
Queen and Drone Biology
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METRIC 1
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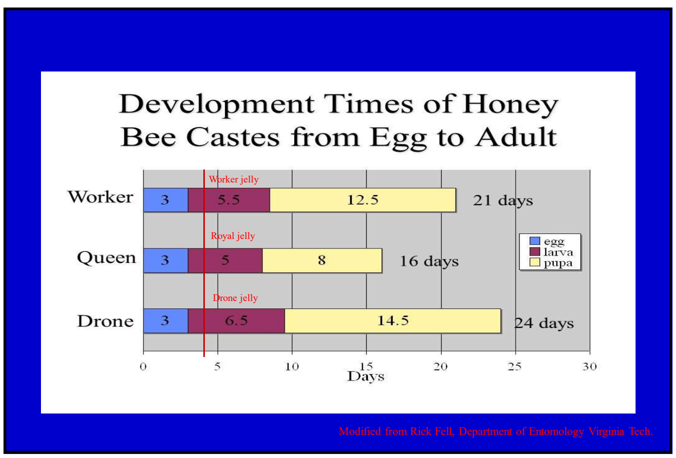
Development Times of Honey Bee Castes from Egg to Adult
Worker
Queen
Drone
Worker jelly
Royal jelly
Drone jelly
3
5.5
12.5
21 days
3
5
8
16 days
3
6.5
14.5
24 days
egg
larva
pupa
0
5
10
15
20
25
30
Days
Modified from Rick Fell, Department of Entomology Virginia Tech.

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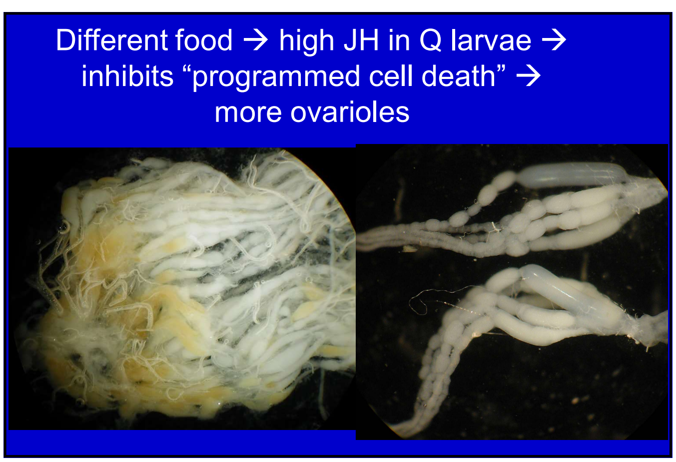
Different food → high JH in Q larvae → inhibits "programmed cell death" → more ovarioles

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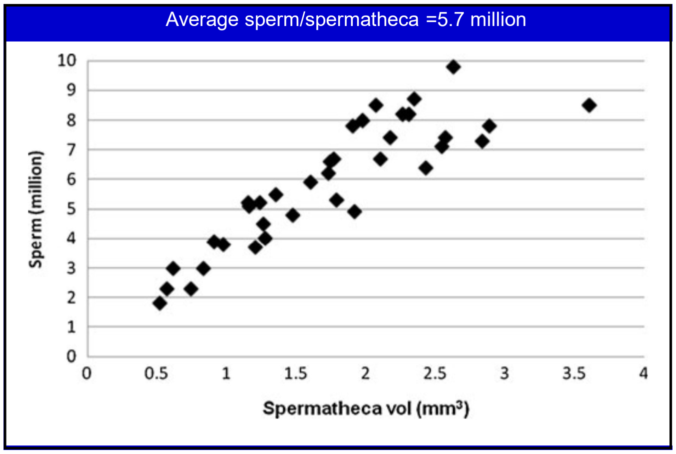

