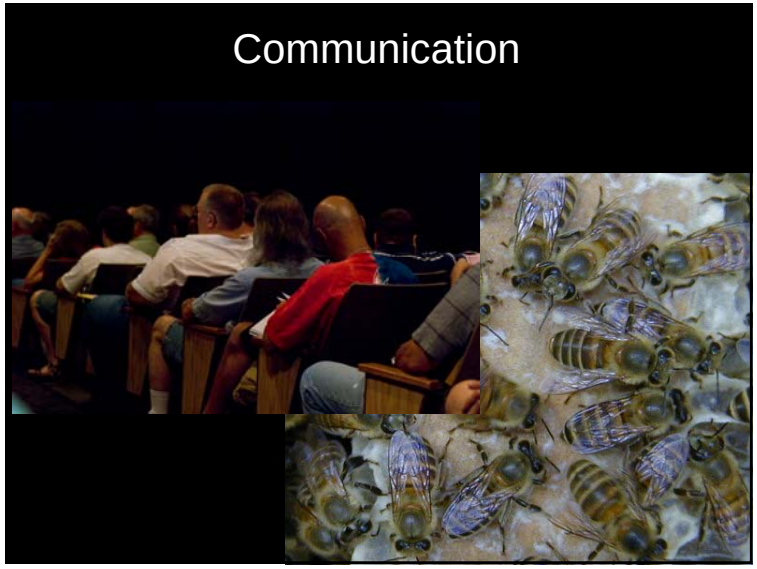
What is one thing in common between a colony & a human society?

Society: a coherent entity consisted of many individuals

To maintain coherence / coordinate group behaviors (division of labor, swarming, war):
one must have:



Chemical signals:

- Pheromone: communication within the same species, usually mutualistic.
- Allomone: communication between different species, receiver is harmed.
  e.g. chemical mimicry of the honey-stealing sphinx moth.
- Kairomone: communication between different species, receiver benefits.
  e.g. chemicals from larvae that attract Varroa mites.

4

Two types of pheromones:

1). Releaser pheromone:
causes immediate changes in behavior
e.g. retinue behavior, alarm pheromone

2). Primer pheromone:
slow acting, physiological changes, then behavioral changes.

e.g. ovary development in workers takes about one week when queen and open brood are both gone.

Difficult to identify. Only 4 so far, 3 from bees. Why?

3

Retinue behavior: workers surrounding, licking and feeding Q

1. Queen Mandibular Pheromone (QMP)

QMP →

9 Oxo 2-decenoic acid

R (-) 9 Hydroxy (E) 2-decenoic acid

S (+) 9 Hydroxy (E) 2-decenoic acid

Two new components
Winston + Slessor (1991)

Methyl hydroxybenzoate

2 Methoxy 4-hydroxyphenyl ethanol

Newest components
Queen retinue pheromone
Keeling et al. 2003

Methy oleate
Coniferyl alcohol
Hexadecan-1-ol
Linolenic acid

8

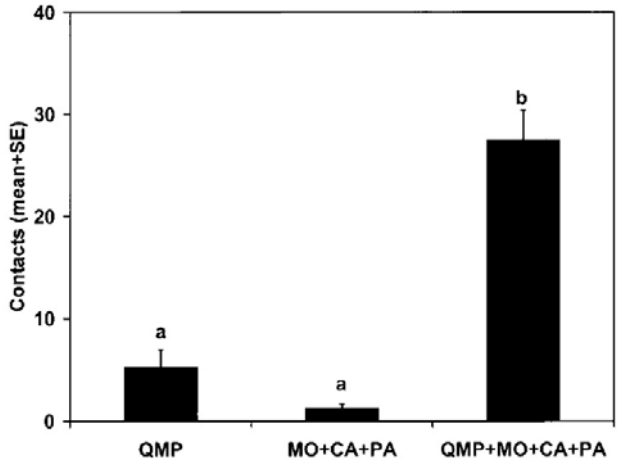


Fig. 4. Synergy of QMP with the three new components. One-way ANOVA $F = 51.6$, $P < 0.0001$, $n = 20$.

