

Microorganisms from aphid honeydew attract natural enemies and tending ants

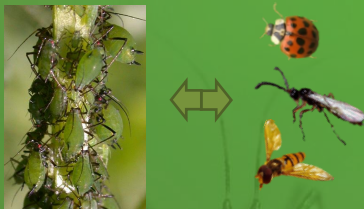
Verheggen F, Leroy P, Fischer C, Sabri A, Francis F, Heuskin S, Thonart P,
Felton G, Detrain C, Lognay G, Haubruge E

Gembloox Agro-Bio Tech - University of Liège (Belgium)
Free University of Brussels (Belgium)
Penn State University (USA)

Verheggen et al. - ISCE 2011

Part I.

Role of microorganisms from aphid honeydew on aphid natural enemies



Part II.

Role of microorganisms from aphid honeydew tending ants



Verheggen et al. - ISCE 2011

Aphid honeydew



Homopteran liquid excretion mainly containing sugars and amino acids

Honeydew accumulates on the host plants and is used by natural enemies to locate aphids

Honeydew acts as **volatile** and **contact** kairomone for hoverflies



Leroy et al., 2010. Biological Control 54

Verheggen et al. - ISCE 2011

Part I.

Role of microorganisms from aphid honeydew on aphid natural enemies



- ➔ Identify honeydew volatiles
- ➔ Evaluate their biological activity
- ➔ Look at the bacteria responsible for the production of these volatiles
- ➔ Include the most active cues in field protection strategies

Verheggen et al. - ISCE 2011

Part 1. Role of microorganisms from aphid honeydew on aphid natural enemies



- *Episyrphus balteatus* (Diptera: Syrphidae)
- Adults are efficient pollinator
- Larvae are voracious aphid predators
- Adult females locate aphid colonies using volatile cues associated with aphids and their host plants

- Aphid alarm pheromone
- Aphid host plant induced volatiles
- Aphid honeydew

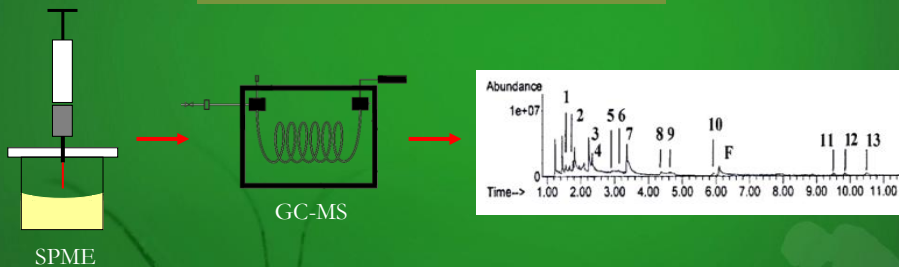


Verheggen et al (2008) J Chem Ecol 34
Verheggen et al (2009) Behav Ecol 20

Verheggen et al. - ISCE 2011

Part 1. Role of microorganisms from aphid honeydew on aphid natural enemies

SPME volatile collection from aphid honeydew



- 3-methyl-3-buten-1-ol ; 3-methyl-1-butanol ; 2-methyl-2-buten-1-ol ; benzeneethanol
- 2-propanone ; 2,3-butanedione ; 3-hydroxy-2-butanone
- 3-méthylbutanal ; 2-méthylbutanal ; 3-méthyl-2-butenal
- 2,5-diméthylpyrazine
- Limonene
- Butanoic ac ; 3-methylbutanoic ac ; 2-methylbutanoic ac

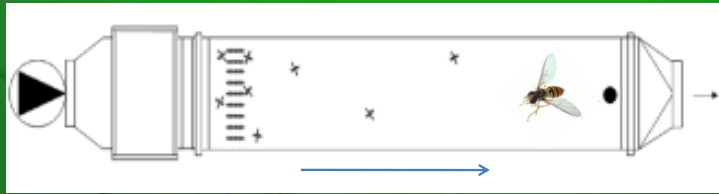
Leroy et al., 2011. Nature Communications 2: 348