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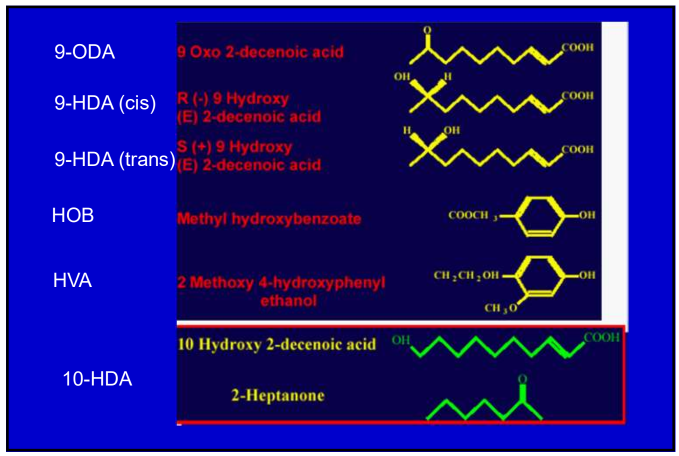

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The same pheromone is important for mating with drones

Context dependent: drones do not respond to the same pheromone while inside the hive. Only while flying in the `drone-congregation` area.

We do not know what is the switch

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Virgin Queen Mating Areas and Drone Congregation Areas (DCA's)

by Gerald M. Loper

Drones fly out from their colonies every afternoon (season and weather permitting) in a search for virgin queens. Studies from other parts of the world and the United States conducted in the 1960's-1970's discovered that drones congregate in specific aerial locations day after day and year after year. These DCA's are of various sizes but often about 100m in diameter and, in these areas, they will fly higher (up to 60m) than the 12-20m elevation they fly as they leave the apiary or fly between DCA's. Beginning in 1985, we used a modified radar with a rotating parabolic dish to track the drones and to locate DCA's.

This picture shows the radar screen in which a large DCA was observed. First, at the top of the picture, from left to right, the numbers indicate that the year was (19)89, on the 89th day. The next numbers indicate that it was 3:01 MST. Just below the time is the angular elevation of the radar beam above the horizontal. Inside the circles, the center is where the radar is located, the first circle is a radius of 463 meters and the outer circle has a radius of 926 meters. Thus a large area, or actually a volume of space was being "viewed" every 2 seconds (dish rotation rate). All the dots inside the circles, are insects, in this case drone honey bees. As you can see, many drones are congregated in a particular area (the drones in this view were between 40-50m above ground) about 100m wide and 200m long. Actually, the drones in this picture are seen as a "slice" through the middle of the DCA. Even more drones were seen at the 4o and 5o "slices" and the top of the DCA was seen in the 7.1o "slice" topping out at 60m above ground. By moving the radar and making such observations, we found 28 such DCA's and documented the interconnecting flyways between them.

These studies are written in the paper "Honey bee drone flyways and congregation areas, radar observations", 1992 in Jr. Kansas Entomological Society, 65:223-230 written by G.M. Loper, W.W. Wolf, and O.R. Taylor, Jr.

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http://www.pbs.org

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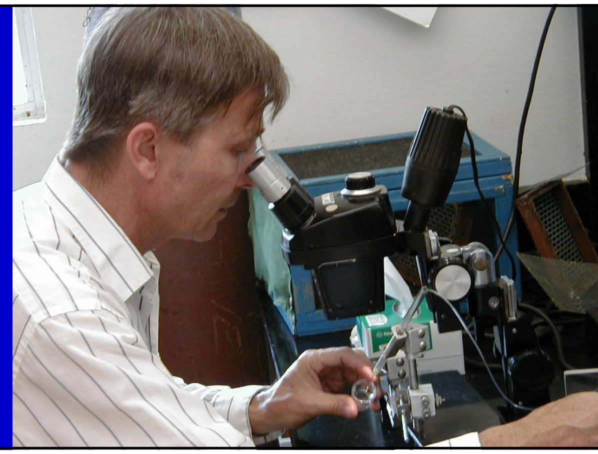

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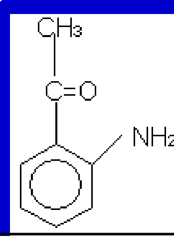
The only fecal stuff that smells good...
only by the virgin queen!

