

Chemical communication in social insects

Comunicazione chimica negli insetti sociali



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Queen pheromones or «fertility signals» are chemical signals that characterize queens and other reproductive individuals in social insects.



❑ CHCs or «cuticular hydrocarbons»

- Ants
- Wasps
- Bumblebees

❑ QMP or «Queen mandibular pheromone»

- Honeybees

❑ 2 components gland blend

- Termites



Target of the meta-analysis

Main focus

Do «fertility signals»
reduce the fecundity of
other females?

Second aim

The response to these
chemicals depends on
context?

Third aim

Are queen pheromones
composed of single or
multiple chemicals? Do
they act synergistically?

Methods

Meta-analysis consists in pooling data from multiple studies, to estimate the overall effect size for the experimental condition or relationship of interest . Each study is weighted by its precision.

- Literature search** → Using Web of Science
- Raw data** → Or model parameters like F o t statistics
- Recorded** → Whether each chemical was a putative fertility signal



Inclusion criteria

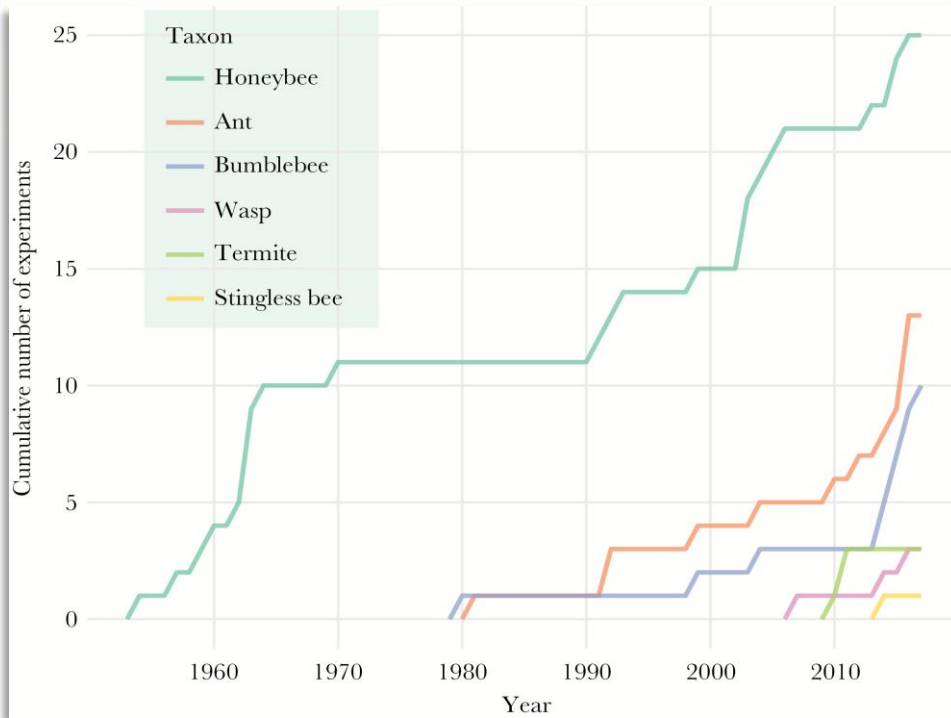
Included

- Any study that exposed eusocial insects to queen chemicals
- Studies that measured fecundity or some proxy for fecundity

Not included

- Studies that experimentally tested whether workers react behaviorally to fertility signals
- Experiments where workers were housed with or without a queen
- Studies with confounding effects