Verheggen et al. - ISCE 2011

Part 1. Role of microorganisms from aphid honeydew on aphid natural enemies

Impact of bacteria volatile chemicals on the oviposition behavior of a syrphid predator

Wind-tunnel assays



Plants + one single semiochemical
10 hoverflies introduced

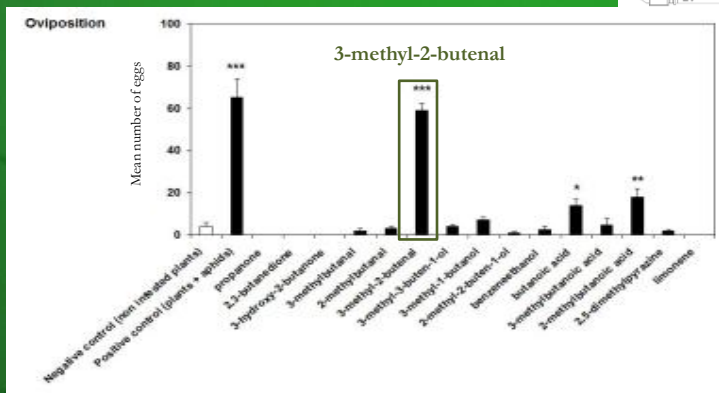
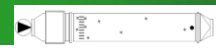
Leroy et al., 2011. Nature Communications 2 : 348

Verheggen et al. - ISCE 2011

Part 1. Role of microorganisms from aphid honeydew on aphid natural enemies

Impact of bacteria volatile chemicals on the oviposition behavior of a syrphid predator

Wind-tunnel assays







Leroy et al., 2011. Nature Communications 2 : 348

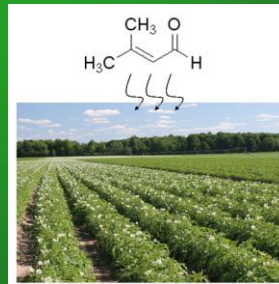
Verheggen et al. - ISCE 2011

Part 1. Role of microorganisms from aphid honeydew on aphid natural enemies

Impact of bacteria volatile chemicals on the oviposition behavior of a syrphid predator

Field assays

-  Potato field *Solanum tuberosum* var. Ditta (6 ha)
-  40 parcels (1 m²) :
 - 20 parcels + 3-methyl-2-butenal
 - 20 untreated parcels
-  Natural enemies were trapped for 2 days
-  Eggs were counted after 2 days



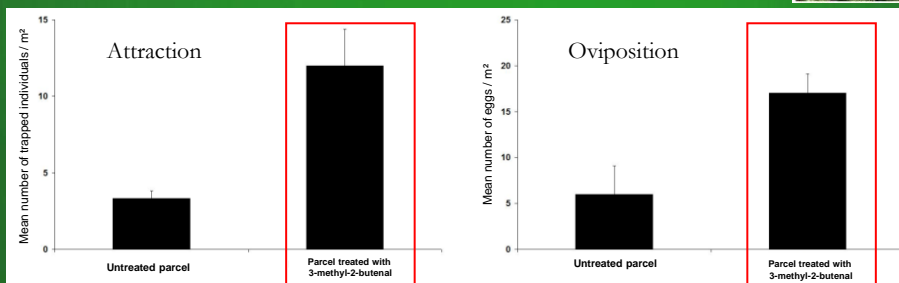
Leroy et al., 2011. Nature Communications 2 : 348

Verheggen et al. - ISCE 2011

Part 1. Role of microorganisms from aphid honeydew on aphid natural enemies

Impact of bacteria volatile chemicals on the oviposition behavior of a syrphid predator

