

BIOLOGY OF A HONEY BEE COLONY PART 2

Advanced Level Training
Texas Master Beekeeper Program



Outline

- Honey bee colonies as eusocial "Superorganisms"
- Age polyethism in honey bee workers
- Annual cycle of honey bee colonies
- Colony reproduction via swarming
- Nest site selection by honey bee swarms
- Communication using the dance language

Outline

- Honey bee colonies as eusocial "Superorganisms"
- Age polyethism in honey bee workers
- Annual cycle of honey bee colonies
- Colony reproduction via swarming
- Nest site selection by honey bee swarms
- Communication using the dance language

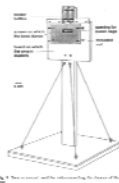


Swarms temporarily cluster on nearby vegetation

Testing swarm decisions



Shake a package of bees with a caged queen



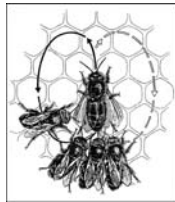
Shake a package of bees with a caged queen

Quinlan & Robinson (1988) *Animal Cognition* 6: 19-27

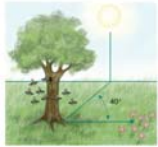
Pioneering discovery by Martin Lindauer:
scout bees report potential home sites with
waggle dances (1955)



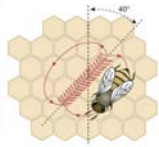
Martin Lindauer Karl von Frisch



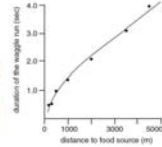
Site location is coded in waggle dances



1. **Angle** of waggle run indicates direction.

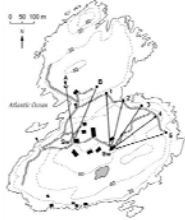


2. **Duration** of waggle run indicates distance.



How is site value coded in waggle dances?

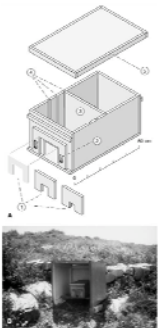
How is site value coded in dances?



- Each swarm was presented with two types of nest boxes: high value (40-L) and medium value (15-L)
- Labeled and monitored first few bees that visited ea. box



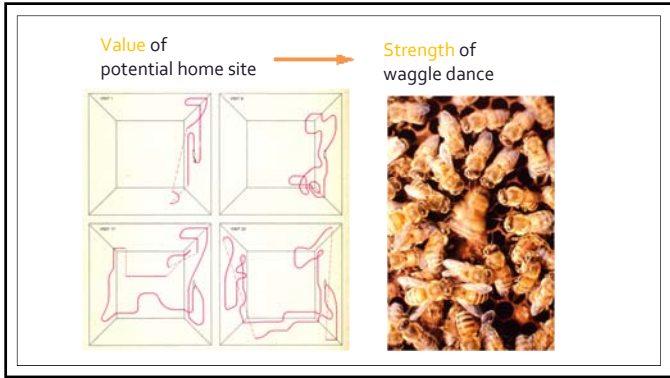
Seeley & Buhrman (2001) Behav Ecol Sociobiol 49: 416-427

