Anatomy of a Swarm

What I Learned from Honeybee Democracy by Dr. Thomas Seeley

Honeybee Democracy

Dr Seeley writes about his expanded research on how a swarm of honey bees chooses its new home

- 1944 Karl von Frisch waggle dance
- 1949-51 Martin Lindauer "dirty dancers"
- 1976 Thomas Seeley nest site preferences
- 1980 Bernd Heinrich temp and metabolism regulation
- 1996-7 consensus building, site selection
- 2000-5 quorum sensing, swarm flight triggers

Book addresses:

- How bees decide on new site
- Navigation to new home



Swarms

Honeybee colony reproduction

What triggers a swarm?

Crowded hive conditions:

- Iots of capped and uncapped brood
- No storage space for nectar being brought in >>> This leads to idle workers:

Foragers return to the hive full of nectar and there is no place to put it. They can not return to foraging as they still are full so they hang around the hive "Idle".



Swarms

What are the precursors?

- The creation of Queen Cells
- Workers stop feeding the queen who stops laying
- Workers "shake" the queen forcing her to run around the hive >>> she will lose ~25% of her mass and be able to fly
- Workers gorge themselves with honey
- Scout bees know when it is time to fly based on QC development and weather
- "Worker Piping" & "Buzz Runs"



What's Happening at the Parent Hive ?

After the swarm has left, the parent hive has:

- several Queen Cells (QC) capped or almost capped
- Thousands of workers
- Thousands of capped brood
- Lots of food stores
- The virgin queens (VQ) emerge approximately 3 days after the QCs are capped.



What's Happening at the Parent Hive ?

IF the hive is still crowded after the swarm has left

- Once she emerges, the 1st VQ will be chased away from the other QCs
- Workers will not release the other VQs, but will feed them through the broken caps
- Piping: Toots and Quacks >> piping of other VQs may encourage 1st VQ to leave with some of the bees >>> After Swarm(s)

IF the hive is no longer crowded The VQ will go around and kill the other VQs in their cells or if they have emerged the VQs battle to the death.



What's Happening at the Swarm Cluster?

The bees have clustered near by. The resting metabolism of the bees maintains a cluster core temperature of ~35C/95F.

Above 20C/70F the bees spread out to create ventilation channels through the cluster.

As temperatures drop below 17C the mantle or exterior bees crowd inward shrinking the cluster.

To conserve energy, mantle bees do not shiver and allow body temp. to drop to just above the chill-torpor temp.

Below 10C/50F the mantle bees must shiver to keep warm.

Scout bees are exploring and reporting back to the cluster.



Scout Bees

Of the roughly 10,000 bees in an average swarm only 3-5% (3-500) are scouts.

These are foragers with a genetic predisposition to exploration.

They will search cavities and crevices at distances from 200m to 4800m (they scour about 30mi2).

Only about 24 scouts will actually locate possible nest sites.

Scouts are influential bees:

- Find and propose new nest sites
- Assess nest sites suggested
- Select the best option proposed
- Guide the cluster to the new home



What Makes a Good Home?

Analysis of hives in bee trees and research experiments determined that the following are important:

- Cavity Volume
- Entrance Height
- Entrance Size
- Entrance Direction
- Entrance Location
- Old Comb



What Makes a Good Home?

The findings revealed that the bees prefer the following for their new home:

Cavity Volume

45 liters = 1.589ft³

- Entrance Height 6.5m = 21ft
- Entrance Size 10-30cm = 2-5in
- Entrance Direction southerly
- Entrance Location @bottom
- Old Comb conserves energy



Scout's Nest Site Assessment

Other observations from the studies of scout behavior:

- Scouts need 37 minutes (on average) to assess a site.
- 75% of the time is spent walking the inner surfaces of the cavity.
- 10 to 30 visits will be made; half are spent inside, half outside the cavity.
- Scouts have site fidelity they will only visit one site.
- They convey site information to their swarm sisters via waggle dances.



Waggle Dances

Bees have an internal qualitative knowledge of nest properties.

A waggle dance circuit consists of a waggle run and a return.

As with foraging data

- Orientation = direction
- Run length = distance to site
- Return run speed = desirability

Faster/more circuits is more desirable.

A single scouts' dance conveys the better site 80% of the time; when looking at any random six scouts dancing for the same site, the better site always gets stronger dances 100% of the time.

So collectively the scouts are choosing the best site.



Abandoning a Poor Choice

Research Observations:

- Scouts do not compare sites and convert allegiance to the better one.
- Scouts for the best site must recruit the most supporters by performing the best (most zealous/longer) dances.
- A poor site with a zealous dance will not be promoted as recruited scouts will subsequently correct the "error" of a false zealous dance.
- There is a steady reduction in the number of dance circuits. It is thought that over time scouts are driven by a neurophysical tendency to stop dancing for any site.
- More zealous dances have more circuits thus will take longer to taper off.
- This regular turnover as bees stop dancing leads to a rapid consensus. (the longer dances linger > thus can gather more support).