Field assays



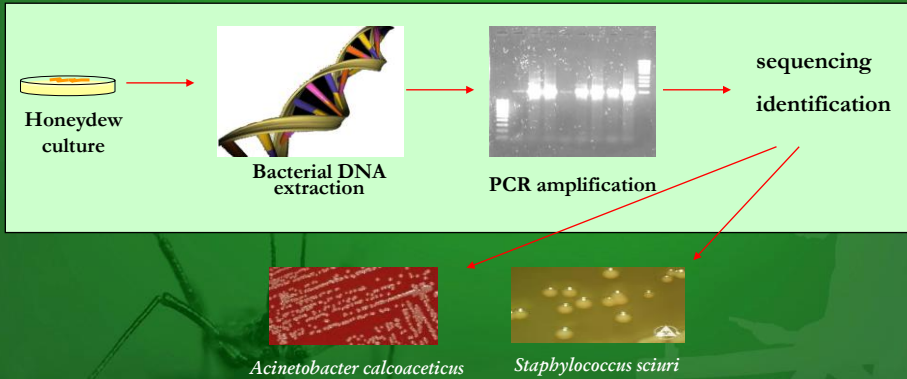
3-methyl-2-butenal attracts syrphid flies and induces oviposition

Leroy et al., 2011. Nature Communications 2 : 348

Verheggen et al. - ISCE 2011

Part 1. Role of microorganisms from aphid honeydew on aphid natural enemies

Identification of the bacteria from aphid honeydew

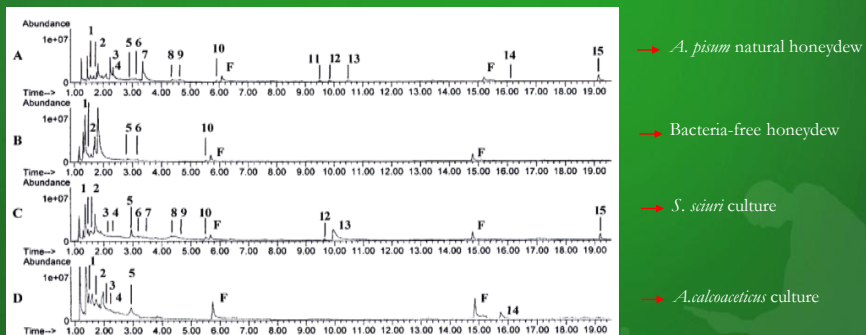


Leroy et al., 2011. Nature Communications 2 : 348

Verheggen et al. - ISCE 2011

Part 1. Role of microorganisms from aphid honeydew on aphid natural enemies

Identification of the volatile chemicals produced by honeydew-associated bacteria



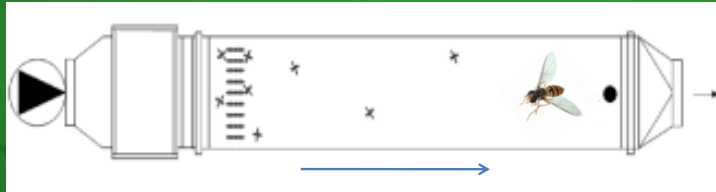
Leroy et al., 2011. Nature Communications 2 : 348

Verheggen et al. - ISCE 2011

Part 1. Role of microorganisms from aphid honeydew on aphid natural enemies

Impact of bacteria volatile chemicals on the oviposition behavior of a syrphid predator

Wind-tunnel assays


Plants treated with :

- + natural honeydew
- + Sterilized honeydew
- + *S. scirri* re-inoculated honeydew
- + *A. calcoaceticus* re-inoculated honeydew
- + culture medium
- + a culture medium of *S. scirri*

