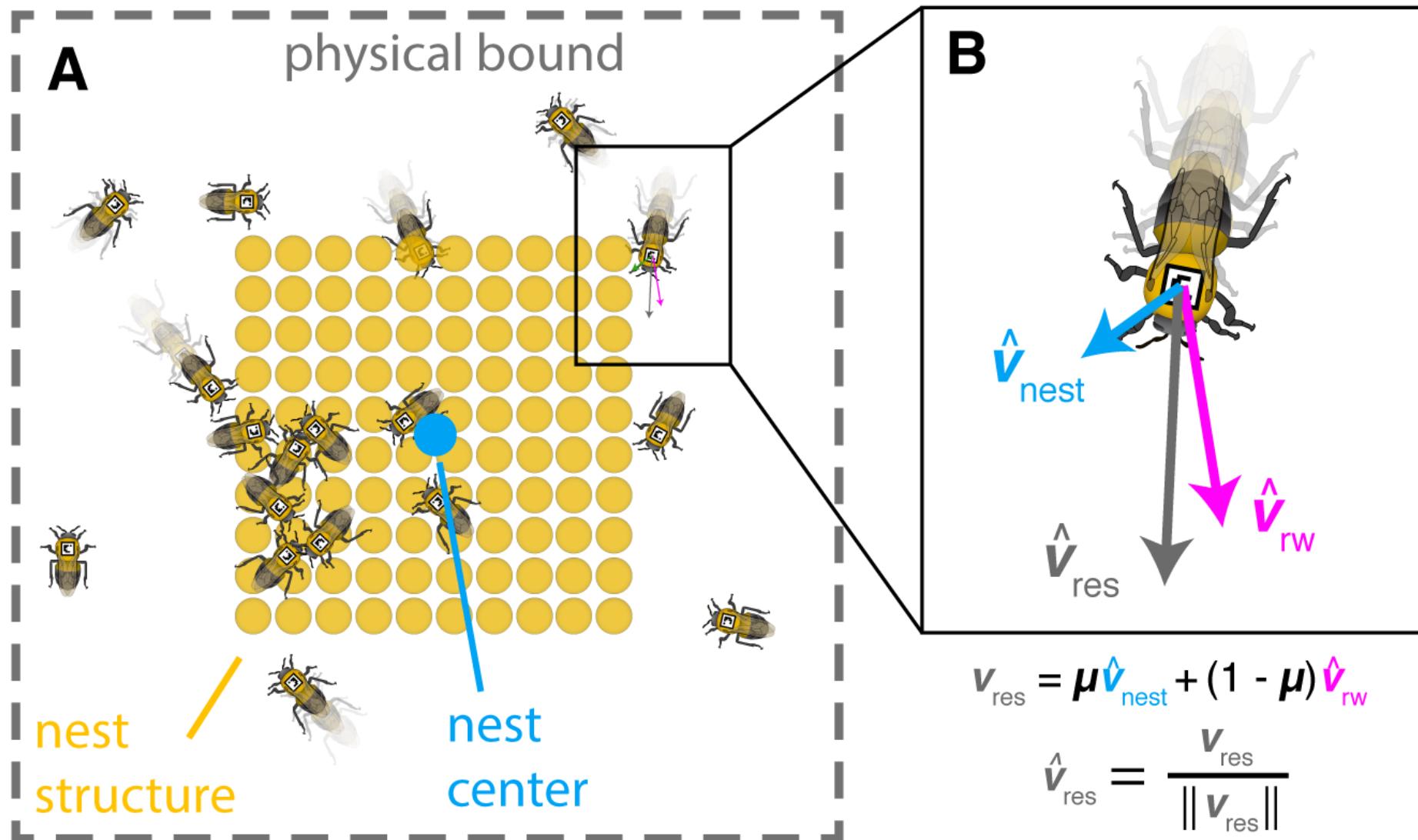
# Bumblebees exposed to pesticides are less active and on their nests less frequently