Choosing a Site



The Debate:

- Multiple nest sites proposed
- Neutral or uncommitted scouts =>>> the neutral scouts can become a supporter of a site and start dancing



Getting the Cluster Moving

How does a swarm maintain coherence as it switches from decision making to moving to its new home?

- Bees generate heat by moving their flight muscles; these muscles must be at 35C/95F to fly
- During the site selection, the mantle bees in the cluster are too cold to fly. So before they break up to fly to the new home mantle bees must warm to 35C/95F.
- Studies revealed that soon after a decision is made by the scouts, the non-scouts began moving around excitedly and thoraces on all bees were glowing with warmth.
- As soon as the mantle bees reached 35C they began flying and the interior bees were flying as well.
- It takes about 60 seconds for the cluster to break apart.



Start Your Engines!

About an hour before dispersal, high pitched piping can be heard coming from a swarm.

Frequency increases closer to takeoff.

Excited scouts pipe: They press their thorax down, pull wings tight over the abdomen and activate the wing muscles to produce the vibration.

Each pulse is ~1sec at 200-250 Hz with harmonics between 400-2000Hz.

Scouts were spotted "shaking" other bees- placing front legs on a be and shaking her body up and down.



Buzz Runners

Buzz runners are scouts that run across the surface of the swarm turning this way and that, wings spread out and whirling noisily. Sometimes they run over the backs of their sisters, other times they bulldoze through them. All runners produce audible noises: Piping, buzzing, or both piping and buzzing in that order.

It seems the buzz runners inform the cluster that a new nest site decision has been made.

More and more bees run just before takeoff.

Clustered bees were more dispersed after an encounter with a buzz-runner.



Ritualization

It seems that an incidental action has been adapted to an intentional action = Ritualization

The hypothesis is that by barging through the cluster they may initiate the takeoff.

There are still many questions:

- Is there a connection between piping and buzz-running?
- Do just scouts buzz-run?
- How do they know when to buzz-run (temperature?)



Consensus or Quorum?

<u>Consensus</u> - a general agreement; Unanimity

<u>Quorum</u> - when the number of individuals needed to make a decision has been reached

Experiments determined that when the scouts sense a certain number of bees at a given nest site that the quorum has been reached.

When the quorum has been reached, piping and buzz-running at the cluster is triggered.



A Split Decision

What happens when two equally good sites are proposed by the scouts?

If the dancing remains strong for both and the quorum is reached at both nest sites, the swarm will take off and will head in two directions.

If the queen is not lost, the two will re-combine and come to a new decision (scouts monitor for queen pheromone in flight and if not detected stop to find her).

If the queen is lost during the split, the swarm will return to the parent hive.



Swarm Flight Guidance

Foragers and scouts navigate using the sun as a guide. A swarm of ~11,500 bees create a cloud that measures roughly 10m long, 8m wide, 3m tall at a height 2m off the ground.

How does a swarm – of which only a small percentage (3-4%) are scouts and have visited the new nest site – manage to navigate to this location as a group?

Measured swarms dispersed, collected in a cloud for about 30s, slowly accelerated, reached max speed(6km/h), decelerated, and stopped at the site.



Swarm Flight Guidance cont'd

As only 3-4% of the bees know the location of the new nest site, the swarm must be relying on the scouts to get them there, but how? Three hypotheses:

- Chemical signal Nasanov
- Subtle Guide scouts guide the swarm others avoid collisions and correct course
- Streaker Bee scouts zip forward through the swarm

Experiment with cross-directional foragers



Guiding the Colony Home

Once the cloud stops near the new nest site there is a slight delay as the scouts gather at the entrance to the cavity and begin emitting the Nasanov gland pheromone to guide everyone to the entrance.

It usually takes less than 15 minutes for the swarm to resettle from cluster location to cavity.



Unanswered Questions

- What happens without the streaking bees?
- Once a swarm is moving, how do they slow down?
- How do streaker bees perform their flights? Do they let the swarm pass them by or do they fly to the rear?
- Why do scout bees that return from the nest site remain with the swarm just before they disperse (they normally would make another visit to the site)? Do they stay because of the piping/buzz run signals of the other bees?



So, What Makes a Good Bait Hive?

Cavity Volume 45 l = 4500cm³ = 1.589ft³ = 2746.069in³

This is a space approximately 14x14x14 inches in size

A Langstroth 8 frame deep measures approximately: $9\frac{1}{2} \times 20\times 14 = 2660$ in³ A 10 frame deep ~ 3040in³

- Insert the entrance reducer with the 3-inch opening.
- Add some old smelly frames
- Apply some lemon grass oil or queen pheromone.
- Situate up in a tree or on a roof.
- If possible face the opening to the south.



The Wrap

- What triggers a swarm and after swarms
- Who discovers the new nest sites for the swarm
- What defines a good home
- Making the choice of new nest site
- How the cluster breaks up and gets moving
- How the swarm stays together and gets to the new location

