Quorum Sensing During Nest-Site Selection by Honeybee Swarms

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Introduction/Recap

- Bee colony occasionally needs to separate and migrate
- Scout bees mange finding a new hive site
  - Non-scout bees coalesce on a branch
  - Organize and lower their temperature
  - Scouts notify the bees when to awake via piping

Deciding On a Nest Location

- Two separate decision methods: consensus and quorum
  - Consensus: All bees at the swarm site support one location
  - Quorum: A sufficient number of scout bees are consistently travelling to one location
- Previous experiments suggested quorum-sensing
  - This is the focus of the paper's experiment

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Basic Experimental Design

- To delay quorum formation, limited number of good sites to one, and provided five close-together nest boxes
- Monitored buildup of scouts at each site
- Each swarm had a control with just one nest box
- Order of tests and site location varied between swarms to control treatment-order or side effects

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Location and Swarm

- Study conducted at Shoals Marine Laboratory on Appledore Island, Maine
- Used artificial swarms headed by a “New World Carniolan” queen
- 1kg (roughly 7500) of worker bees was assigned to each swarm
- Queen trapped in a cage on a swarm mount to ensure bees returned to original site

Table 1 Number and location of the nest boxes used in each of the eight trials of the experiment. Note that each of the eight possible treatment/order/site combinations (e.g., five-nest-box treatment, used first, at Guano Bench) was used only once

Swarm	Trial, date	Treatment	Nest-box site
1	1, 28–29 June	Five-nest-box	Guano Bench
	2, 29–30 June	One-nest-box	Broad Cove
2	1, 4 July	One-nest-box	Guano Bench
	2, 5 July	Five-nest-box	Broad Cove
3	1, 8–9 July	Five-nest-box	Broad Cove
	2, 9–10 July	One-nest-box	Guano Bench
4	1, 23 July	One-nest-box	Broad Cove
	2, 24–25 July	Five-nest-box	Guano Bench

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Apparatus, Layout, and Data Collection

- Video camcorders and two small 5-mm-diameter microphones were placed to observe the swarm cluster
- Each trial consisted of swarm mounted on the porch of Bartel’s Hall and nesting sites at either Guano Bench or Broad Cove
- Used pheromone swarm lures to initially attract bees
- Once bees found the nesting site, pheromone lures were placed in jars to prevent influence of a specific site
- Counted the number of bees outside each nest every 15 minutes

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Data Analysis

- Mean counts were used for the number of scouts outside a particular nesting box
- Video recordings were analyzed to determine the number of waggle runs over 10 minute intervals before takeoff
- Audio recordings were analyzed to estimate the percentage of time worker piping was heard

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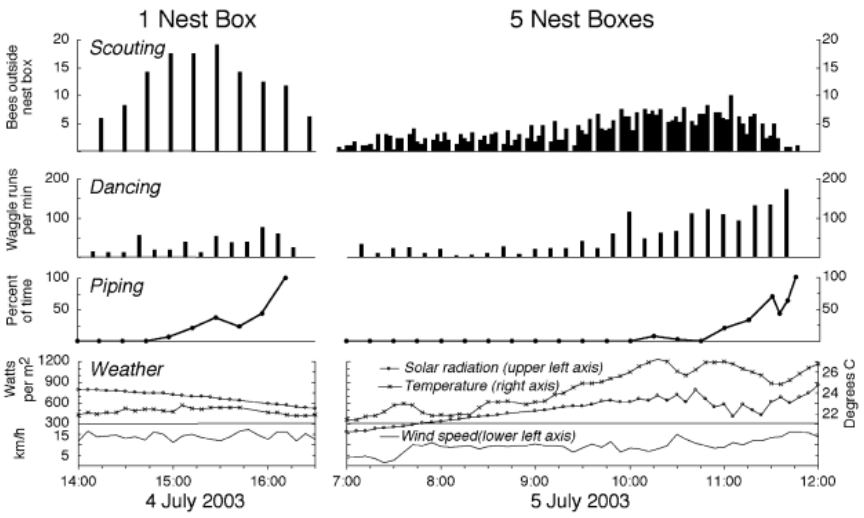
Results

- Days described were similar and optimal
- Time for 1 nest much smaller than 5 nests



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Results

- Average number of bees between the one-nest and five-nest trials are significant.
- Total number of scout bees in the five-nest trial is larger than the number for the one-nest trial
- Average numbers going to each of the nests in the five-nest trial are similar to each other

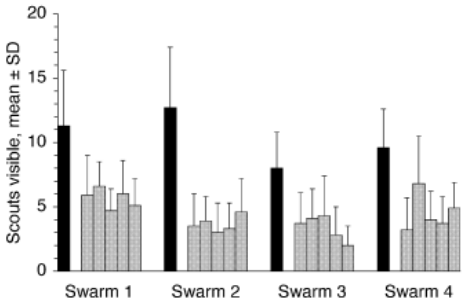

Fig. 2 Mean number of scouts visible on the outside of each nest box during one-nest-box trials (*black bars*) and five-nest-box trials (*grey bars*) of each swarm. In all swarms, the one-nest-box mean differs significantly from the five five-nest-box means

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Evaluating the Experiment and Activity at the Nest Boxes

- This experiment studied the quorum-sensing hypothesis by identifying a testable prediction: “That inducing a delay in the formation of the quorum at a swarms chosen nest site should delay preparations for takeoff”
- Challenge to develop an experiment that delays the buildup of scouts but does not interrupt the other processes
- Based on the results, the five-nest-box treatment slowed the buildup of scouts while not reducing the traffic of scout bees

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Dancing on the Swarm and Other Stimuli

- Was concerned that five nest boxes at one site might reduce the level of waggle dancing at the swarm cluster, however the mean rate of waggle-run production did not differ between the two trials
- In both trials, the bees were always unanimous with their dancing
- There could be other signals that informs scouts to start piping, including the shaking signal (a signal that simulates a general activation of the bees in the swarm), however the data shows that other stimuli would have effects on the results

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Cues Used to Identify a Quorum

- Possibly identify other scouts visually
  - Clear to identify bees surrounding a location
- Tactile perception (touch)
  - Increased touching between scout bees as their numbers go up
  - Possibly used in identifying siblings
- May only identify bees that are interested in the site

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Effects of Quorum Sensing

- Size of quorum
  - Depending on the quorum detection method, the swarm size may affect the speed of site choosing
- Competition
  - Identifying a quorum means that competing hives will make the bees decide on a site more quickly

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Reasoning for Quorum Sensing

- Safety concerns
  - Ensures that enough bees know where to go
  - Consensus does not contain enough precise information
- Efficiency concern
  - Bees can start takeoff even as others are still scouting
    - This prefers a smaller quorum size
  - Because a quorum relies on the scouts agreeing with each other, bad options are removed
    - This prefers a larger quorum size
  - Similar displays shown in ants

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Any Questions?

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