FONDAZIONE EDMUND MACH

BIOFRUITNET
Boosting Innovation in ORGANIC FRUIT production through stronger networks

Biofruitnet 2nd Online Seminar

Connecting and Innovating the Organic Fruit Production

10th March 2022

Introduction to Applied Biotremology

Valerio Mazzoni

RESEARCH AND INNOVATION CENTER

Prologue

New Challenges – New Solutions

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Agriculture Revolutions

PROs	Increased Production Growth of Population Surplus and development of other works
CONs	Pollution Reduced Soil Fertility Reduced Biodiversity Resources Waste

Modern Agriculture Revolutions: Agriculture 4.0


Precision Agriculture

Smart Farming


Internet of Things

Information is processed to make proper strategical and operational Decisions

Field sensoring – Remote sensoring – Decisional Models

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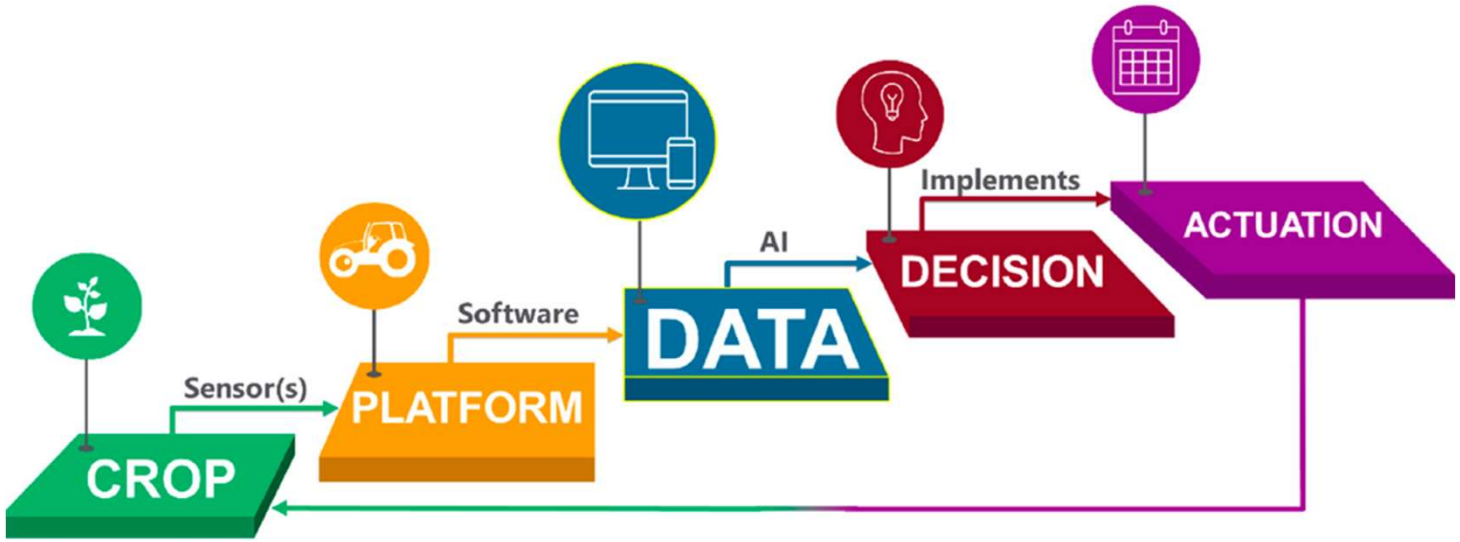
Modern Agriculture Revolutions: Agriculture 5.0



Use of Robotic and Artificial Intelligence (A.I)

Two further implementations:

Autonomous decision support

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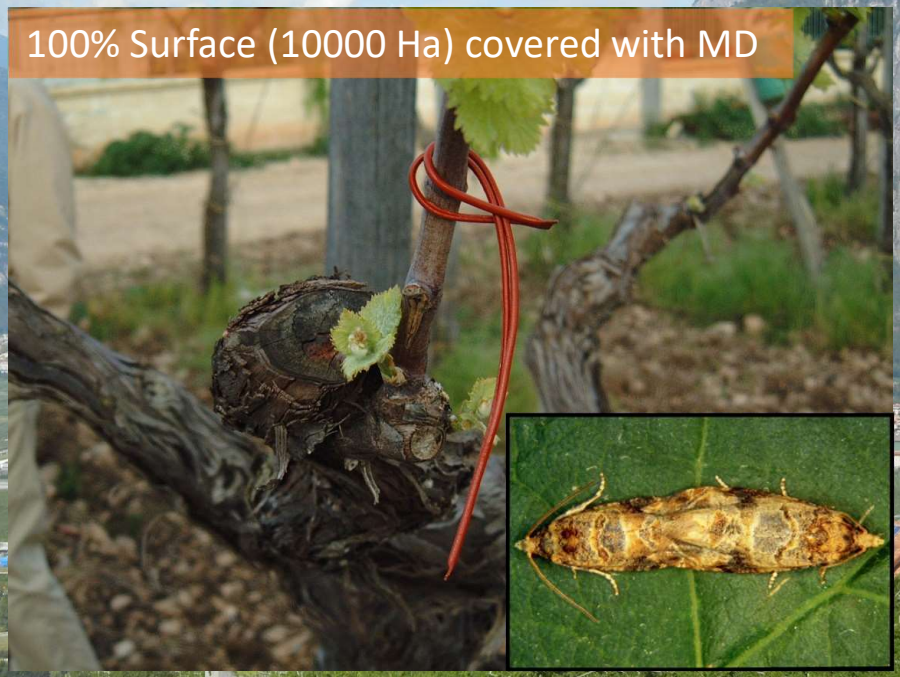
Some crucial Requirements

