Things you didn't know about swarming

www.rogerdboyle.net/Bees/Swarmtalk.pdf

Roger Boyle

December 2, 2020

Things you probably didn't know about swarming

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Things you probably didn't know about swarming

(but perhaps don't need to)

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Aberystwyth starlings

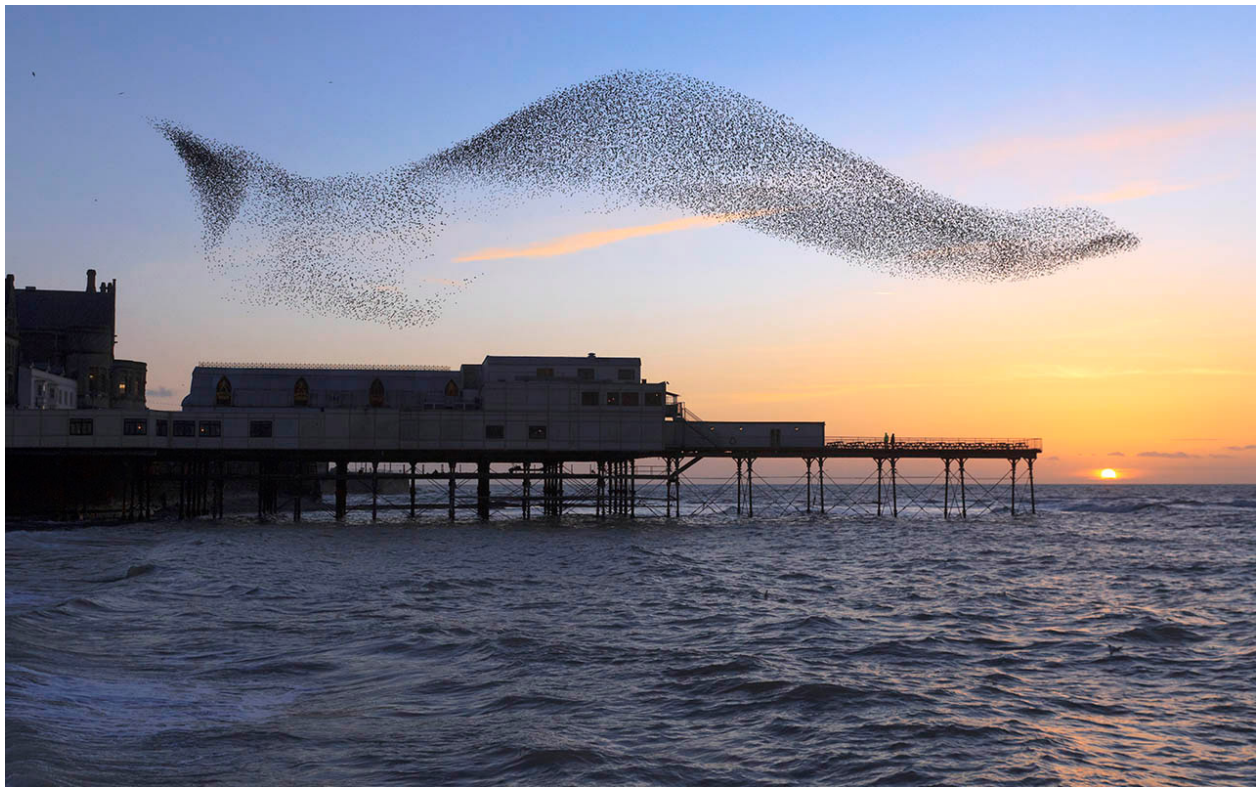


image: www.llain.com/about-us/links/aberystwyth-starlings/

Swarm intelligence

Swarm intelligence is a term appropriated by AI to describe 'intelligent' behaviour resulting from the collective behaviour of large number of 'unintelligent' individuals.

The individual starlings of not aware of the pretty patterns they are making!

Beekeepers don't need telling about this concept.