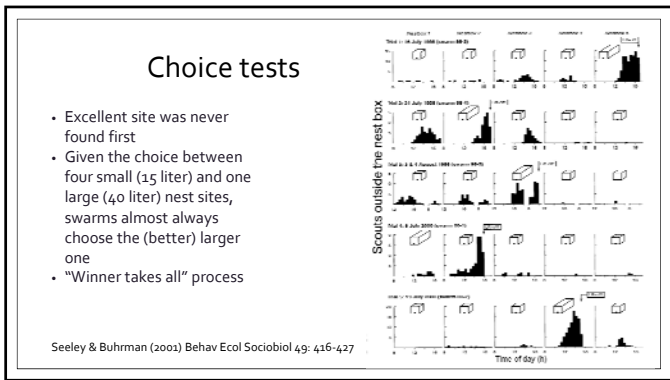


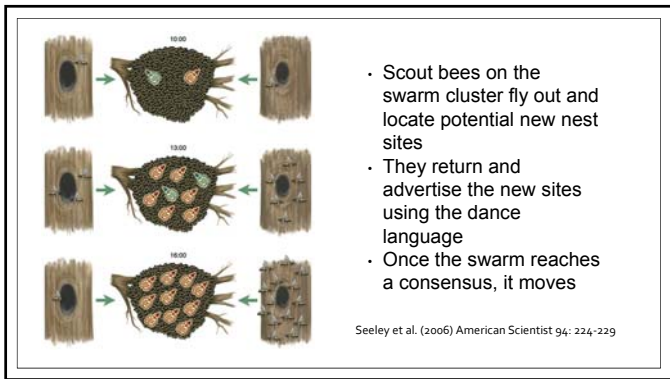
- Artificial nest box with interchangeable and moveable parts
- Can alter cavity volume, entrance size and location, and other variables



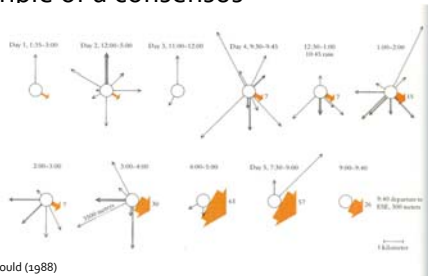
Seeley & Buhrman (2001) Behav Ecol Sociobiol 49: 416-427







Example of a consensus



from Gould & Gould (1988)



A Swarm of bees

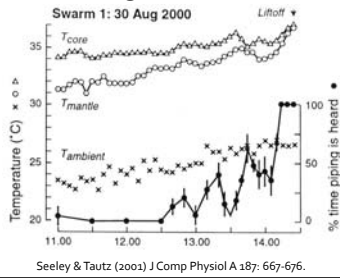
- 1 queen
- ~ 10,000 workers
- 3-5% are active & hot
- 300-500 scouts
- 95-97% quiet & cool

Swarm must warm up to be able to fly to new home.
Warming takes at least 30-60 minutes (B. Heinrich)

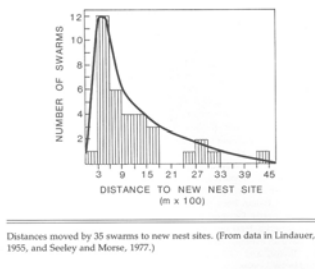


Seeley, Kleinhenz, Bujok & Tautz (2003) Naturwissenschaften 90: 256-260

Piping starts long before liftoff



Liftoff! How far do they go?



Swarm in flight to chosen home: DECISION ACCOMPLISHED!!



- Once the swarm lifts off, bees follow the scouts to the new nest site
- Scout bees fly faster through the swarm, or **streak**, and the other bees follow them to the site

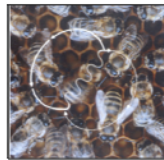
Outline

- Honey bee colonies as eusocial "Superorganisms"
- Age polyethism in honey bee workers
- Annual cycle of honey bee colonies
- Colony reproduction via swarming
- Nest site selection by honey bee swarms
- **Communication using the dance language**

Communication and the dance language

Communication is needed to:

- Identify colony members and their queen
- Alert of dangers
- Notify of food sources
- Hive duties



Communication and the dance language

Communication

The cooperative transfer of information from a signaler to a receiver

Alcock, J. 2005. *Animal Behavior*. Sinauer. Sunderland, MA.

Referential communication

- The transfer of information from a signaler to a receiver in which the information exchange is typically dependent on successful acts of reference, whereby entities are identified (by naming or describing), are located or moved relative to other entities (by giving instructions or directions), or are followed through sequences of location and events (by recounting an incident).

Yule, G. 1997. *Referential Communication Tasks*. Lawrence Erlbaum. Mahwah, NJ.