- **Education and Training of Farmers**
- **Information sharing**
- **Demand of quality from the consumers**
- **Support from government and associations**


TRENTINO
Bolzano
S. Michele all'Adige
Trento
Verona

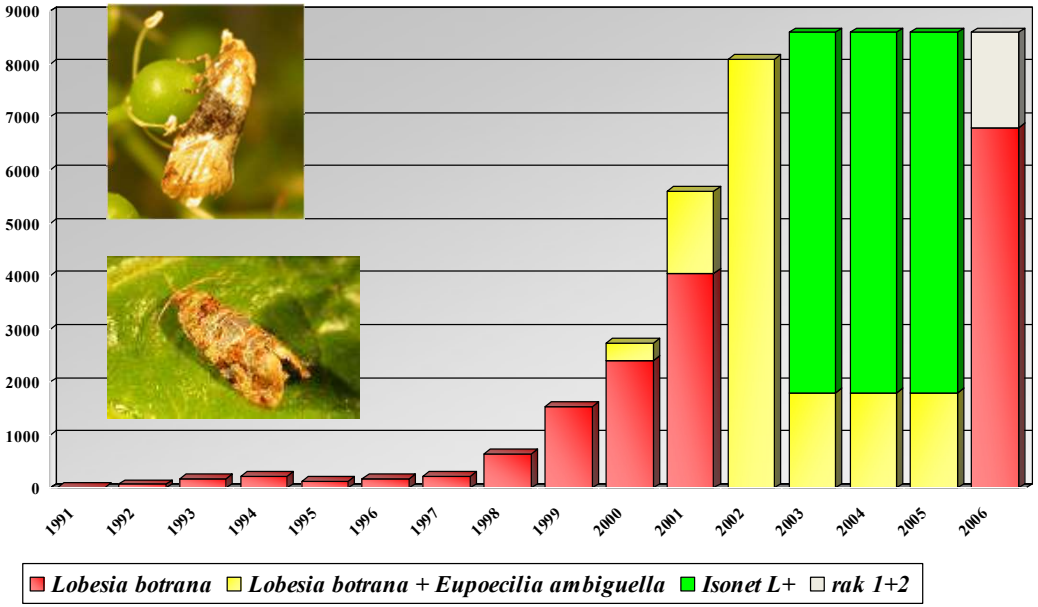
PIANA ROTALIANA

100% Surface (10000 Ha) covered with MD



Grape Surface with MD application

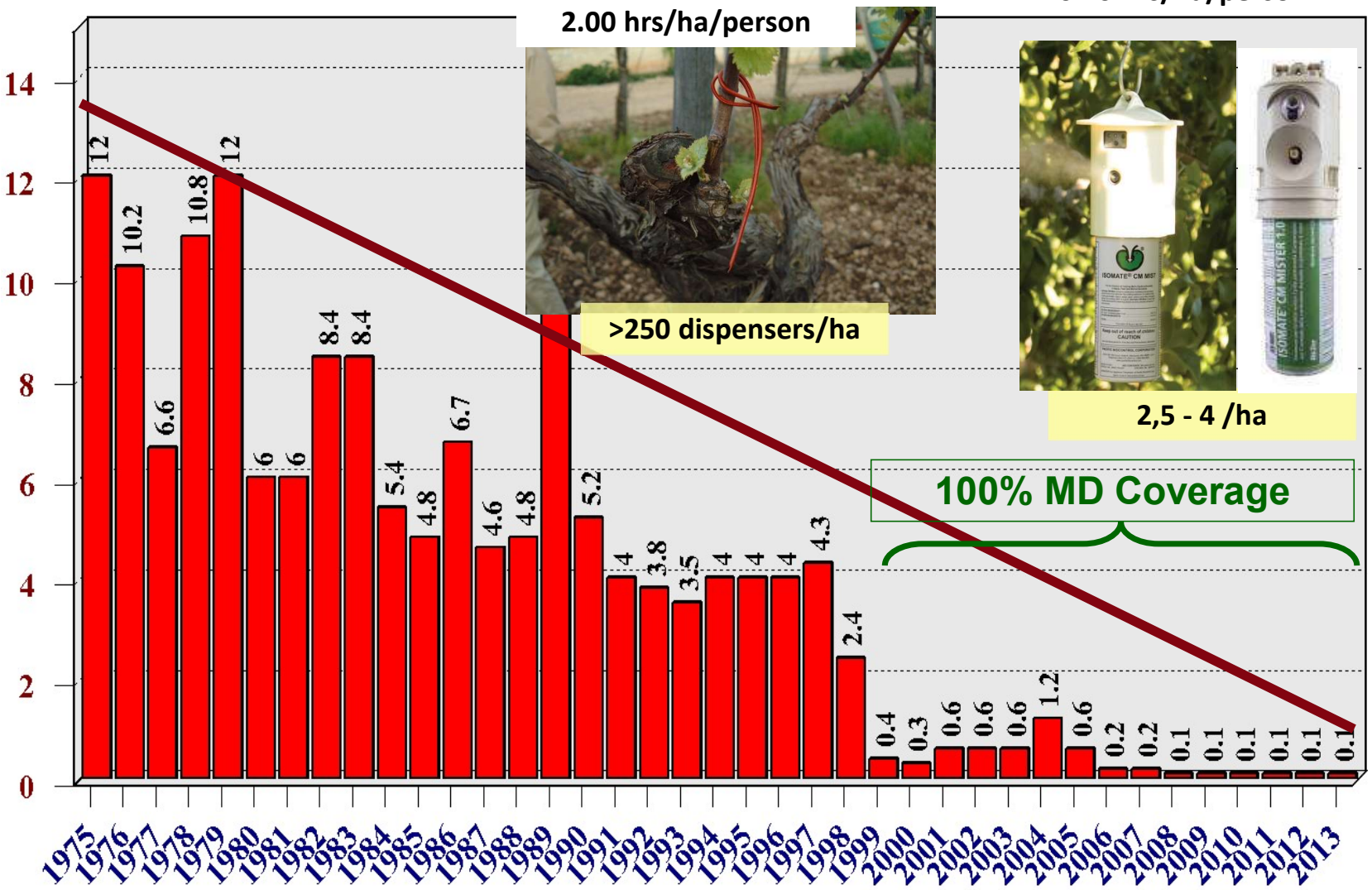
Alternative approaches: mating disruption



2011

- Application of MD is compulsory for growers adopting provincial IPM guidelines (9300 ha)
- Chlorpirifos has been banned (no OPs admitted)
- If chemical treatments are needed metoxyfenozide is applied (about 100 ha)

Insecticide treatments (Hl/Ha)



ALIEN INVASION!

Scaphoideus titanus

Drosophila suzukii

Halyomorpha halys

Chapter 1

Behavioral Manipulation

Behavioral manipulation in Chemical Ecology

Semiochemicals
Definition: Chemical (gustatory and olfactory) stimuli able to modify the behavior of the receiver.