A super-organism

Actually a colony is usually referred to as a *super-organism* (The Super-organism: The Beauty, Elegance, and Strangeness of Insect Societies, B Hölldobler and E O Wilson, Norton, 2008)

> *A colony of honeybees is far more than an aggregation of individuals, it is a composite being that functions as an integrated whole.*

Honeybee Democracy, T Seeley, Princeton UP, 2010

Bee swarms

image: www.countryliving.com/uk/wildlife/countryside/a28179606/bee-swarm-uk/

Bee swarms

Swarms are populated predominantly by young [inexperienced] bees. They do not always have their final destination ready. They need to stay secure in a temporary home, find a destination, and get everyone there.

So some number of 000's of bees need *collectively* to

- Agree on a destination
- Fly there
- Stay safe until the destination is determined

Appledore island

About 10km off the Maine coast, and 0.8km across

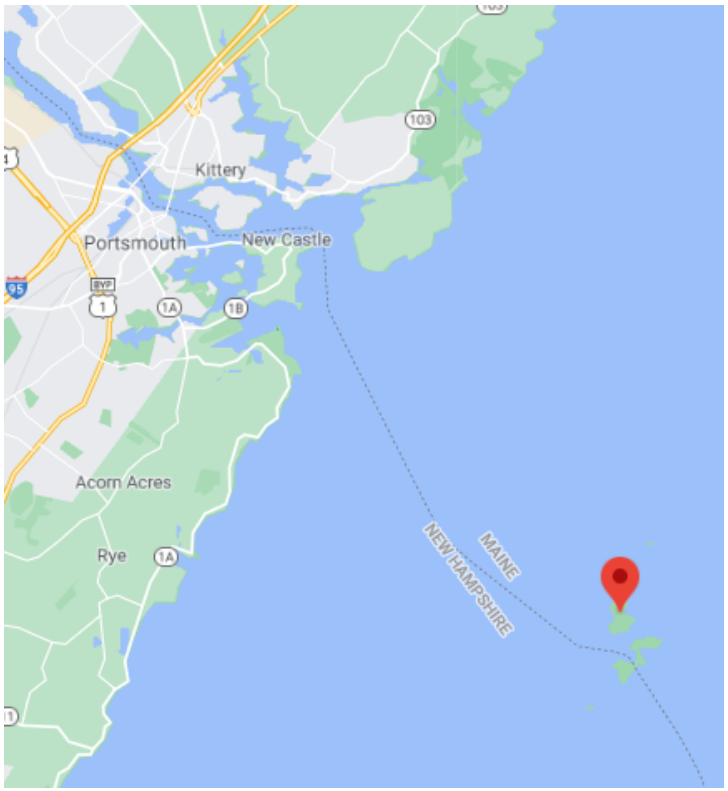


image: Google maps

Observing sites

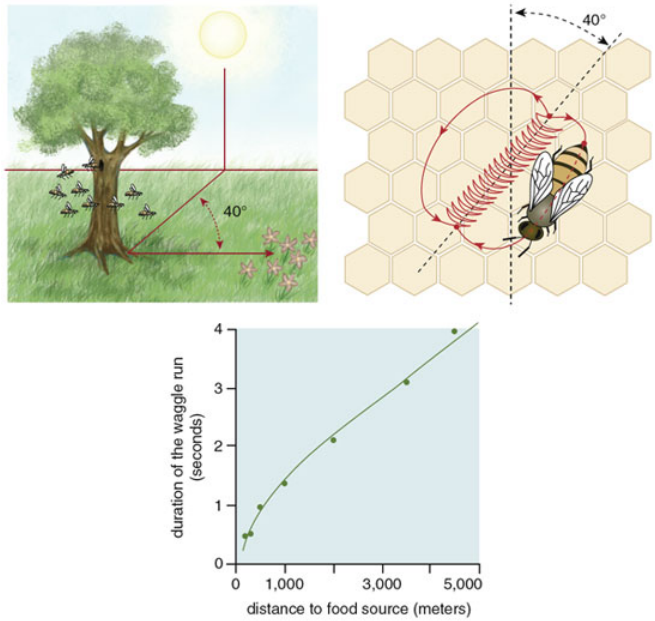
Group Decision Making in Honey Bee Swarms, T Seeley et al., American Scientist, 94(3), p220, 2006

Finding a site

How it works
(overlooking a lot of work!)