Results



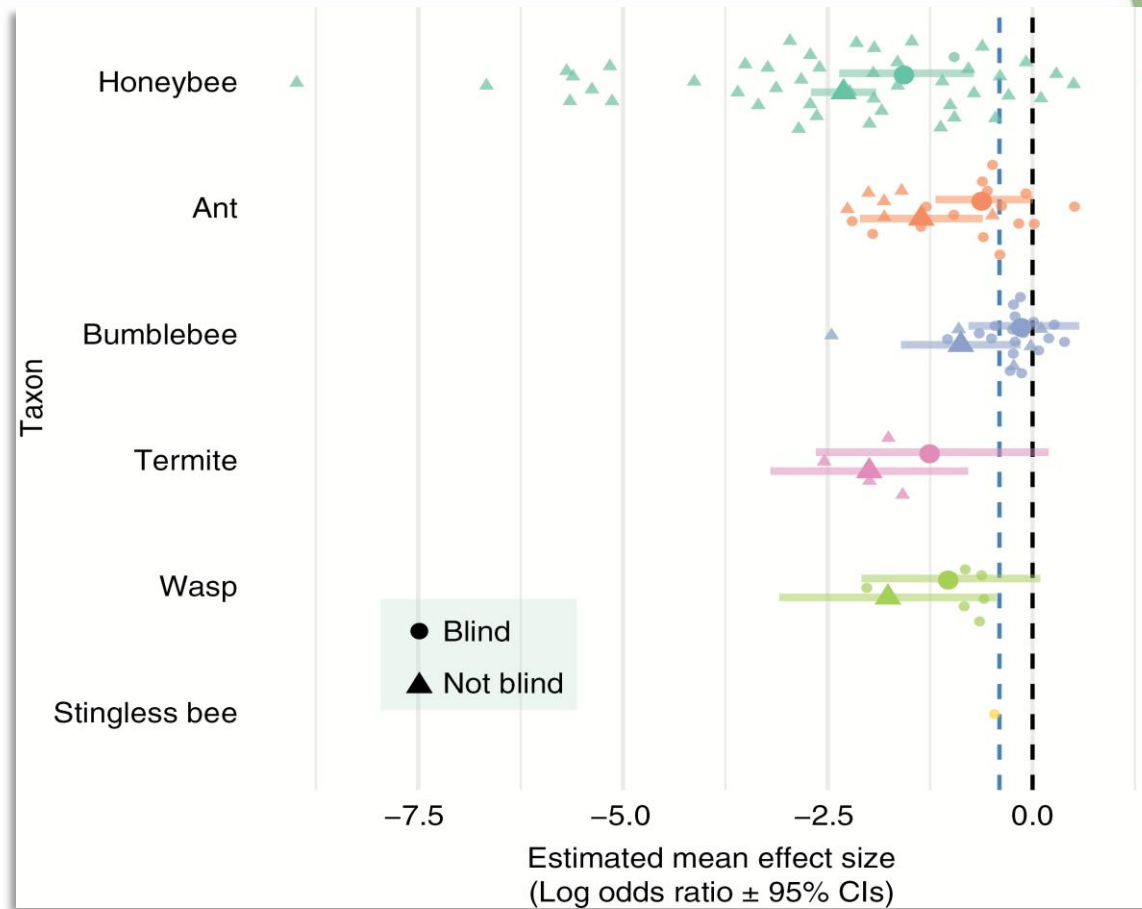
Holman 2018

Quantity

n

Effect sizes	117
Experiments	55
Publications	44
Blind experiments	17
Blind publications	12
Unique species	16
Effect sizes (ants)	33
Effect sizes (honeybees)	47
Effect sizes (bumblebees)	26
Effect sizes (wasps)	6
Effect sizes (termites)	4
Effect sizes (stingless bee)	1

Cumulative number of experiments relative to the effect of queen chemicals on fecundity per year, in each taxon.



Holman 2018

Most **fertility signals** tested, in each taxon, reduce the fecundity of recipients



Effect size < 0

Context-dependent response or learning

There is **no direct evidence** that queen pheromones have context-specific effects on fecundity, or that the response to them must be learned.

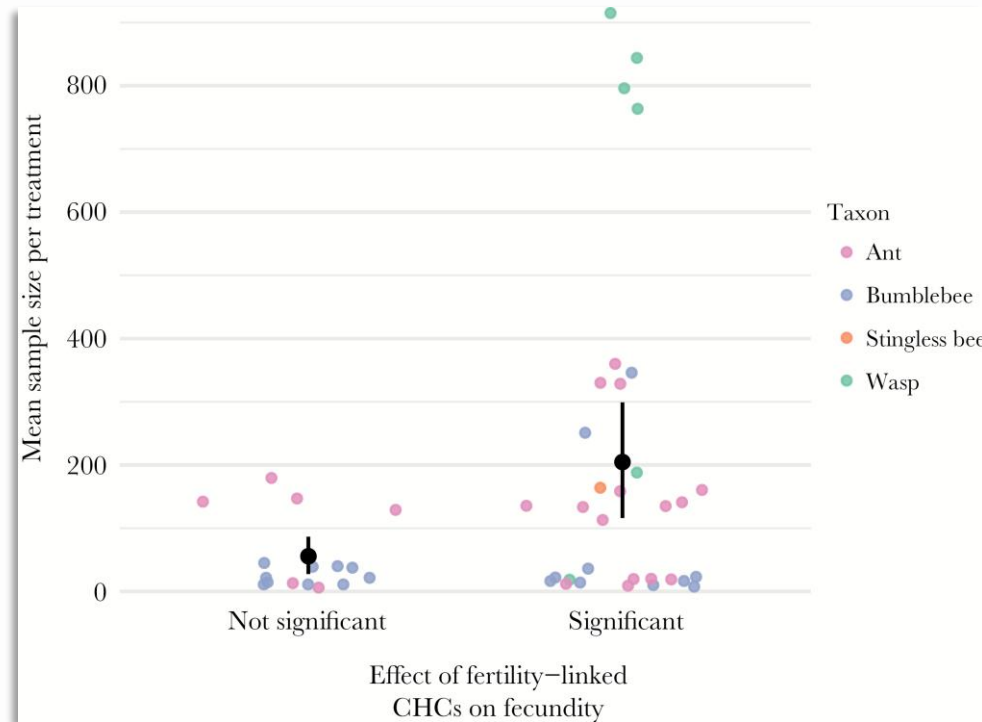
One component or many?