# Bumblebees exposed to pesticides are less active and on their nests less frequently



# We created an agent-based model of bee movements in their nests: BeeNestABM



# github.com/ashleefv/BeeNestABM

ashleefv / BeeNestABM

Code

Issues 0

Pull requests 0

Projects 0

Wiki



Agent-based model of spatiotemporal distribution of bumblebees in nests

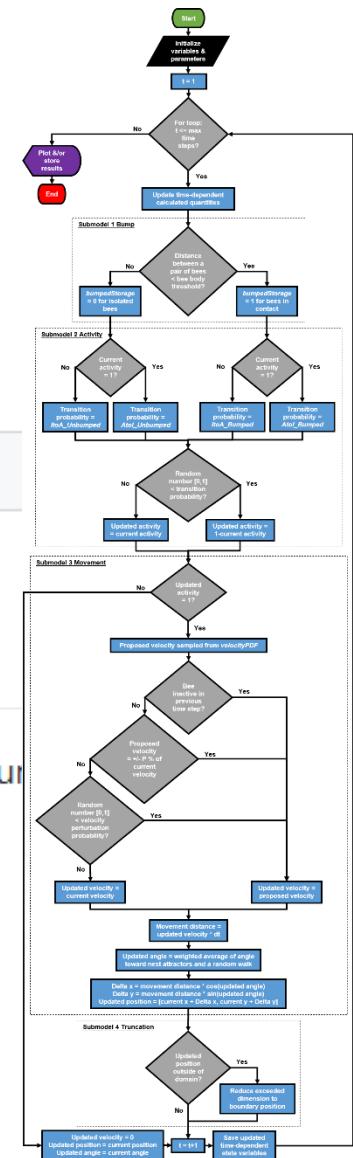
README.md

## BeeNestABM

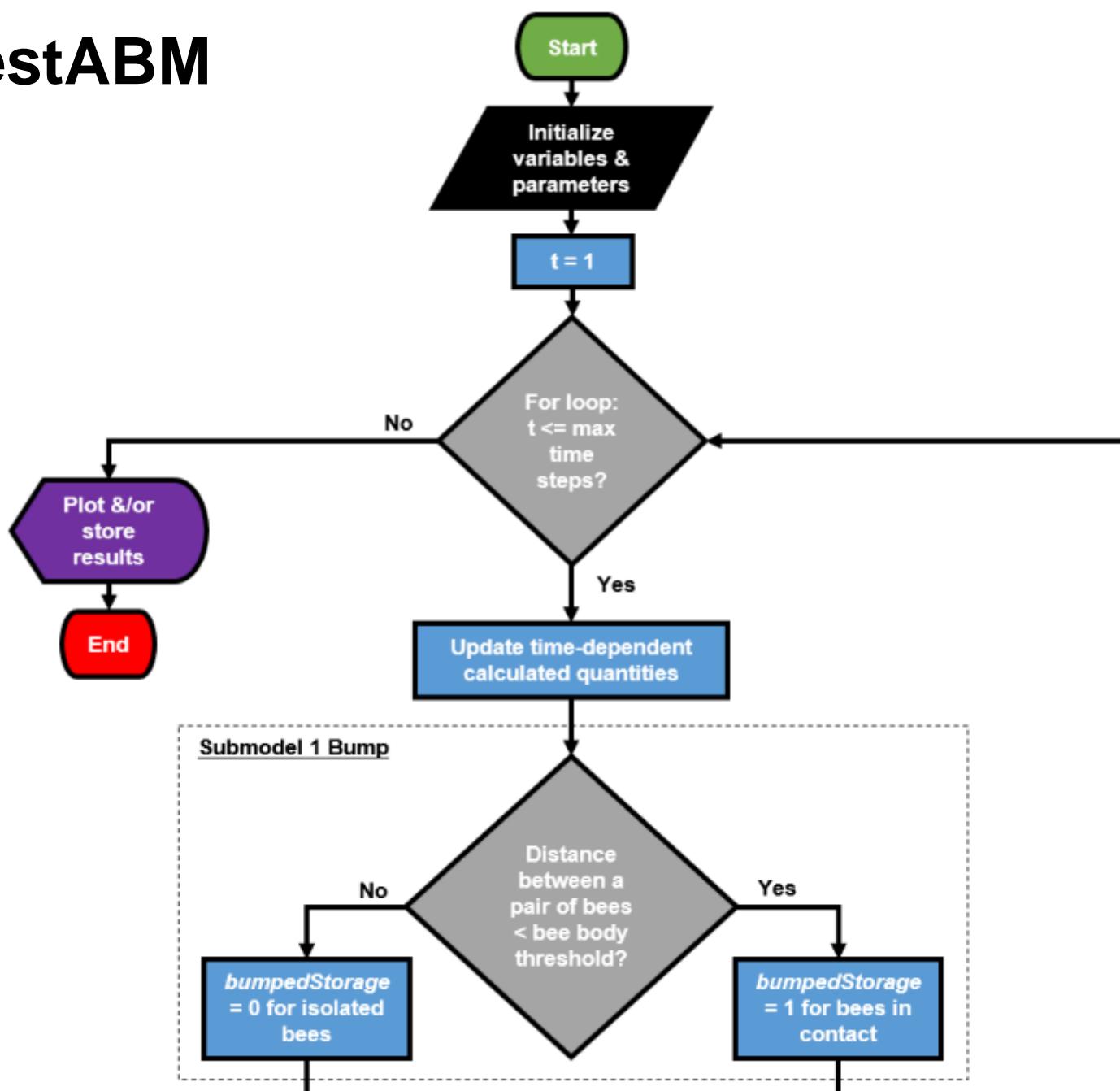
BeeNestABM: An open-source agent-based model of spatiotemporal distribution of bumblebees in nests

Code: DOI [10.5281/zenodo.1303422](https://doi.org/10.5281/zenodo.1303422)