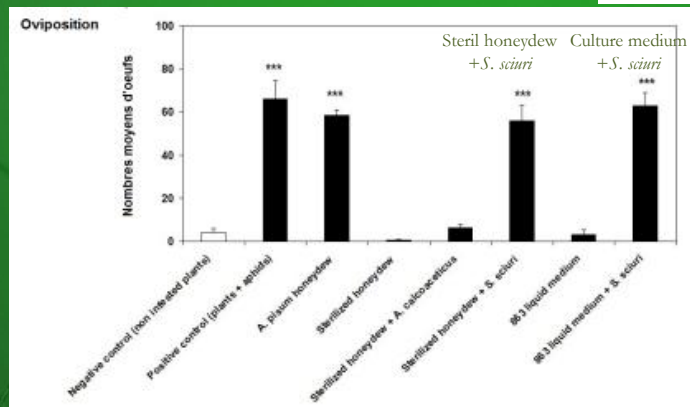
Leroy et al., 2011. Nature Communications 2 : 348

Verheggen et al. - ISCE 2011

Part 1. Role of microorganisms from aphid honeydew on aphid natural enemies

Impact of bacteria volatile chemicals on the oviposition behavior of a syrphid predator

Wind-tunnel assays



Leroy et al., 2011. Nature Communications 2 : 348

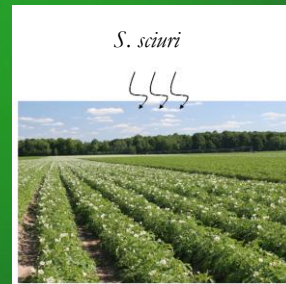
Verheggen et al. - ISCE 2011

Part 1. Role of microorganisms from aphid honeydew on aphid natural enemies

 Effect of *S. sciuri*-inoculated medium on *E. balteatus* in the field

Field assays

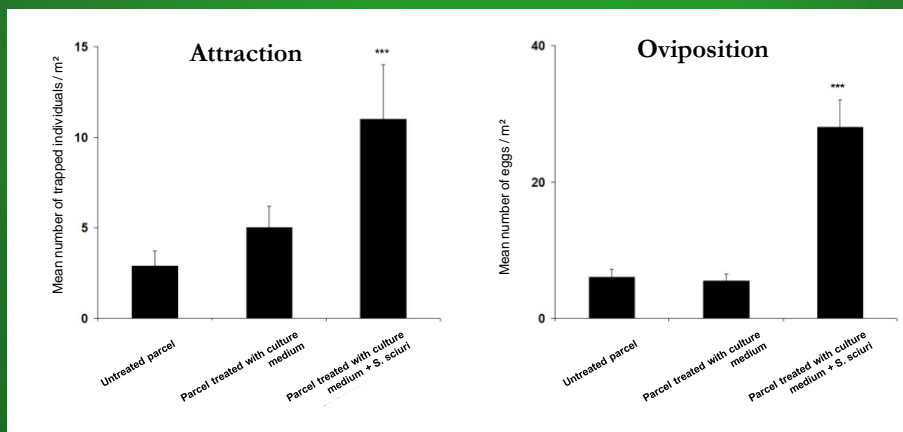
- Potato field *Solanum tuberosum* var. Ditta (6 ha)
- 60 parcels (1 m²) :
 - 20 untreated parcels
 - 20 parcels + culture medium
 - 20 parcels + culture medium + *S. sciuri*
- Natural enemies were trapped for 2 days
- Eggs were counted after 2 days



Leroy et al., 2011. Nature Communications 2 : 348

Verheggen et al. - ISCE 2011





Part 1. Role of microorganisms from aphid honeydew on aphid natural enemies

 Effect of *S. sciuri*-inoculated medium on *E. balteatus* in the field


Leroy et al., 2011. Nature Communications 2 : 348

Verheggen et al. - ISCE 2011

Part 1. Role of microorganisms from aphid honeydew on aphid natural enemies

-  Honeydew attract natural enemies and induce oviposition
-  3-methyl-2-butenal carries the biological activity
-  *S. sciuri* is the source of the biological activity
-  It is possible to increase the presence of natural enemies in a field by spraying either a bacterial or a simple chemical formulation

Leroy et al., 2011. Nature Communications 2 : 348

Verheggen et al. - ISCE 2011

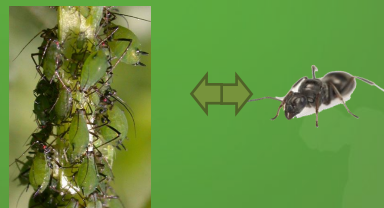
Part I.