Keeling et al, 2003, PNAS

Queen Mandibular Pheromone has both effects:

1). Releaser effect:

Retinue behavior (to workers)
Sex attraction during mating (to drones)
Swarm stabilization (to both workers and drones)
Simulating foraging

2). Primer effect:

Inhibiting swarm cell construction
Inhibiting swarming process
Inhibiting worker ovary development
Delay foraging age in workers
Stimulating brood rearing

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QMP and beekeeping:

1. Workers detect Q absence within ~4 hr

2. Queen strips available (www.PheroTech.com)
   1. Workers show retinue behavior to strips
   2. Swarm attraction
   3. Catching stray bees in an extraction room
   4. "Queenless package bees?"
   5. Temporary queen surrogate for mating nucs
   6. Sprayed to fruit trees for better pollination (Fruitboost, PheroTech)

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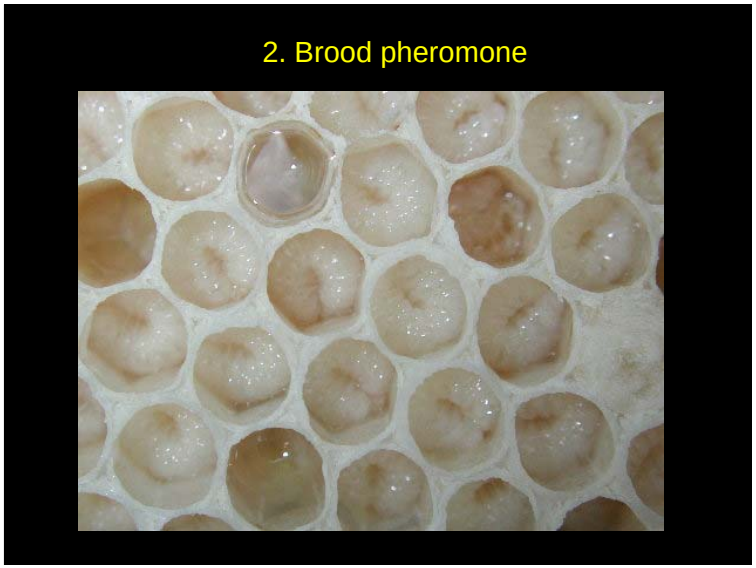
http://www.pherotech.com/fruit_boost_with_qmp_for_polli.html

12



1960s

It is has been shown (by S.C. Jay, Canada) that open brood can inhibit worker ovary development (more potent than the queen herself!).

A colony only becomes “hopelessly” queenless, when both the queen is lost and all brood are sealed.

15

1972

As stimulus for “warming behavior” for brood.

This chemical was identified as glycerol-1,2-dioleate-3-palmitate, in 1972 by N. Koeniger.

16

1989

The chemicals in brood pheromone were identified (by Yve Le Conte), this was done because of the releaser effect on mites (as a kairomone for the Varroa mite). The blend from larval cuticles turns out to be very simple chemicals, 10 of them.

They are methyl and ethyl esters of five different fatty acids:

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FATTY ACID ESTERS IDENTIFIED ON THE LARVAE

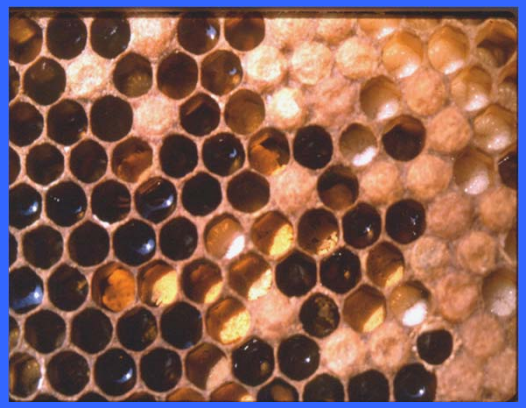
methyl and ethyl Palmitate	$C_{15}H_{31}COO\text{-}R$
methyl and ethyl Stearate	$C_{17}H_{35}COO\text{-}R$
methyl and ethyl Oleate	$C_{17}H_{33}COO\text{-}R$
methyl and ethyl Linoleate	$C_{17}H_{31}COO\text{-}R$
methyl and ethyl Linolenate	$C_{17}H_{29}COO\text{-}R$