Results from the experiments are not clear. They were all done in different modalities and lead to different outcomes.

However it is plausible to say that **a synergistic effect exist** but escaped detection.

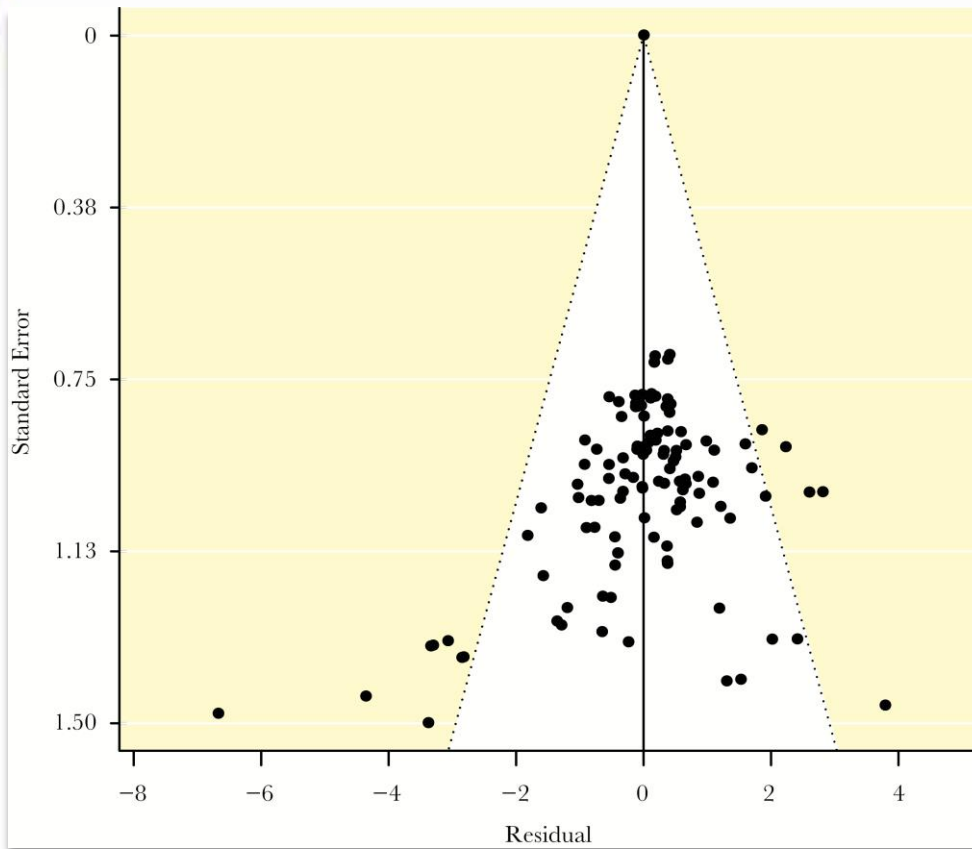


Discussion



Holman 2018

Almost every nonsignificant study had a **lower than average sample size**, Qualitative differences between studies, can be explained by underpowered experiments and not biological differences.



Holman 2018

Publication bias is weak
or almost absent

Funnel plot of the effect sizes in the meta-analysis.
Very small studies needs to find significant results to be published.

Suggestions for future work

- Determine how communication through pheromones vary across the phylogeny
- Discover what happens when a pheromone binds to its receptor in workers
- Get experimenters working blind while collecting data
- Increase sample size in the experiments

Conclusions



Queen pheromones have an **inhibiting power** over other females.

Some experiments concluded that ants and bumblebees CHCs, are not queen pheromones



False negatives

The mechanisms and the evolution of the queen-worker chemicals remains incompletely understood and we're looking for new, exciting, developments.

Bibliography

Holman, L. (2018). Queen pheromones and reproductive division of labor: a meta-analysis. *Behavioral Ecology*, 29(6), 1199-1209.

Pictures

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Abstract

Chemical communication between queens and workers, in eusocial insect, has been a matter of study only in the recent years.

Fertility signals, in almost every studies, are been apparently confirmed to be directly involved, in the inhibition of fecundity over the other females of a colony.

Some nonsignificant results were produced by a few experiments but, using meta-analysis, we can consider them as false negatives, since they lack of statistical power. For the same reason, whether queen pheromones are effective regardless of the context, can't be established yet.

Results recorded, with not blind experiments, were much more stronger than the blind ones, affecting their truthfulness with an observer bias.

Several suggestions for future works has been written, to get a progressively better knowledge, about queen pheromones' hidden mechanisms.