Communication and the dance language

Aristotle

- First noticed that a successful forager soon recruits many bees to a rich food source

"Each bee on her return is followed by three or four companions . . . how they do it has not yet been observed." Historia Animalium, IX



Reverend Ernst Spitzer

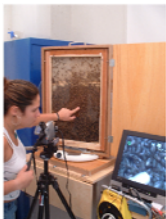
- In 1788, reported the initial alerting maneuver:

"When a bee comes upon a good supply of honey anywhere, on her return home she makes this known in a peculiar way to the others. Full of joy, she twirls in circles about those in the hive, from above downwards and from below upwards, so that they shall surely notice the smell of honey on her, for many of them soon follow when she goes out once again."

Communication and the dance language

Observation hives

Feeders in the field



Training foragers

Communication and the dance language

Marking Bees



Photo by T. Pankiw



from Gould & Gould (1988)

biolo.bg.fcen.uba.ar/inssocweb/photos.html

The discovery of the dance language

Nicholas Unhoch

- In 1823, he independently discovered the "dance," but failed to notice that it was performed by returning foragers and served in recruitment:

"Without warning, an individual bee will force its way suddenly in among three or four motionless ones... They twist and run together in something more than a semicircle now to the right then to the left five or six times... The dance mistress open repeats her dance four or five times at different places."

Maurice Maeterlinck

- In 1901, he captured a forager as she fed, and then carried her from the hive entrance to another location. After marking her, he went back to hive, recaptured her, and noticed a recruit arrive at food without following a forager



The discovery of the dance language

Karl von Frisch

- Austrian-born German scientist who is credited with describing forager recruitment through dancing



The discovery of the dance language

Karl von Frisch

- In 1919, he took up the question of the dance language
- Knew how to train bees to a feeder to test color vision:
 - Drops of highly [redacted] scented sugar solution at entrance
 - With feeder farther away, foragers and recruits arrived
 - Diluted the [sucrose], unscented feeder to decrease recruitment but keep forager force at the right size

• Re-discovery of dances:

- 2 basic forms
 - The round dance
 - The waggle



The round dance

As per Karl von Frisch

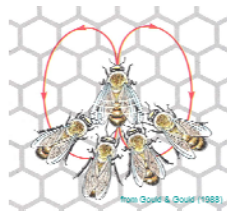
- Forager circles one or more times clockwise, then counterclockwise, and so on.
- Foragers perform this dance after being trained and marked at a feeder collecting sugar sln a few meters away from nest



The waggle dance

As per Karl von Frisch

- Forager waggles her body from side to side (about 13 times/sec) while running in a straight line, then circles to the right back to the starting point, waggles again, then circles back (this time to the left), so on.
- Foragers that had pollen on their legs always performed this dance



The waggle dance: distance

As per Karl von Frisch

- His original theory was challenged by Americans having reported round dances by pollen collectors
- Europeans also rejected his hypothesis for the = reason
- In 1944, he watched the dancing of marked foragers as they were trained farther away:
- Up to about 75 m, **round dances**
- Beyond 90 m, **waggle dances**
- Dancing was done for sugar solution, **not pollen**
- 1st to graph duration of waggle run against the distance to the food



The waggle dance: direction

As per Karl von Frisch

- He later decoded the dance **direction**:
 - When the waggle run in a dance is pointed up (the dances are performed on vertical sheets of comb), the feeding station is always in line with the sun.
- When the food source is directly away from the sun as viewed from the hive, the dances point down.
- When the food is located 80° to the left of the sun, the dance points 80° to the left of vertical
- Therefore, a bee attending a dance need only determine the orientation and duration of the waggle run to know the distance and direction to the food

The waggle dance: other components

As per Karl von Frisch

- Dance has an **acoustic** component:
 - As dancer waggles, she produces a sound (moving her wing muscles) in short bursts about 1/13 sec long
 - Occasional silent dances seem to arouse no interest
 - Therefore the sound must be essential to communicate
- The dances are fairly **sloppy** when food is near:
 - No 2 cycles of the = dance have the same # of waggles or sound bursts, and the angle alternates left and right of the true direction
 - Therefore, recruits attend several cycles (6-8) and seem to average them together before setting a course