Virgin queens produce a chemical (in her defecation) that repels workers:

Chemical name:

o-aminoacetophenone.



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Whose egg is it? The queen's or the workers?

We cannot tell, but the workers can!

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Workers can recognize the source of eggs

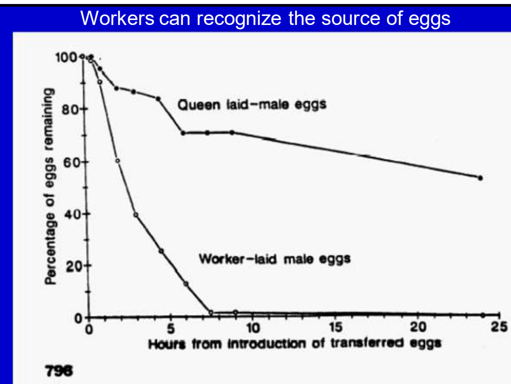

FIG. 1 Time course of egg removal for worker- and queen-laid male eggs within the brood area of a populous queenright honeybee colony. (Data from trial 4, experiment 2.) Ratnieks, F. L. W. & Visscher, P. K. *Nature* 342, 796–797 (1989)

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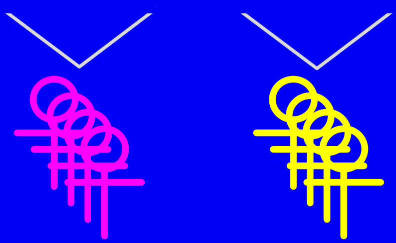
The kin structure of the big family

DRONE QUEEN DRONE



SUBFAMILY SUBFAMILY

R = 0.75 <--R=0. 25 --> R = 0.75

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Worker policing:

The removal of worker eggs by other workers (usually workers of another subfamily).

Policing requires that

1). Workers have the ability to distinguish queen eggs from worker eggs.

2). Workers do remove worker laid eggs under natural conditions.

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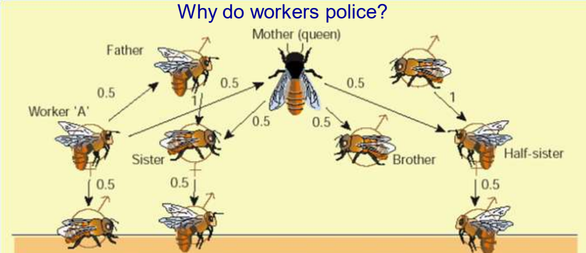
Why do workers police?



	Sister	Half-sister	Own son	Son of full sister	Queen's son (brother)	Son of half-sister
Worker 'A'	0.75	0.375	0.5	0.375	0.25	0.125

Numbers game: to determine the degree of relatedness between a worker and her nest-mates, follow the arrows, multiplying the values on each route and adding the products.

The police state, Nature, 2002

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Dufour's gland (alkaline gland)

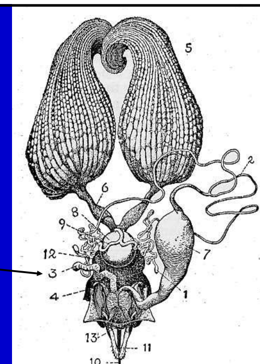

FIG. 537.—REPRODUCTIVE ORGANS, ETC., OF QUEEN BEE.

1, acid gland and 2, its duct; 3, alkaline gland; 4, bursa copulatrix; 5, ovary; 6, oviduct; 7, poison sac; 8, spermatheca and 9, its gland; 10, terebra; 11, sting palp; 12, vagina; 13, 9th sternum. Adapted from Snodgrass, *loc. cit.*

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Sound communication:

Queen piping

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Behav Ecol Sociobiol (2003) 53:199–205
DOI 10.1007/s00265-002-0567-y

ORIGINAL ARTICLE

Workers also pipe!, but now called a stopping signal

Corinna Thom · David C. Gilley · Jürgen Tautz

Worker piping in honey bees (*Apis mellifera*): the behavior of piping nectar foragers

Received: 9 April 2002 / Revised: 2 December 2002 / Accepted: 4 December 2002 / Published online: 8 February 2003