Role of microorganisms from aphid honeydew on aphid natural enemies



Part II.

Role of microorganisms from aphid honeydew tending ants



Verheggen et al. - ISCE 2011

gembloLux
agro bio tech

Université de Liège

Part II.

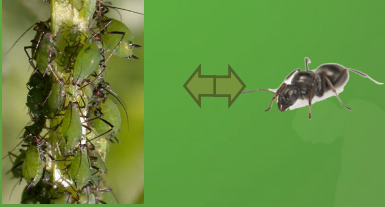
Role of microorganisms from aphid honeydew tending ants

Evaluate distance attractiveness of aphid for ant scouts

Identify honeydew volatiles

Evaluate their biological activity

Look at the bacteria responsible for the production of these volatiles




Verheggen et al. - ISCE 2011


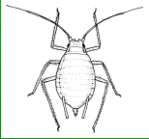
gembloLux
agro bio tech

Université de Liège

Part 2. Role of microorganisms from aphid honeydew on tending ants

Do ants use aphid associated cues to locate aphid colonies and establish mutualistic relationships ?



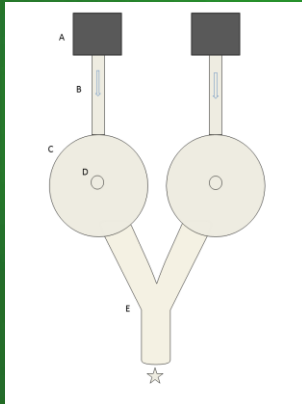

 +
 
 + Honeydew

Fava bean *Aphis fabae*

Three potential sources of volatile chemicals that may be used by ants

Verheggen et al. - ISCE 2011

Part 2. Role of microorganisms from aphid honeydew on tending ants


 Uninfested plant *vs* Aphid infested plant

 N=100, 68% attraction, $P < 0.001$


 Uninfested plant *vs* Aphid infested plant (aphid removed)

 N=100, 64% attraction, $P = 0.005$

 Empty chamber *vs* Aphid honeydew

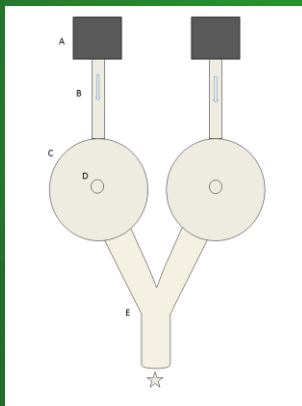
 N=120, 64% attraction, $P = 0.002$
A. fabae infested plant *vs* *A. pisum* infested plant

 N=110, 60% attraction, $P = 0.036$
A. fabae honeydew *vs* *A. pisum* honeydew

 N=60, 67% attraction, $P = 0.010$

 Ants use volatile odors from aphid honeydew to locate an aphid colony

Verheggen et al. - ISCE 2011

Part 2. Role of microorganisms from aphid honeydew on tending ants


 Culture medium + honeydew *vs* Sterile culture medium

 N=63, 78% attraction, $P < 0.001$

 Ten bacteria species identified from *A. fabae* honeydew.

 None induced attraction of *L. niger* scouts except *S. saprophyticus* !

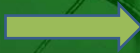
Verheggen et al. - ISCE 2011

Conclusions :


S. sciuri has been identified from *A. pisum* honeydew
S. sciuri induces the emission of kairomones from honeydew that attract natural enemies



Ant scouts use honeydew volatile chemicals to find aphid colonies
 Bacteria are at the origin of the volatile production from honeydew



Microorganisms from aphid honeydew attract natural enemies and tending ants

Verheggen et al. - ISCE 2011

Special acknowledgments to :


Pascal LEROY



Christophe FISCHER

Verheggen et al. - ISCE 2011

Thank you !