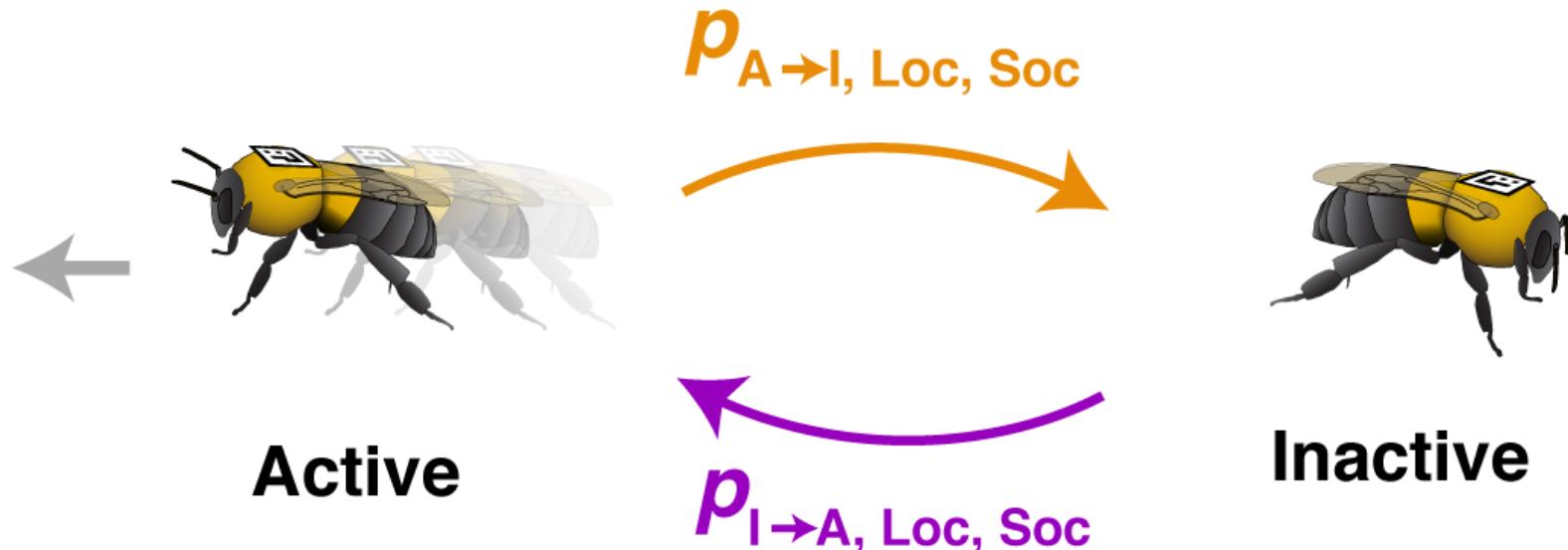
Paper: JOSS [10.21105/joss.00718](https://doi.org/10.21105/joss.00718)



# BeeNestABM



# BeeNestABM: bump submodel

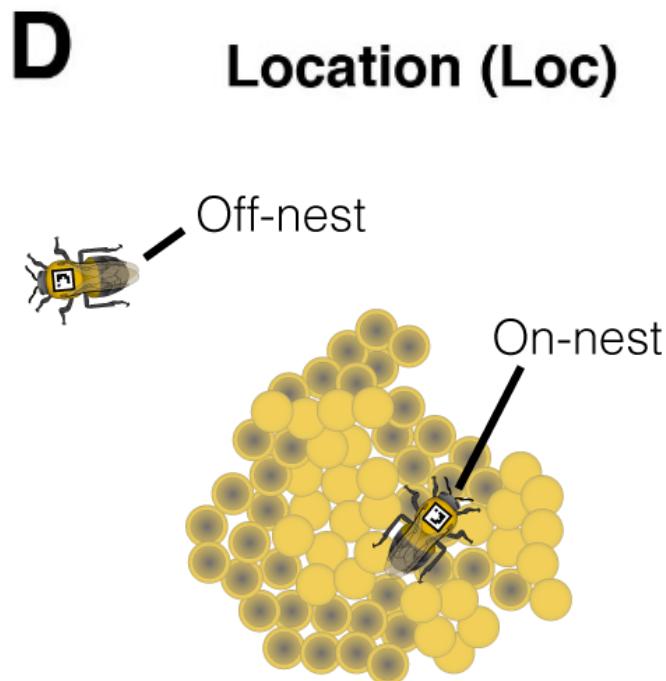


Crall, ..., Ford Versypt, et al., *Science*, 2018

Ford Versypt, Crall, Dey, *J Open Source Software*, 2018

Crall, de Bivort, Dey, & Ford Versypt, *Frontiers in Ecology and Evolution*, 2019