Abstract This study investigates the brief piping signals ("stop signals") of honey bee workers by exploring the context in which worker piping occurs and the identity and behavior of piping workers. Piping was stimulated reliably by promoting a colony's nectar foraging activity, demonstrating a causal connection between worker piping and nectar foraging. Comparison of the behavior of piping versus non-piping nectar foragers revealed many differences, e.g., piping nectar foragers spent more time in the hive, started to dance earlier, spent more time dancing, and spent less time on the dance floor. Most piping signals (approximately 99%) were produced by tremble dancers, yet not all (approximately 48%) tremble dancers

Introduction

Animal communities often rely greatly on communication to achieve coordination between members. Colonies of social insects, with their many individuals, provide easily available and controllable model systems for the study of the role of communication in task coordination. The foraging communication system of honey bees (*Apis mellifera*) has received special interest, and its role for the coordination of foraging is comparatively well understood (e.g., von Frisch 1967; Seeley 1995). Honey bee nectar foraging involves several communication signals (e.g., waggle dances, tremble dances, shaking signals, and

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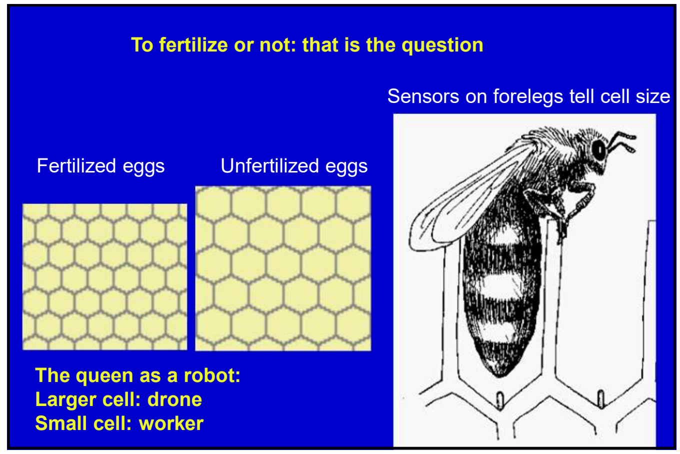

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Hypothesis 1 :
Smart queen: if she only has access to drone frame, and it is late in the season (August-September), she will lay mostly workers in drone cells -- no point to rear drones late in season because few queens to mate by then.

Test: if queens are confined to drone frames at different times of the year, one should see drone proportions in drone cells DECREASE.

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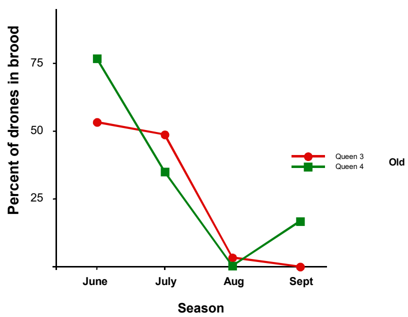

It worked! As season progressed, proportion of drones decreased (more workers in drone cells)

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Another queen tidbit

Unmated queens, like workers will produce only drones (no sperm to ferlize eggs)

However, *Apis mellfiera capensis* (cape bee), unmated queens or workers can produce female offsprings at a high rate 60%ish. By fusing the polar body back to the original cell during meiosis.

Our bees will have about 1% for unmated virgin queens. But usually only for the eggs from the first few days.

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Queen mating statistics

Queens left their nucs on 2.20 ± 0.98 flying days (min. 1; max. 5),

Most of the nuptial flights (82.49%) taking place between 13:00 and 16:00 h (Figure 2).

The earliest and latest departure time: 11:50 and 17:38 h, respectively.

Number of recorded flights per queen was 5.04 ± 3.11 (min.1; max. 16), with a maximum of seven flights of one queen on one day.

Daily number of nuptial flights per queen was 2.30 ± 1.35,

with a mean duration of 17.69 ± 13.19 min (min. 3.08; max. 57.07; Figure 3).

