Overview of the honey bee colony model ApisRAM: a model for integrating multiple stressor effects on bees

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Multiple stressors – surely we can just sum effects?

Unfortunately no, observations from the real world show that this is too simplistic.
...the reason is feedbacks & interactions

Bees forage when the weather is good to fill the colony’s food resources
...the reason is feedbacks & interactions

These resources are used in the winter to keep the bees warm and alive!
...the reason is feedbacks & interactions

Anything interfering with this process can reduce the colony fitness over winter
...the reason is feedbacks & interactions

Anything that lowers the number of bees means less chance of being able to keep warm by consuming resources.
...the reason is feedbacks & interactions

But the bees ‘know’ this and will try to compensate for any problems they encounter as they go through the season
Balancing these factors is a complex thing

...but the bees do it – so do we think the hive operates with a hive intelligence solving these problems?

Probably, yes, but we don’t think it is a central brain.

Rather it is the emergent response of all the bees reacting to their surroundings - but also influencing them.
1. Behaviour occurs at the individual level
2. Behaviour depends on the individual bee’s situation
3. Behaviour depends on individual motivation not a systems response
4. From the bee’s perspective these decisions are ‘selfish’

It’s mine, I’m not sharing!

Selfish, not in this way, but in that decisions benefit the individual bee at that time
Design II: Selfish bees and temperature

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When it's cold bees move towards the warm, and form a cluster while they metabolise resources to keep warm.

The cluster of bees also insulates, so we have a feedback interaction: the colder it is, the tighter the bees cluster, the more heat they conserve.
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Each bee is like a small mobile heater but needs to be refuelled.

Calculating the effect of each individual bee on each other is very complicated, but can be done by using efficient computational algorithms.
In hive activities & bee development

Development

• Three castes
  • Worker, Drone, Queen

• Life stages
  • Egg -> Larva -> Pupa -> Adult

Stressors

• Thermal
• Nutrition
• Pesticides
• Disease/Varroa

Activities

• Feeding
• Cleaning cell
• Capping brood
• Attending brood
• Receiving nectar
• Deposting nectar
• Ripening nectar
• Capping honey

• Packing pollen
• Comb building
• Ventilating entrance
• Warming up
• Guarding
• Removing debris
Design III: Context

Once we have the bees behaving sensibly in the colony, the next step is consider the landscape context the colony finds itself.
ALMaSS Landscape modelling

WEATHER CONDITIONS

CROP MANAGEMENT

CROPPING SYSTEM: CROP ROTATION

LANDSCAPE ELEMENTS

SPECIES-LANDSCAPE SPECIFIC INTERACTIONS

FARM TYPE

PESTICIDE APPLICATION ENGINE

Resources & Pesticides

VEGETATION GROWTH MODELS – Nectar & Pollen
Mapping data used to create the landscape model

WATER  CULTURAL FEATURES  NATURE  CULTIVABLE/UNUSED
ROADS  BUILT-UP  FIELDS
Farm classification, and rotations

NL example: national classification using subsidy data
Farm classification, and rotations

Rotation input per farm type
- NLMaizeSpring
- NLCatchPeaCrop
- NLBeetSpring
- NLCabbage
- NLSpringBarley
- NLWinterWheat
- NLWinterWheat
- NLWinterWheat
- NLCatchPeaCrop
- NLGrassGrazed
- NLGrassGrazed
- NLMaizeSpring
- NLCatchPeaCrop
Bee foraging, scouting, and communicating

• Model bees will scout for forage resources and communicating the information to the colony
• Foragers will be able to use this information to forage in the landscape
• However, foraging resources will also expose bee to pesticides and pesticide residues in pollen and necar which will be brought to the colony – this will depend on when and where they forage
Putting it all together
The ApisRAM vision

Currently available for: Denmark, Poland, The Netherlands and parts of Portugal.

H2020 projects will provide: Germany (parts), France, Finland, Ireland, Italy, Sweden, Belgium & UK
Overall aims for ApisRAM

- Integrate multi-stressor impacts (pesticides and non-regulated stressors)
- Simulate interactions between components
- Predict complex system-dynamics, including the possibility to integrate mitigation options (e.g. width of sown field margins or restricted pesticide usage).
- Help to clarify the relative importance of different stressors, including how the impact of a pesticide on colony health might change with changing context, e.g. climate, and/or farming.
Current status

- ApisRAM is now designed and being implemented, a prototype model is expected in January 2020
- All ALMaSS development, including ApisRAM is open source
- The model is also supported by a parallel EFSA project on data collection that will provide data to improve and test the model from landscapes located in Denmark and Portugal
- The first version of ApisRAM to be released is expected in Spring 2021
Thank you for your attention!

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