- There is a small number of scouts (a few hundred).
- When they find a plausible site, they return to the swarm and waggle-dance.
- The dance communicates location *and* suitability. This is a little intricate.
- Over time, the more suitable sites predominate in scout exploration.
- The scouts do not delay until all are persuaded of the best destination: a *voting* approach decides.
- At this time the scouts move across the swarm with characteristic piping preparing the workers to fly.
- They go!

Locating good sites



Group Decision Making in Honey Bee Swarms, T Seeley et al., American Scientist, 94(3), p220, 2006

The number of circuits of waggle relates to the quality of site.

Bees actually repeat the dance with less enthusiasm over time: this is a mechanism much loved by AI programmers!

Some science . . .
As used by computational modellers

This nest-site selection process as been modelled[18,20] as:

$$\frac{dx_i}{dt} = \gamma_i x_u - \alpha_i x_i + \rho_i x_u x_i - \sum_{j=1}^{n} x_j \beta_{ji} x_i, \qquad i \in \{1, \ldots, n\},$$

$$x_u = 1 - \sum_{i=1}^{n} x_i$$

Psychophysical Laws and the Superorganism, A Reina et al., Scientific Reports, 8(1), 2018

Getting there

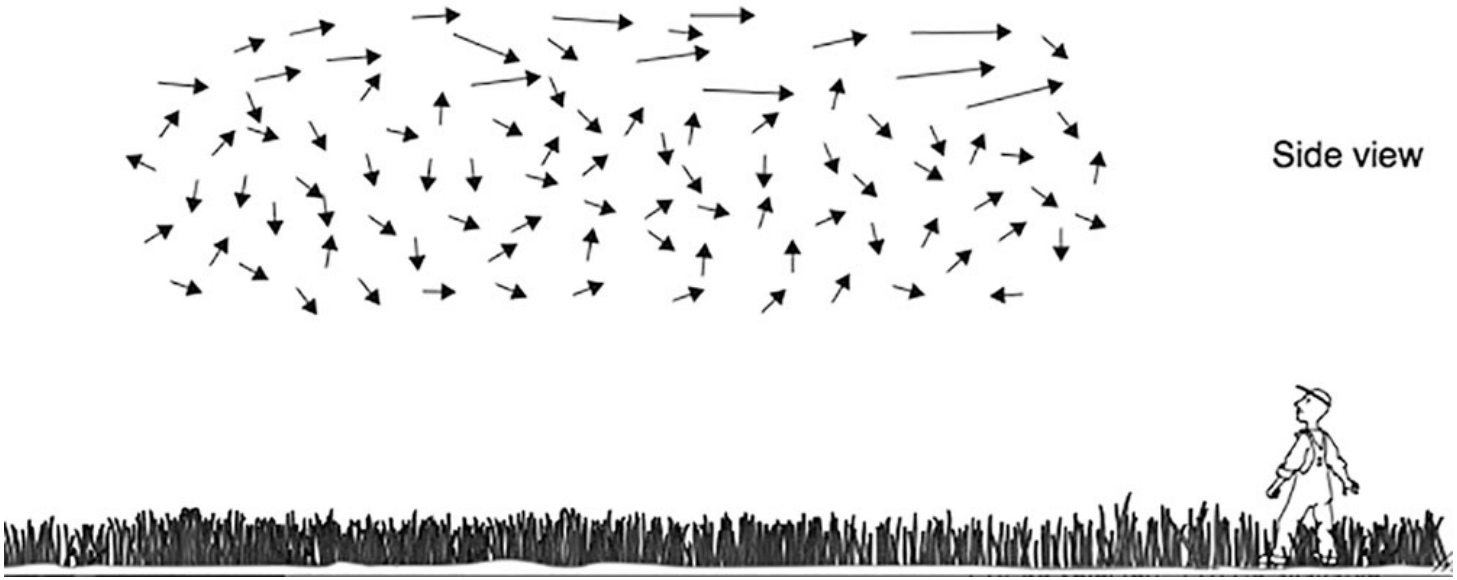
The problem!

A small number of bees know where they want to take the swarm; a very large number – perhaps inexperienced flyers – don't. How does it work?

Theories:

1. Informed bees release an assembly pheromone at the front of the moving cloud.
2. Informed bees move ahead of the cloud and guide it visually
3. Informed bees make high speed flights through the cloud in the correct direction; then return to the rear for another 'streak'.