Methyl: R = $-CH_3$
Etheyl: R = $-C_2H_5$

18

LE CONTE *et al* , 1989 ***Science***, 245, 638-639

Capping of the cells

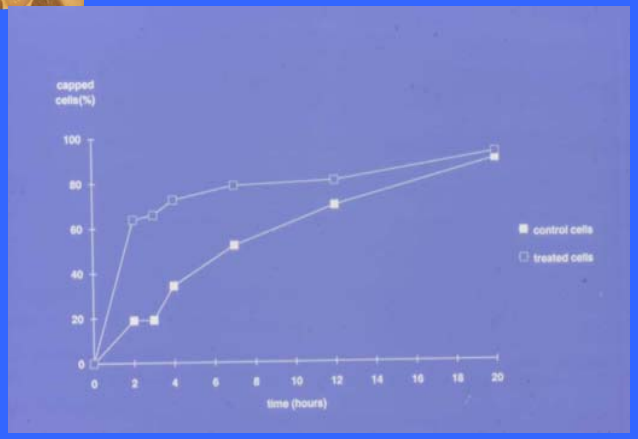


Methyl Palmitate Oleate, Linoleate and Linolenate

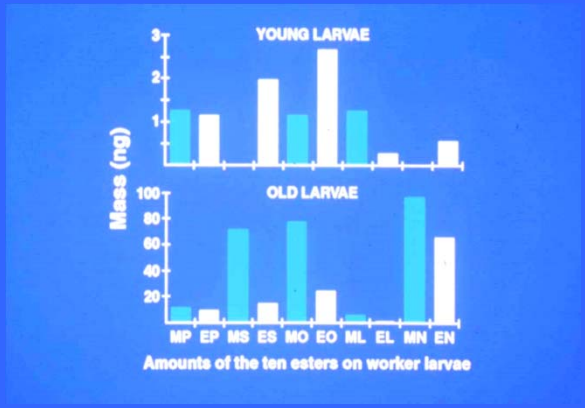
19

LE CONTE *et al* 1990 - ***Naturwissenschaften***, 77, 334-336

Topical applications



Age of larvae



Different mixture of the blend (quantities and proportions)

Dummies containing the different esters

22

Bees respond to old and young larvae mixture differently

Top 2 rows: old larvae extract
Botton 2 rows: young larvae extract

23

LE CONTE *et al.* ***Naturwissenschaften,*** 1994, 81, 462-465.

Brood pheromone and foraging

Pankiw (2004) found that the ratio of pollen foragers to non-pollen foragers increased within one hour of placement of 2,000 larval equivalents of synthetic brood pheromone into a honey bee colony.

Foragers from pheromone-treated colonies returned with heavier pollen loads than foragers from control colonies, and pollen was 43% more likely to originate from the target crop within which colonies were placed to ensure pollination.

Non-pollen foragers, that may visit and pollinate more flowers than pollen foragers while searching for the best nectar sources, had more pollen grains on their bodies than non-pollen foragers from untreated control colonies.

Currently marketed as “super-boost” for pollination units.

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Effects of Brood Pheromone

Releaser

1. As cues for brood capping (“hey, I am ready to be capped”)
2. As a kairomone for the Varroa mite (signal for mite entering)
3. Stimulate pollen collection

Primer

1. Inhibit worker ovary development
2. Stimulate development of hypopharyngeal glands
3. Increase royal jelly production
4. Delay foraging and inhibit juvenile hormone levels

25

BP and Beekeeping

1. Varroa attractant (being tested a few years back)
2. Increase royal jelly production?
3. Stimulate pollen collection: good for pollinating hives?

   “Superboost”, available at Mannlakeltd.com

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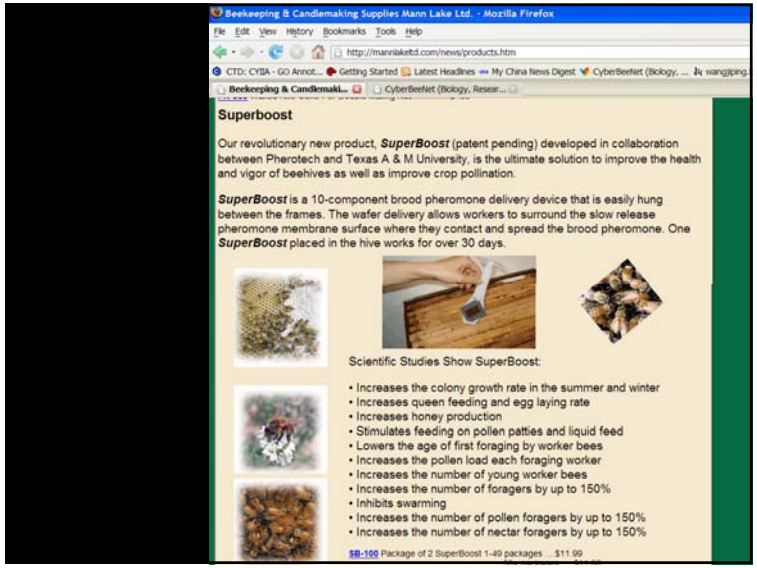

3. Worker inhibitor

How do workers “know” when to start foraging?

hormones: juvenile hormone high in foragers
genetics: some bees forage earlier
colony conditions: bees can forages on day 5

What really “drives” the JH?
What is the essence of colony conditions?