# BeeNestABM: bump submodel



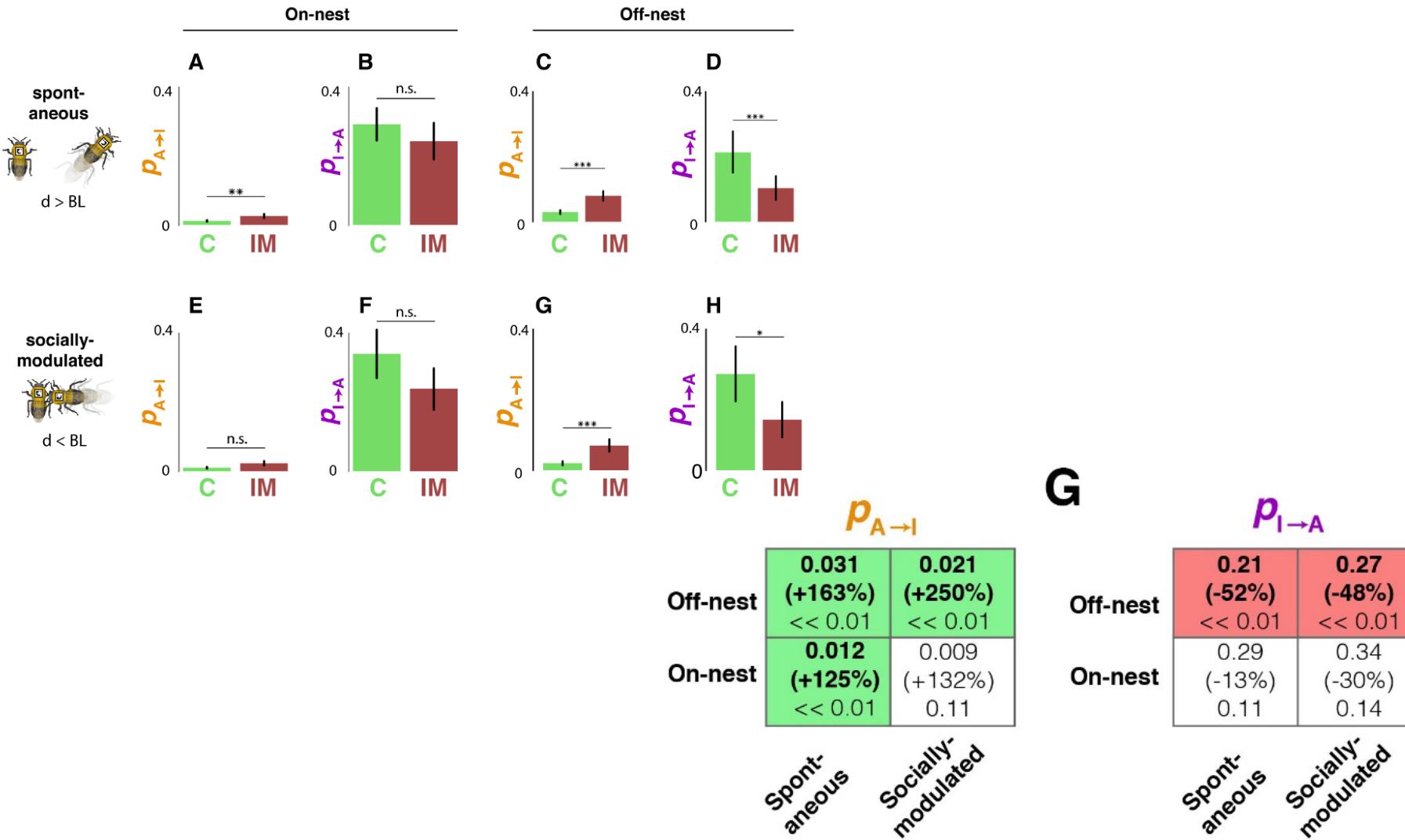
**E Social interaction state (Soc)**

Spont-  
aneous      Socially-  
modulated



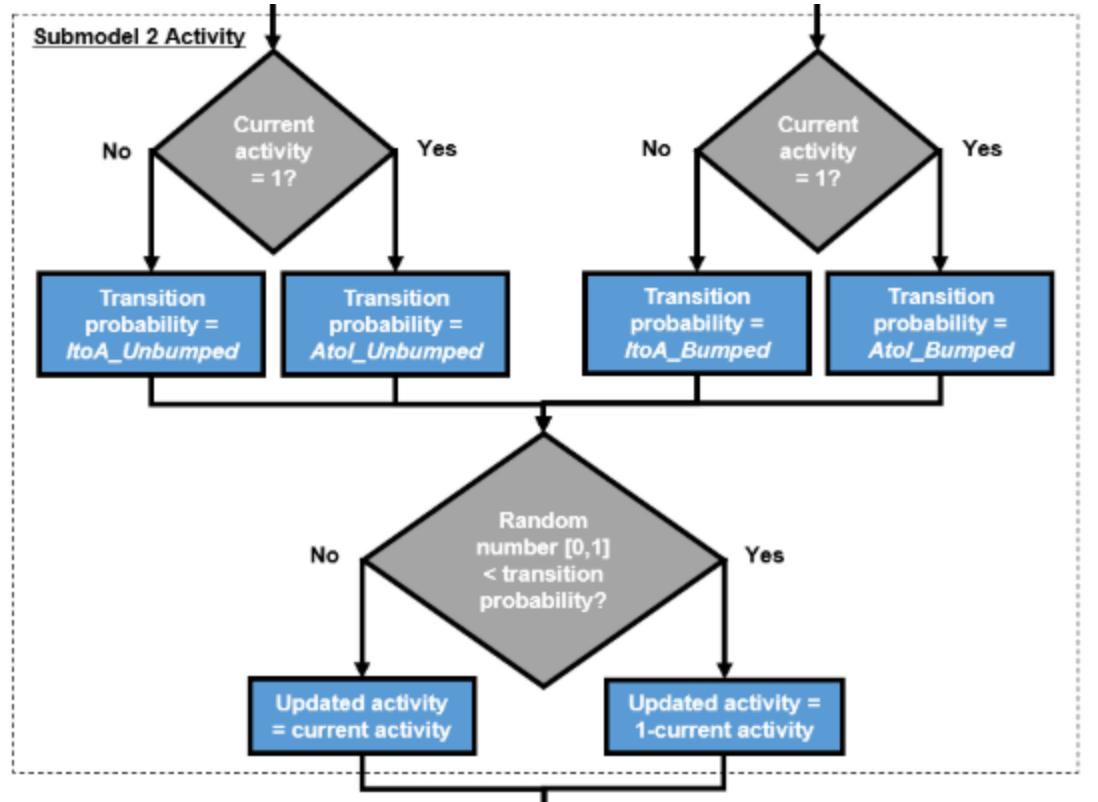