Streakers



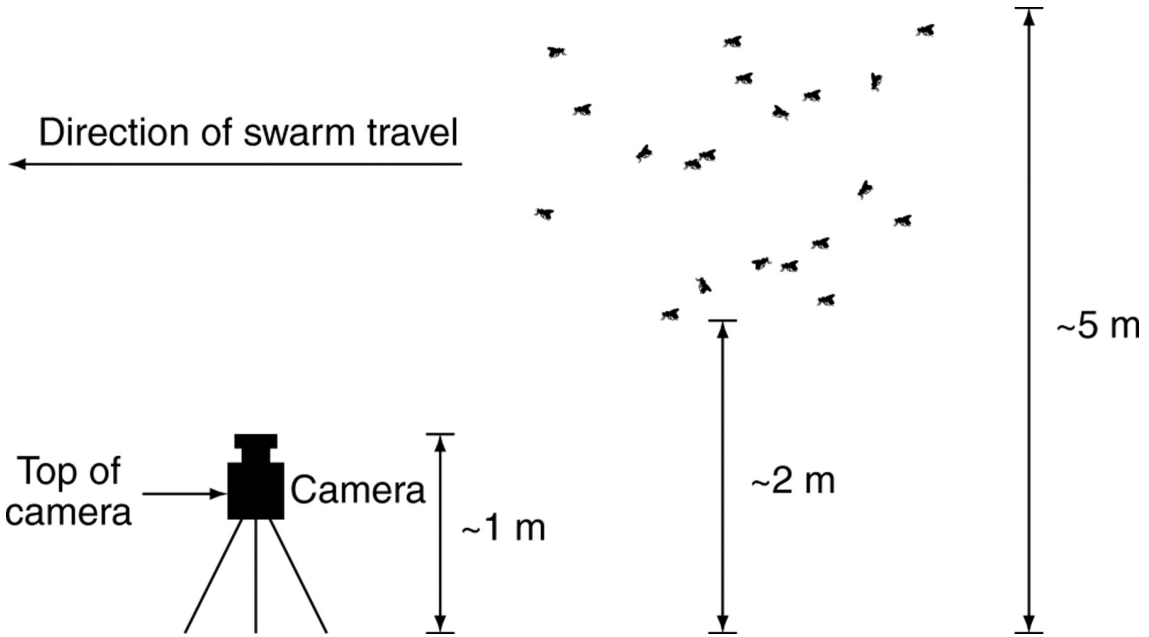
Flight guidance of honeybee swarms, T Seeley et al., Bee Culture, May 25 2015

Per-bee tracking of a swarm

Carefully controlled swarms were studied on Appledore island, and filmed in such a way as to permit tracking of individual bees.

(This implies spectacular amounts of video analysis!)

Camera . . .



The mechanism of flight guidance in honeybee swarms, K Schulz et al., J. Experimental Biology, V218, 3287-3295, 2008

Analysis

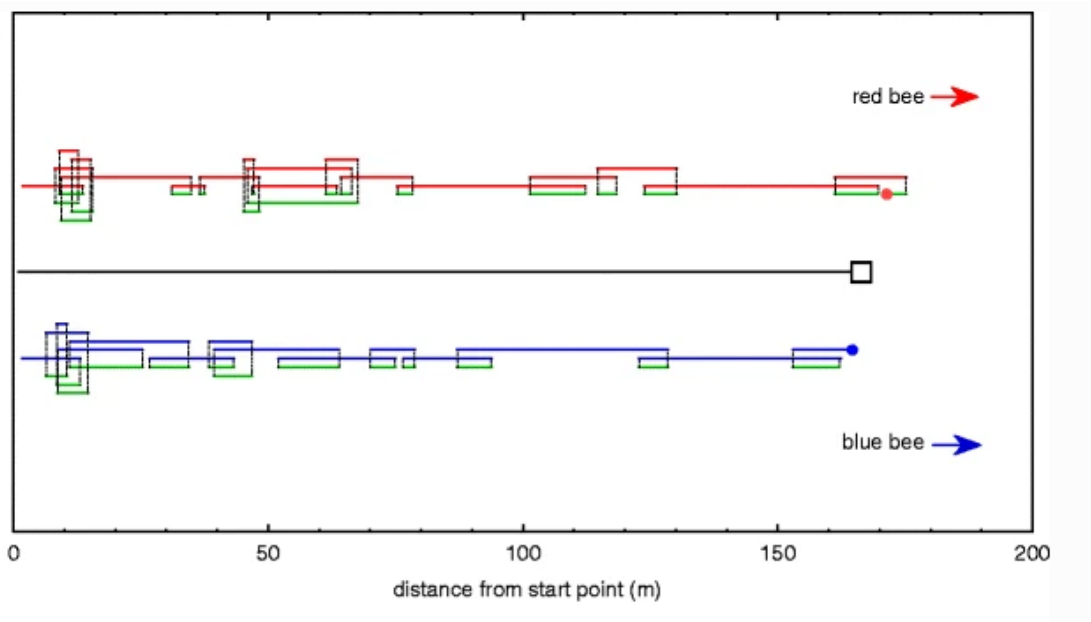
They evidenced that bees flying toward the new home were usually faster while slower bees were rather directionless, lending much weight to the ‘streaker’ hypothesis.