Not known before 1992

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3. Worker inhibitor

1992: Huang & Robinson showed that foragers can prevent young bees from becoming foragers.

They developed the “Social inhibition” model (originally called activator-inhibitor model)

Based on these facts:

- Workers can forage precociously when no old bees present (single cohort colony, SCC)
- This production of precocious foragers can be ‘inhibited’ by putting foragers in an SCC.
- Rearing bees in isolation caused early foraging

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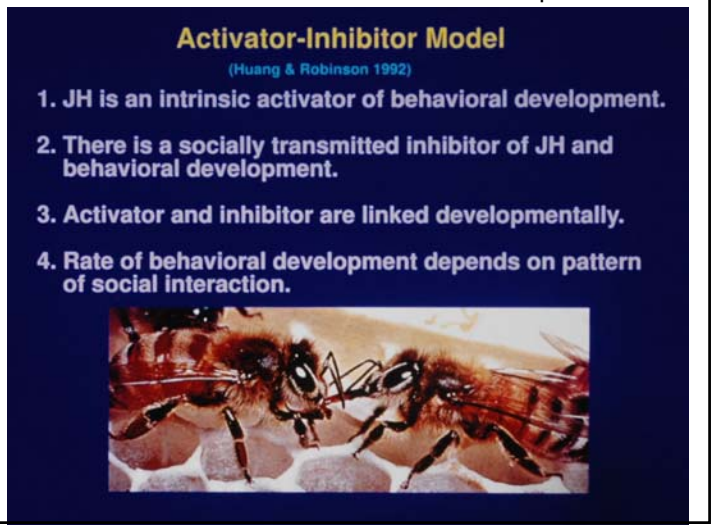
A “social inhibition” model was developed

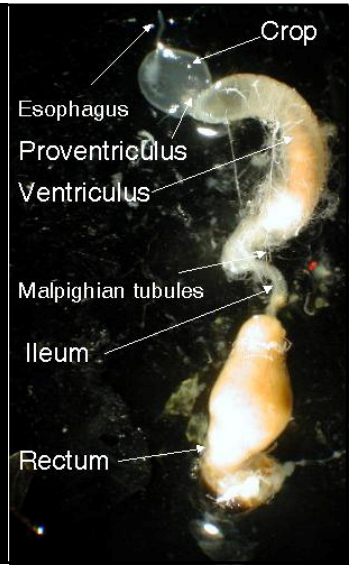


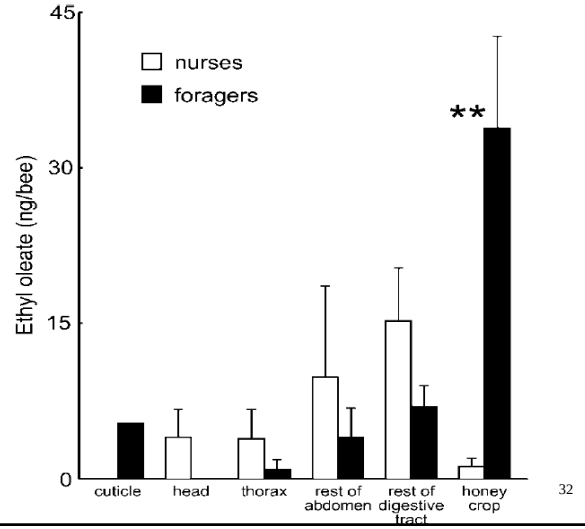
Worker inhibitor recently identified as ethyl oleate