# BeeNestABM: bump submodel

## Parameters estimated from data

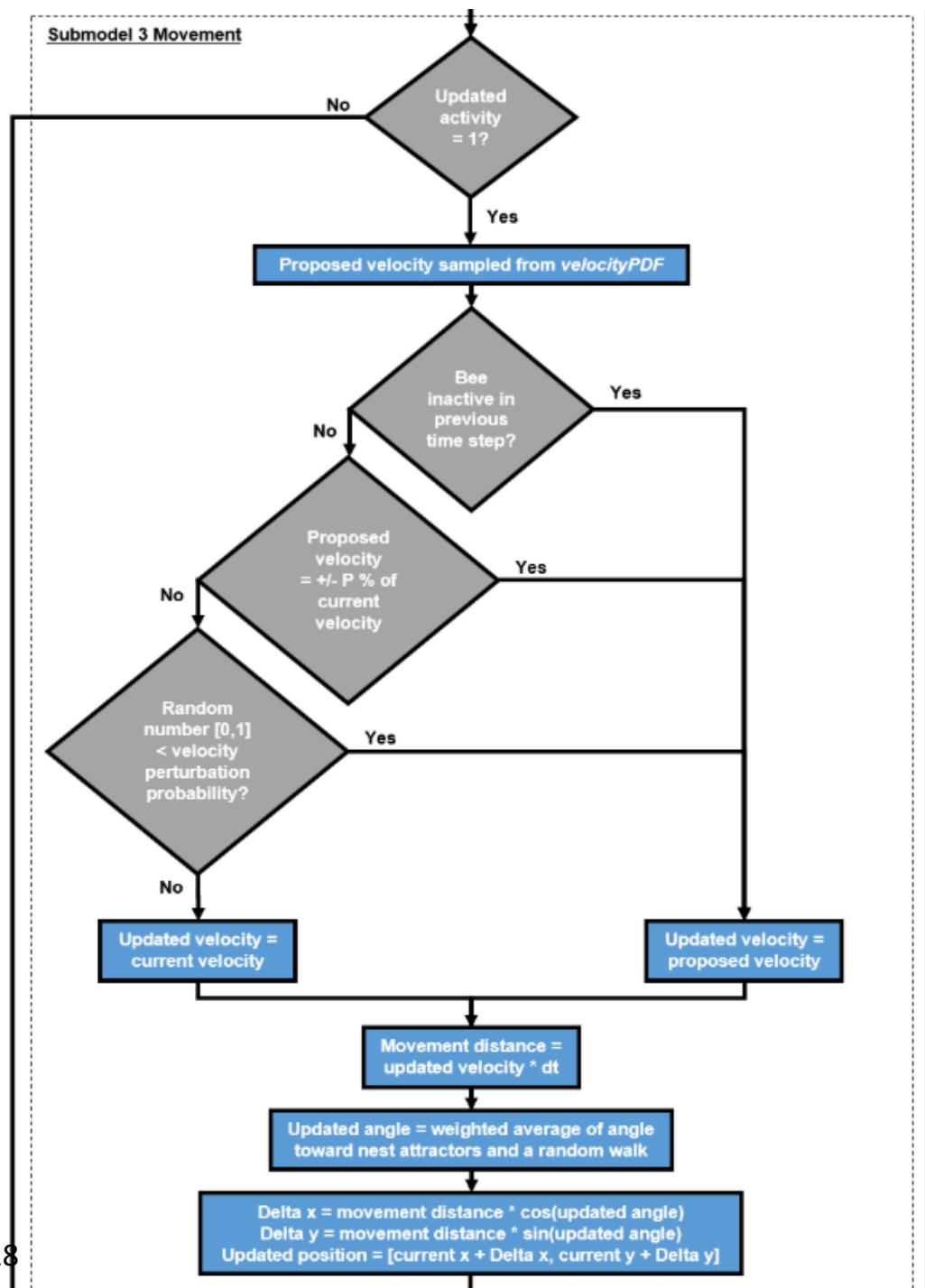


# BeeNestABM: activity submodel

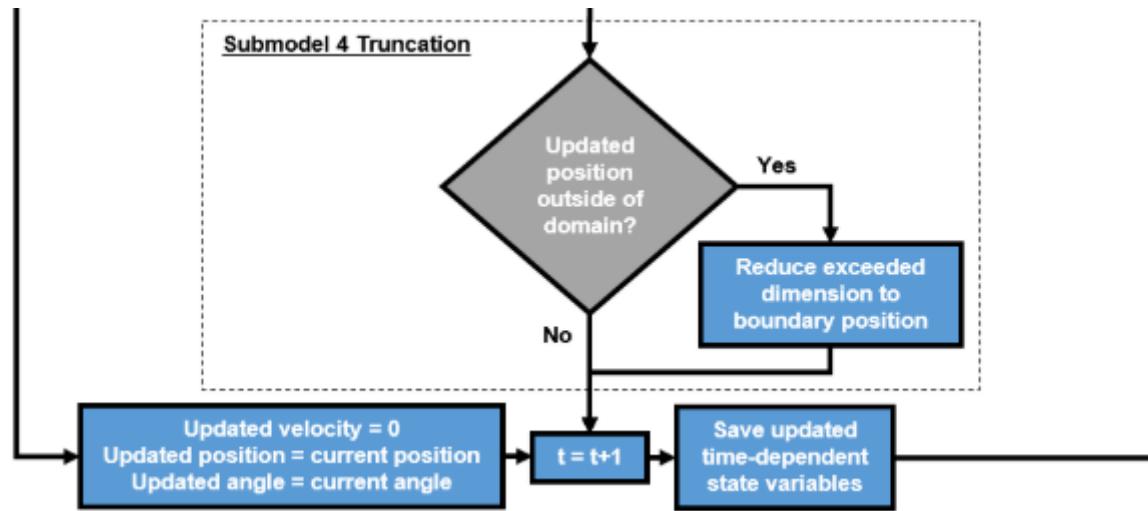
