Group Decision Making in Honey Bee Swarms

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Overview

- Revisit group decision (consensus)
- Problem of consensus hypothesis
  - Introduction of quorum
- Two experiments on appledore islands
  - Support quorum
  - Test delay of quorum
- Behavior mechanism

Revisit Group Decision (Phenomenon)

Lindauer observed waggle dance:

- Only a few bees were active to seek potential nest site/ food resource
- At first dances represented various sites, but eventually they have the same type

Revisit Group Decision (Experiment)

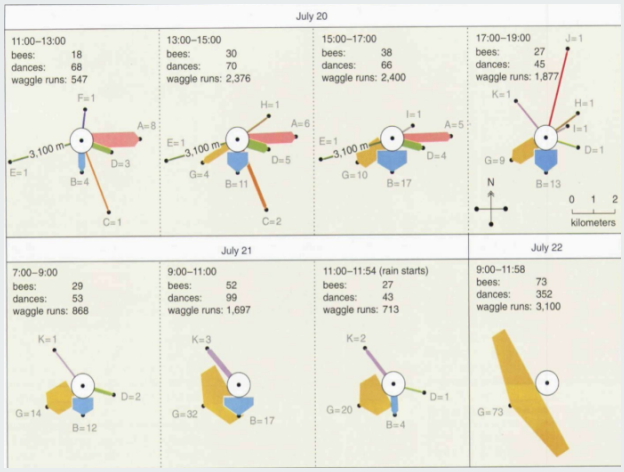
Bees are labeled with a colored and numbered plastic tag affixed to the thorax

- Distinguish between individual scout bees when observing a swarm's behaviour

Revisit Group Decision (Result)

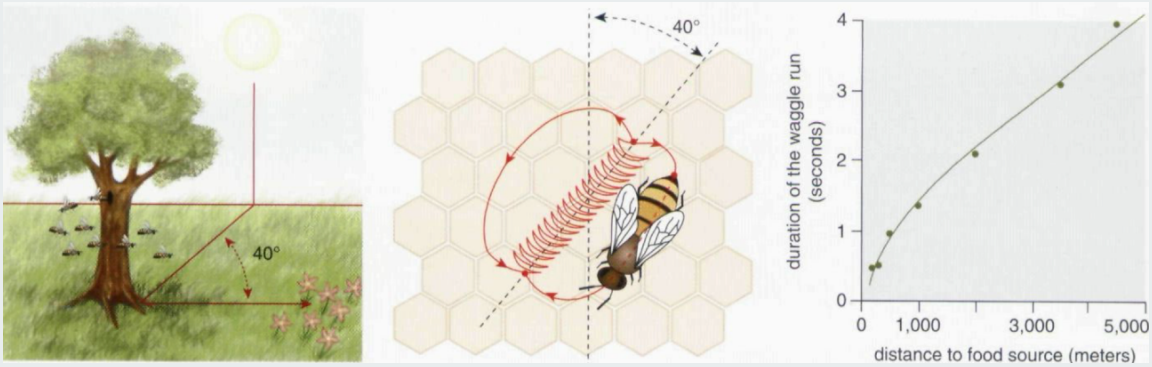
- Dances on a swarm come to represent one site, and then the swarm moves to this site
- Swarm makes decision based on agreement of dancing scouts

→ **Result of consensus building**



Revisit Group Decision (Result)

The relation between duration of waggle dance and distance



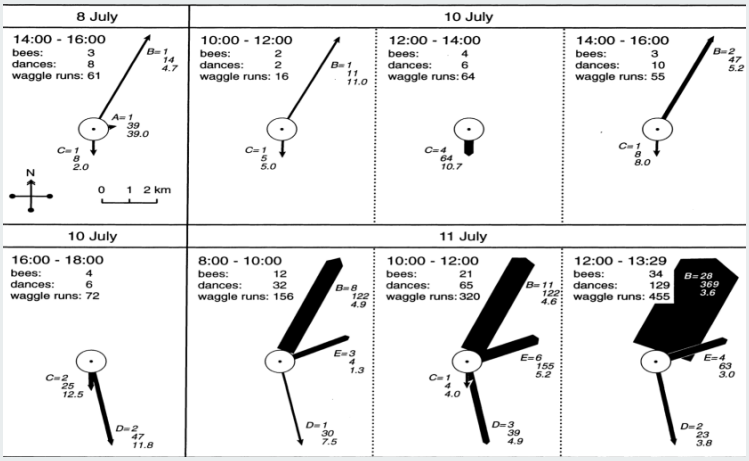
Revisit Group Decision (Conclusion)

Finding and choosing a new nesting site

- Only nest-site scouts are active
  - Only hundred of thousand bees are active
  - Random exploration at first and eventually reach to consensus
- Waggle dance by nest-site scouts
  - Length translates into distance to food source
  - Angle represents direction

Problems with the Consensus model

1. No sign of scout bees polling fellow dancers
2. Occasionally seen a swarm launch into flight without a dance consensus



This graph shows the bees don't reach to a consensus

Consensus and Quorum

Consensus

Agreement of dancing scouts leads to final decision

Quorum

Sufficient number of dancing scouts leads to final decision

- Scout bees could vote for a site and interact
- Scout bees could monitor their number to tell if they reached the thresholds

Quorum

- Exactly how scout bees sense a quorum remains an enigma
  - May use visual, olfactory or even tactile information
- Once quorum thresholds are reached:
  - Return to swarm
  - produce a special high-pitch acoustical noise that stimulate non-scouts to begin warming their muscles (worker piping)
  - Scramble through the swarm cluster
- Steps above happens before the swarm reaches to a consensus and usually takes an hour.