Insects **2014**, *5*(3), 513-527;
doi:10.3390/insects5030513

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Photos from Sue Colby

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Drone Biology

- Drones have no father (haploid!)
- All their sperms are clones (100% identical)
- Most drones are haploid, but inbreeding results in diploid drones
- Diploid drones are sterile and eaten by workers before 4th instar
- Sexually mature around 10-12 days (queens: 5-6 days).
- Mating flights between 3-5 pm.
- Drones fly to “drone congregation areas” to mate
- They die during mating (endophalus explodes)
- They get kicked out of the colonies in the fall

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Drone flight periods
Sabah, Borneo

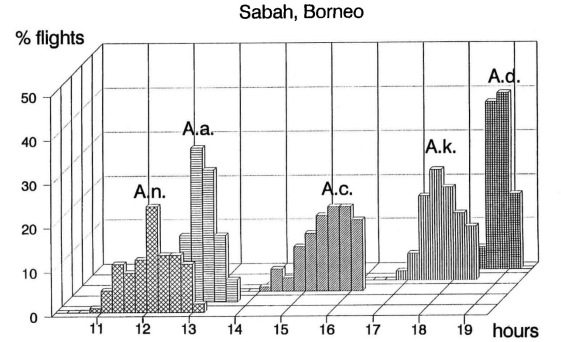

Fig 1. Daily flight activity of drones of five Sabahan *Apis* species. *Aa = A andreniformis; Ac = A cerana; Ad = A dorsata; Ak = A koschevnikovi; An = A andreniformis.*

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Drone sperm numbers:

1. Varroa mites reduce sperm numbers
2. Apistan reduces sperm numbers (Rinderer et al., 1999)
3. Smaller drones (drones reared in workers cells) have less sperms

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From Duay, DeJone and Engles (2002)

Flight performance and sperm production affected by Varroa **231**

Table 1. Flight performance and sperm production of drones in relation to the level of pupal infestation by *Varroa destructor*. Mean values, m = median, SD = standard deviation, r = range, d = diminished in relation to the controls.

Degree of pupal infestation of the drones	Duration of the test flights	Number of spermatozoa
Unparasitized	N = 64. $\bar{x}$ = 6’48” m = 4’54” SD = 5’35” r = 0’09” - 27’27”	N = 68 $\bar{x}$ = 7,540,441 m = 7,475,000 SD = 2,812,780 r = 2.5 x 10^6 - 12.8 x 10^6
One female mite per brood cell	N = 37 $\bar{x}$ = 6’55” m = 5’02” SD = 6’40” r = 0’15” - 22’15”	N = 53 $\bar{x}$ = 5,734,623 m = 4,200,000 SD = 3,574,404 r = 1 x 10^6 - 13.5 x 10^6 d = -24%
Two female mites per brood cell	N = 16 $\bar{x}$ = 2’16” m = 2’27” SD = 1’40” r = 0’09” - 6’01” d = -67%	N = 31 $\bar{x}$ = 4,192,258 m = 3,550,000 SD = 2,506,754 r = 1 x 10^6 - 9.5 x 10^6 d = -45%

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Smaller drones have less sperms (Schluns et al 2003)

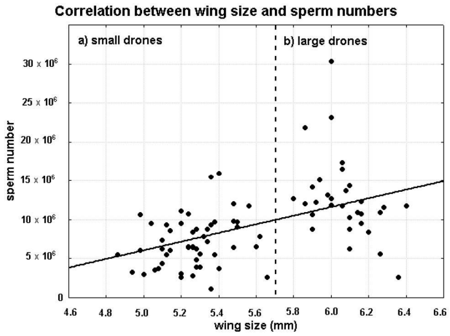

Figure 2. Correlation between wing size (measured as the distance A-R on the wing) and sperm number of small and large drones ($r = 0.49$; $P < 0.001$; $n = 83$): the small drones had wing measurements smaller than 5.7 mm.

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Controlling genetics in breeding:

1. Isolated mating yard (20 km)
2. Lots of drones (flooding, saturation)
3. Instrumental insemination

4. Late hours mating

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