## Parameters estimated from data



# BeeNestABM: Movement submodel

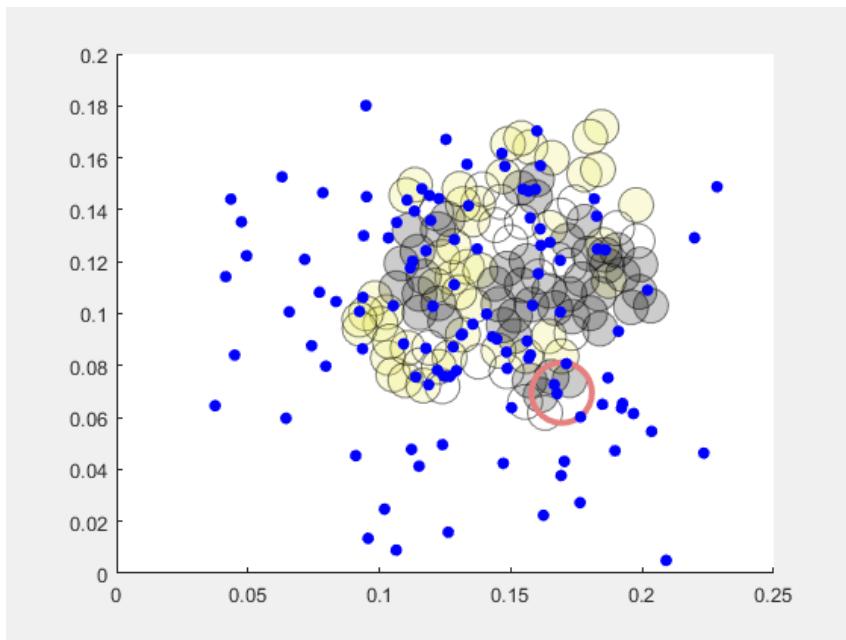


# BeeNestABM: truncation submodel

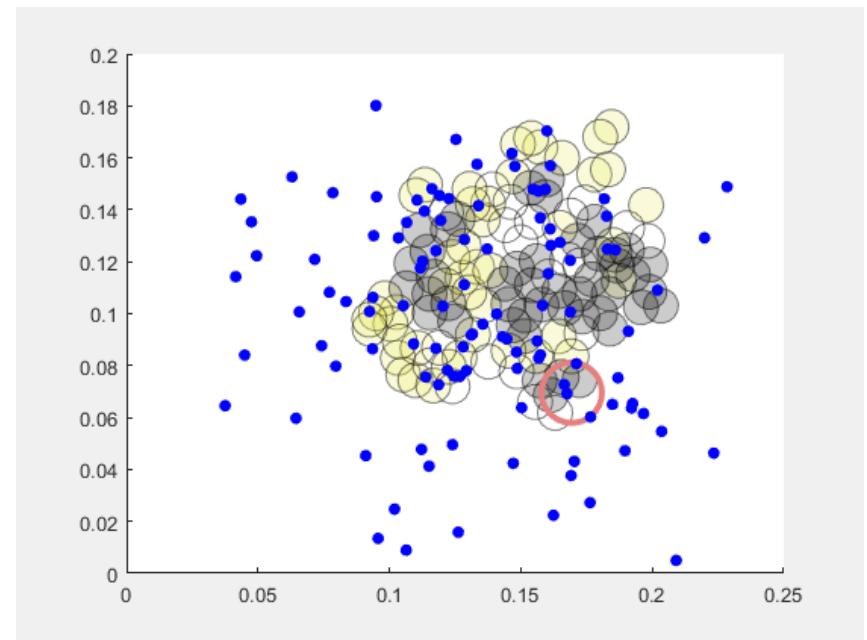