The olfactory theory of dance recruitment

As per Karl von Frisch

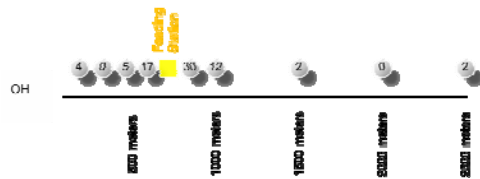
- Recruits are informed by the dance that:
 - There is a good source of food
 - That it is nectar or pollen
 - What the food smells like



- Odor of the flower clings intensely to waxy hairs on foragers, recruits smell odor when following dance
- Recruits look for advertised food and when offered several floral odors, they pick the odor attached on the dancer.

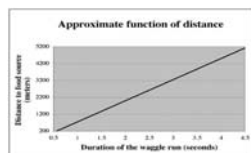
How distance is communicated

Step-wise Experiments By Karl von Frisch



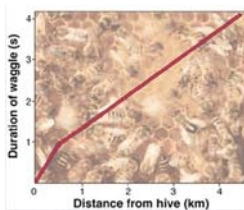
Therefore, distance information is conveyed

How distance is communicated



- 0.5 sec = 200 m
- 1.0 sec = 800 m
- 1.5 sec = 1400 m
- 2.0 sec = 2000 m
- 3.0 sec = 3200 m

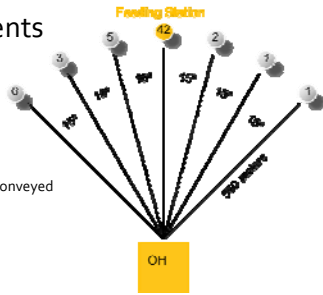
- The duration of the "waggle run," the straight section of the figure eight, correlates with distance to food source



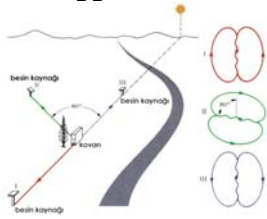
Fan-array experiments

By Karl von Frisch

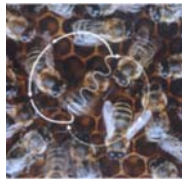
Therefore, **directional** information is conveyed



The waggle dance: direction communication



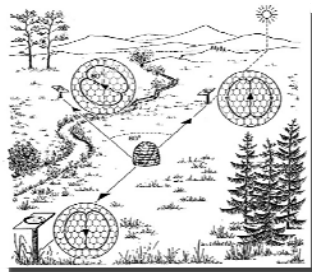
- The **angle** of the waggle run, with respect to vertical, correlates with relative direction to food source



But relative to what??

The waggle dance: direction communication

Relative to the sun



The waggle dance: direction communication

Bees know the position of the sun by using polarized light



0 degrees
180 degrees

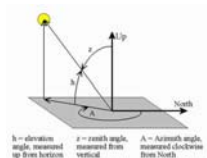


90 degrees
270 degrees

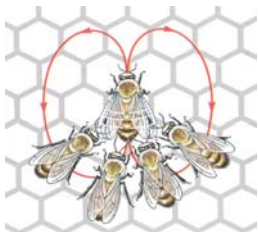
The waggle dance: direction communication



The sun's direction changes throughout the day



The waggle dance



- Indicates that the food source is >200 m away
- Provides both distance and directional information

from Gould & Gould (1988)

The round dance

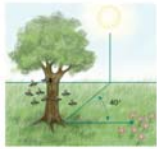


- Indicates that the food source is < 100 m away
- Provides no directional information

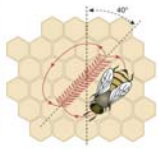
from Gould & Gould (1988)

The waggle dance: a summary

How is site location coded in waggle dances?



1. Angle of waggle run indicates **direction**



2. Duration of waggle run indicates **distance**