Produced by honey crop

Much higher in foragers
Passed to other bees

Feeding of this chemical to young bees delayed their age of foraging





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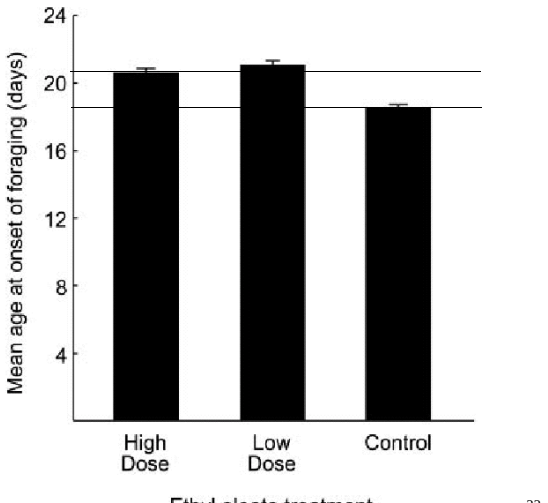

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Perhaps transferred to others from foragers via mutual feeding

Cover photo of Proceedings of National Academy of Sciences (12/14/04)

SPECIAL REPORTS

Contact: Zachary Huang, (517) 353-8136 or bees@msu.edu; or Sue Nichols, University Relations, (517) 353-8942, nichols@msu.edu

New pheromone creates buzz about the clout of older bees

EAST LANSING, Mich. – A recent discovery unveils the chemical secret that gives old bees the authority to keep young bees home babysitting instead of going out on the town.

A hard-to-detect pheromone explains a phenomenon Michigan State University entomologist Zachary Huang published 12 years ago – that somehow older forager bees exert influence over the younger nurse bees in a hive, keeping them grounded until they are more mature, and thus more ready to handle the demands of buzzing about.

The work that identifies the chemical, "Regulation of Behavioral Maturation in Honey Bees by a New Primer Pheromone" is publishing in Proceedings of the National Academy of Science Biological Sciences, Population Biology, Early Edition the week of Nov. 29.

"If the older ones don't keep them in check, the young ones can mature too quickly," Huang said. "It's kind of the same thing as with people, you need the elders to check on the young, even if the young are physically able to go out on their own, it's not the best situation for anybody and now we know how it works."

Huang worked with a team that spanned from the United States , France and Canada to explain how the bees kept an exquisitely consistent balance between the ones that go out to collect nectar and pollen and defend the hive, and those that stay home and nurture the larvae. Huang had documented that this balance is controlled by the elder bees, those that typically spend the final one to three weeks of their five-week lifespan out in the field.

Experiments showed that if a significant number of

A honey bee worker (top left corner) feeds four others simultaneously. Honey bee social feeding was long thought to involve the exchange of communicative substances, in addition to food. The report in the Proceedings of the National Academy of Sciences is the first discovery of a primer pheromone produced by adult worker honey bees that is thought to be transferred via food exchange. (Photo courtesy of Zachary Huang.)
Hi-res jpg

Worker Inhibitor and Beekeeping

1. Possible use for queen rearing colonies
2. Increase royal jelly production?
3. Short term inhibition of foraging? (during a spray)

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4. Alarm pheromones

Mandibular gland: 2-heptanone

Sting glands: isopentyl acetate (have sample).

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Relevance to Beekeeping

1. Check your shampoo for “ethyl acetate” or “butyl acetate”…
2. One sting will increase the likelihood of more stings. But no directional cue.
3. Is it possible to reduce defensiveness by “habituating” the bees to the alarm odor?
4. 2-heptanone induces varroa to drop from bees…recent USDA news

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5. Nasonov Pheromone

5. Nasonov Pheromone

Components:

isomers of citral, nerol, geraniol, nerolic acid, geranic acid and farnesol.

Important for orientation when colony is disturbed, or during swarming

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Use in Beekeeping

- Swarm attraction (used for Africanized bees)

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6. Virgin Queen Pheromone

Virgin queen defecation
Smells good for humans
Repels worker bees

Chemical identified as:
o-aminoacetophenone

Possible use: increase queen acceptance?

Dave Tarpy says bees are attracted to queen-poop…
Decoy for workers?
I tested on entrance…yes, attractive. Went back to Rob Page, who says it might be repellent inside colony…
So jury still out…

44

Un-identified pheromones

Trail Pheromones:

Workers: mark visited flowers?

Queen: tarsal pads deposit pheromone that inhibits queen cell construction

Summary

1. Queen mandibular pheromone (PheroTech)
2. Brood pheromone (superboost, Mannlake)
3. Worker inhibitor (Sigma)
4. Alarm pheromone
5. Nasonov pheromone
6. Virgin queen pheromone

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Thank you for your time
http://photo.bees.net/gallery
www.beetography.com

Stonecrop, Oberlin College, 7/10/2009