# Results: Changing bump transition probabilities for pre & post exposure

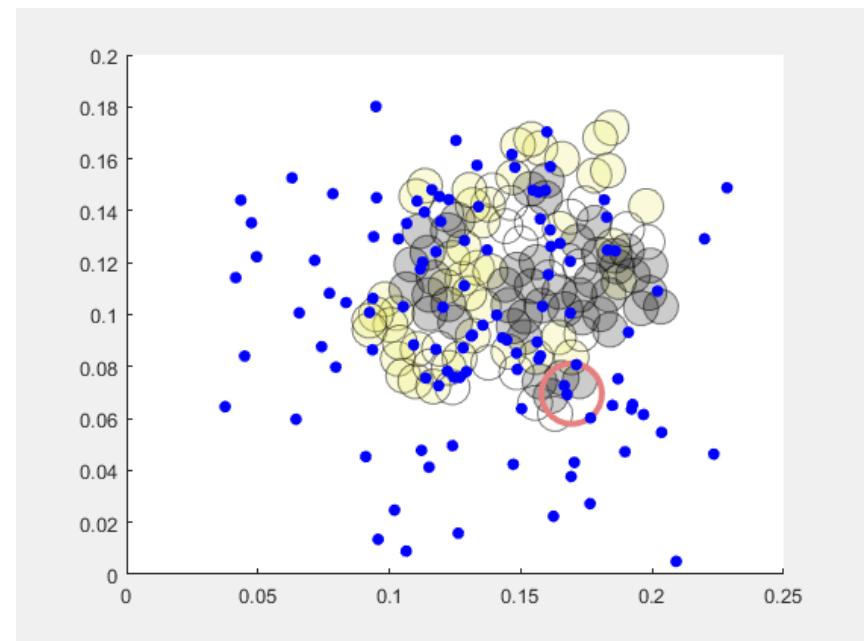
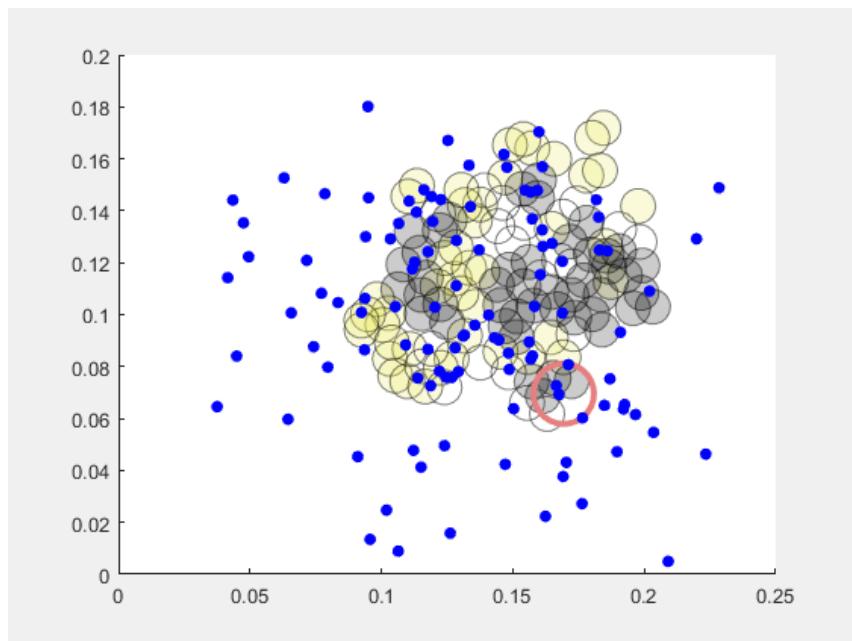
Pre-exposure