These results were confirmed by very sophisticated later work using harmonic radar tracking of individual scouts.

Tracking scouts

An animated video is on line

Red/Blue: moving toward new home; Green: backtracking



Scouts behave as streakers in honeybee swarms, Greggers et al., Naturwissenschaften, 100, 805-809, 2013.

Safeguarding a waiting cluster

Counting out time . . .

While they are waiting, the majority of the bees must keep the core of the cluster at about 36°C. Mechanisms used to do this have been documented.

They also need to be ready for rainfall. Mechanisms used to keep the cluster core dry have also been studied and documented.

But the hanging cluster has no internal structure and is vulnerable to wind (and you or me, or passing bears, shaking a tree-branch). Bees will respond to perturbations by changing the cluster shape – they do this by strictly local (per bee) decisions manifesting as a large scale pattern change. Swarm intelligence!

Under stress

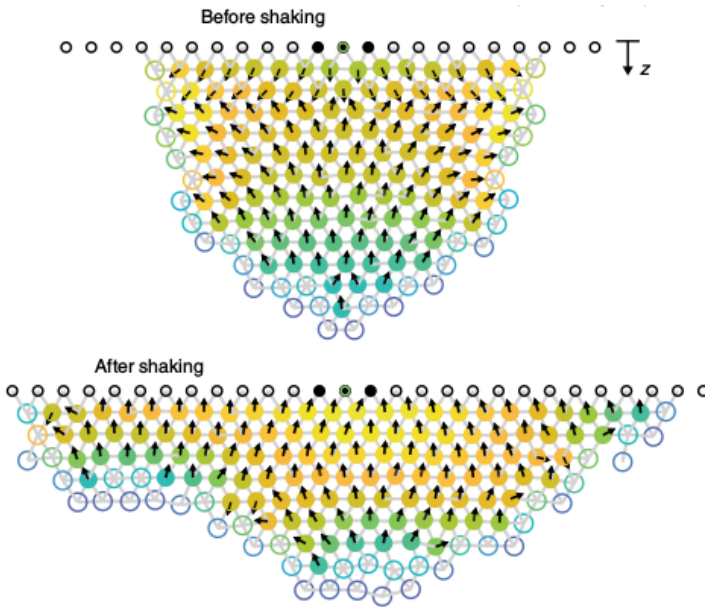
The bees at the top of the cluster affix to the branch (or whatever). Other bees affix to their neighbours.

When the cluster is blown/shaken, the bees at the top are subjected to the worst stress.

Careful study shows that individual bees will move *toward* the point of maximum strain to balance the load. They can do this simply by 'communicating' with their direct neighbours to produce a major global effect.

Shaking a swarm

A simulation in which cells [bees] are encouraged to move in the direction of greatest strain (shown by arrows).



Collective mechanical adaptation of honeybee swarms, Peleg et al., Nature Physics, 14, 1193-1198, December 2018

Youtube

Shake those bees back and forth: Smart swarm intelligence

- `https://www.youtube.com/watch?v=jswSJznyvDI`

Just 3m long – very illustrative!

That's all Folks!