Worker piping

Experiment 1

- Performed at Appledore Island, which is nearly treeless so lacking in natural nesting cavities for honey bees
- Presented swarms with 2 identical superb nest boxes, each one 250 meters from the swarm but in different directions

Conclusions for experiment 1

- Swarms would routinely take off when scout bees were still dancing strongly for both sides

→ **Reject consensus-sensing hypothesis**

- Swarms consistently started preparing for flight once 15 or more bees were seen together at one of the nest boxes(about 150 bees overall)

→ **Support quorum-sensing hypothesis**

Experiment 2

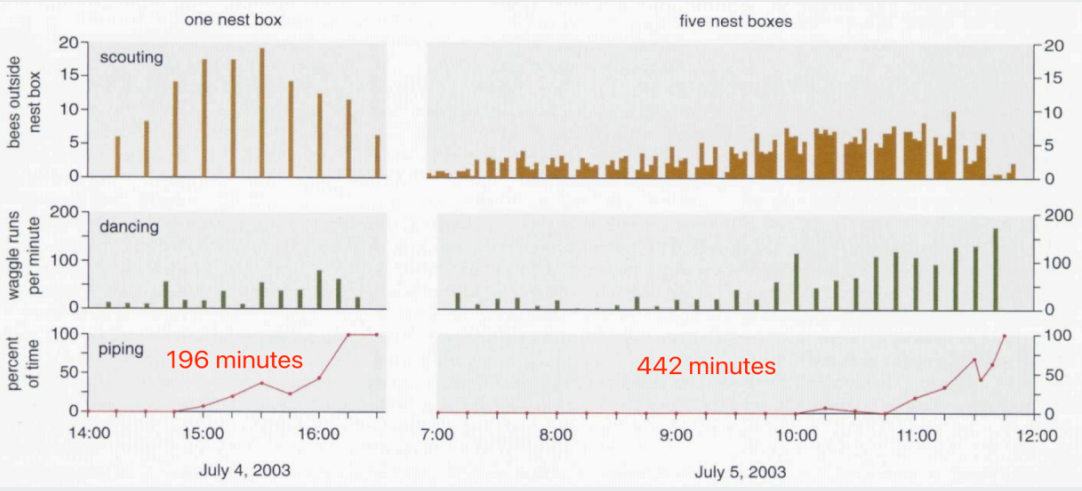
- Also on Appledore island
- Place five desirable nest boxes close together at one location
- Cause scouts visiting site to be dispersed among five identical nest cavities rather than concentrated at one
- A control trail with just one nest box

Conclusion for experiment 2

- Marked delay to takeoff in the five-nest-box treatment(442 minutes) relative to one-nest-box treatment(196 minutes)

→ **Supports quorum-sensing hypothesis**

Conclusion for experiment 2

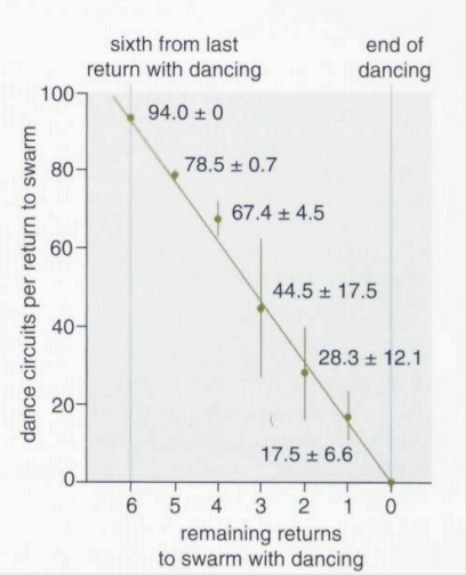


Behavioral mechanisms of scout bees

1. Careful tuning of dance strength
   - One excellent and one mediocre boxes
     - Waggle dance contains 100 or more dance circles for excellent box
     - Only a dozen or so dance circles for mediocre box
   - The greater the strength of dancing for a particular site, the larger the stream of newcomers to it, hence the buildup of scouts will be most rapid at the best site.

Behavioral mechanisms of scout bees

2. If a scout bee commits herself to a site, she will make multiple visits to the site
   Decrease the strength of her dance advertisement each time after revisit the site



Behavioral mechanisms of scout bees

3. Strong positive feedback in recruitment process
    - The greater number of bees committed to a site, the greater the number of recruiters, in turn gives rise to greater number of bees committed to the site

rate of recruitment > rate of abandonment → scouts at site grow

Conclusion

- Behaviour of scouts in honey bee swarms are tuned by natural selection to create a group decision-making process
- Swarms reach a quorum for a nest site before worker piping begins and eventually results in a takeoff

Questions?

FAQ:
Q: Why is this presentation similar to previous ones?
A: Papers are written by the same authors.

Q: Why are the experiments on Appledore Island?
A: The author is a professor at Cornell University, where Appledore Island is located.

Q: Threshold of quorum?
A: one experiment shows that more than 15 bees over a swarm of 150 or so overall bees