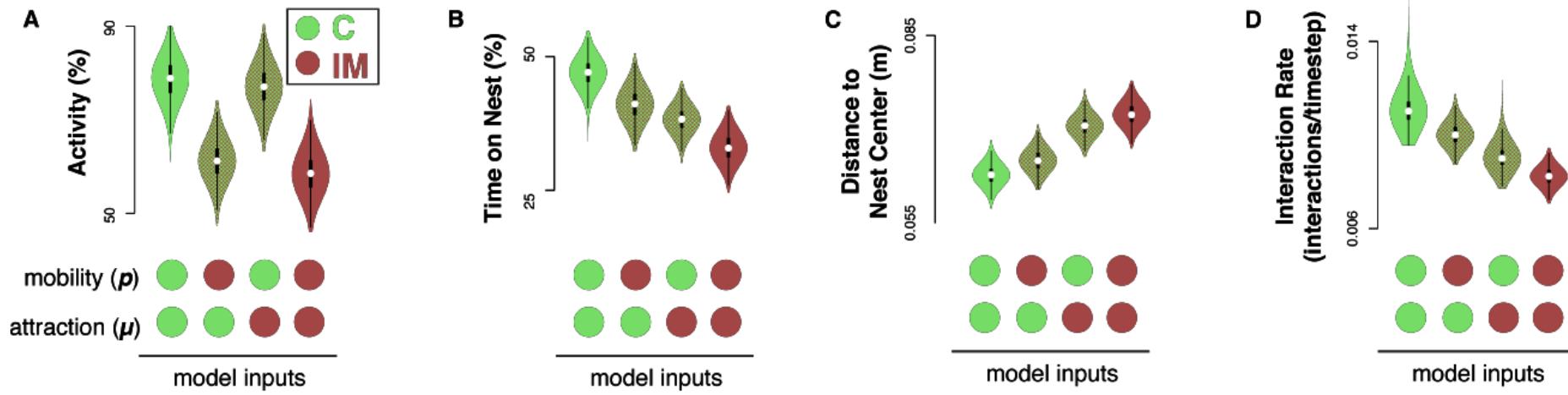
Post-exposure



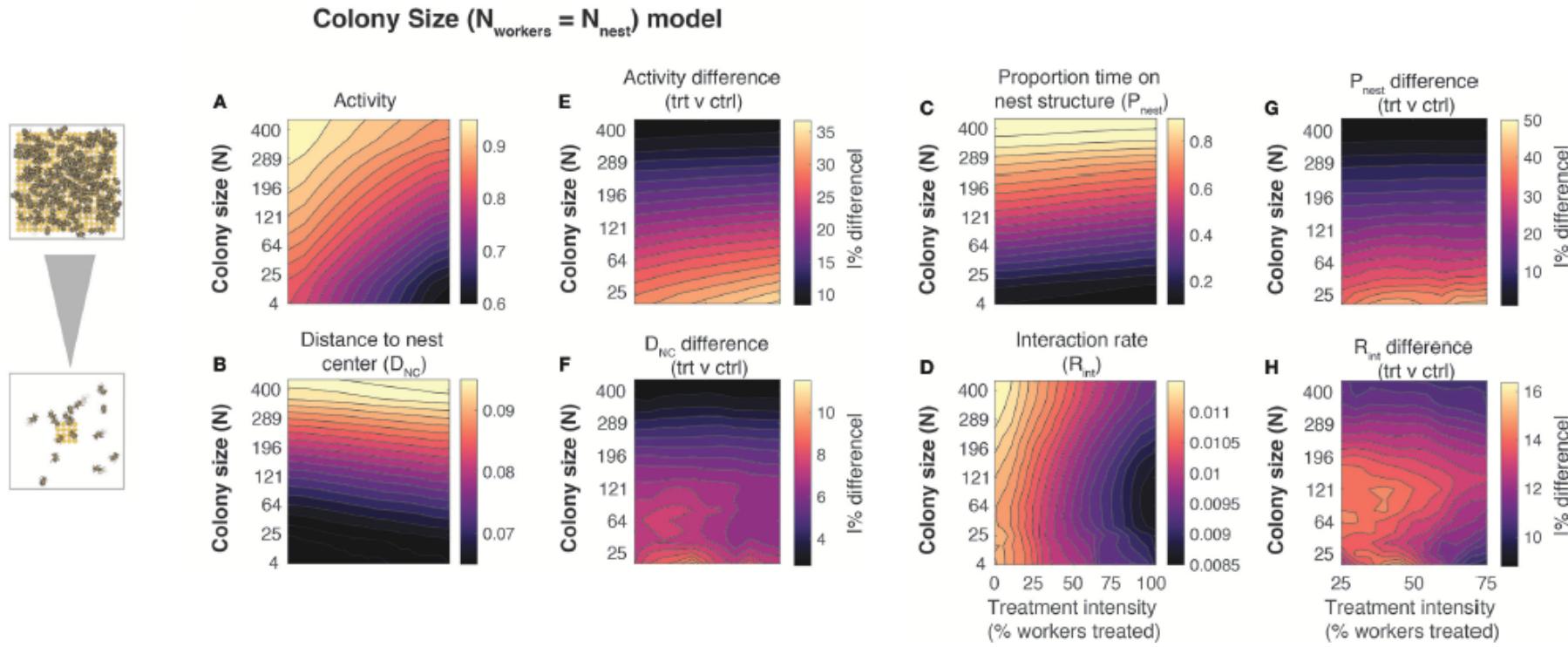
# Results: Changing attraction strength



# We tested combinations of having the bump (mobility) and attraction strength off or on at fitted values

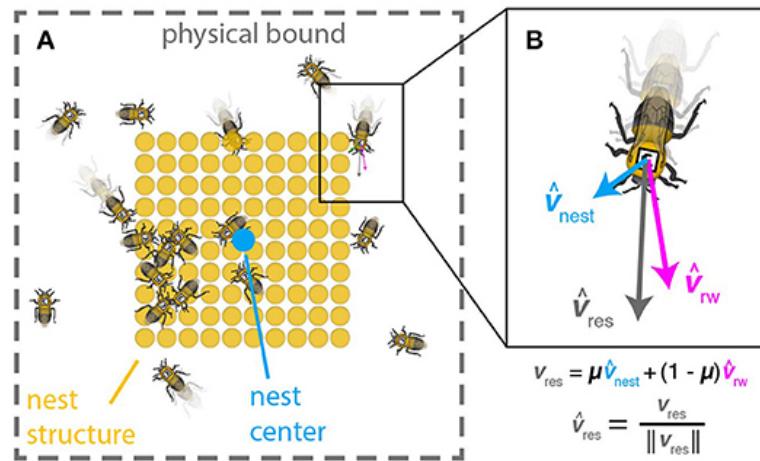


# We extended the model to do *in silico* tests of other conditions to probe mechanisms

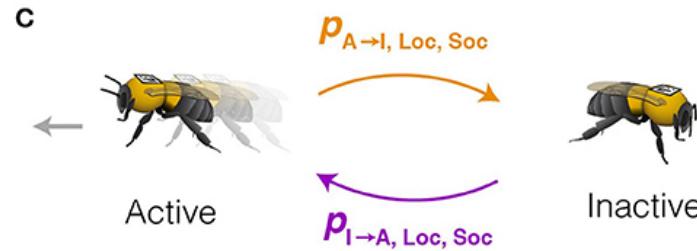


# BeeNestABM

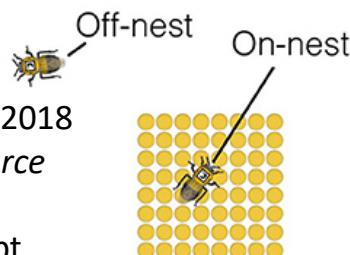
## Agent-based model (BeeNestABM)



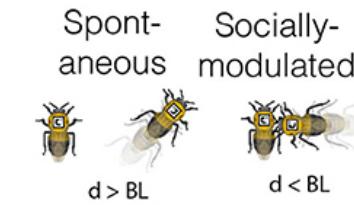
## Activity state parameter estimation (empirical)



## D Location (Loc)



## E Social interaction state (Soc)



Crall, ..., Ford Versypt, et al., *Science*, 2018

Ford Versypt, Crall, Dey, *J Open Source Software*, 2018

Crall, de Bivort, Dey, & Ford Versypt, *Frontiers in Ecology and Evolution*, 2019

[github.com/ashleefv/  
BeeNestABM](https://github.com/ashleefv/BeeNestABM)