Pheromones: intra-specific to the advantage of both sender and receiver
Kairomones: inter-specific to the advantage of the receiver
Allomones: favor the individual producing them to the detriment of the receiver

Volatiles emitted by the host (or the plants)

Kairomones

Shin-Etsu double dispenser (Mating Disruption)

Pheromone

Physical Signals in Biology (SEMIOPHYSICALS)

Semiophysicals
Definition: Physical (acoustical, vibratory and visual) stimuli able to modify the behavior of the receiver.

Nieri et al, 2021 (Entomol Gen)

Entomologia Generalis, Vol. XX (2021), Issue X, XXX–XXX
Published online May 2021

PrePub-Article

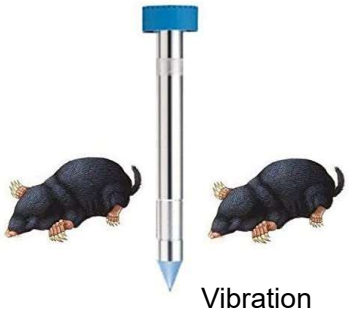
Semiochemicals, semiophysicals and their integration for the development of innovative multi-modal systems for agricultural pests' monitoring and control

1) Attraction/Repellence
2) Stimulation/Inhibition
3) Interference (i.e., MD)

Loudspeaker as a Scarecrow

Colored Sticky Traps for Monitoring

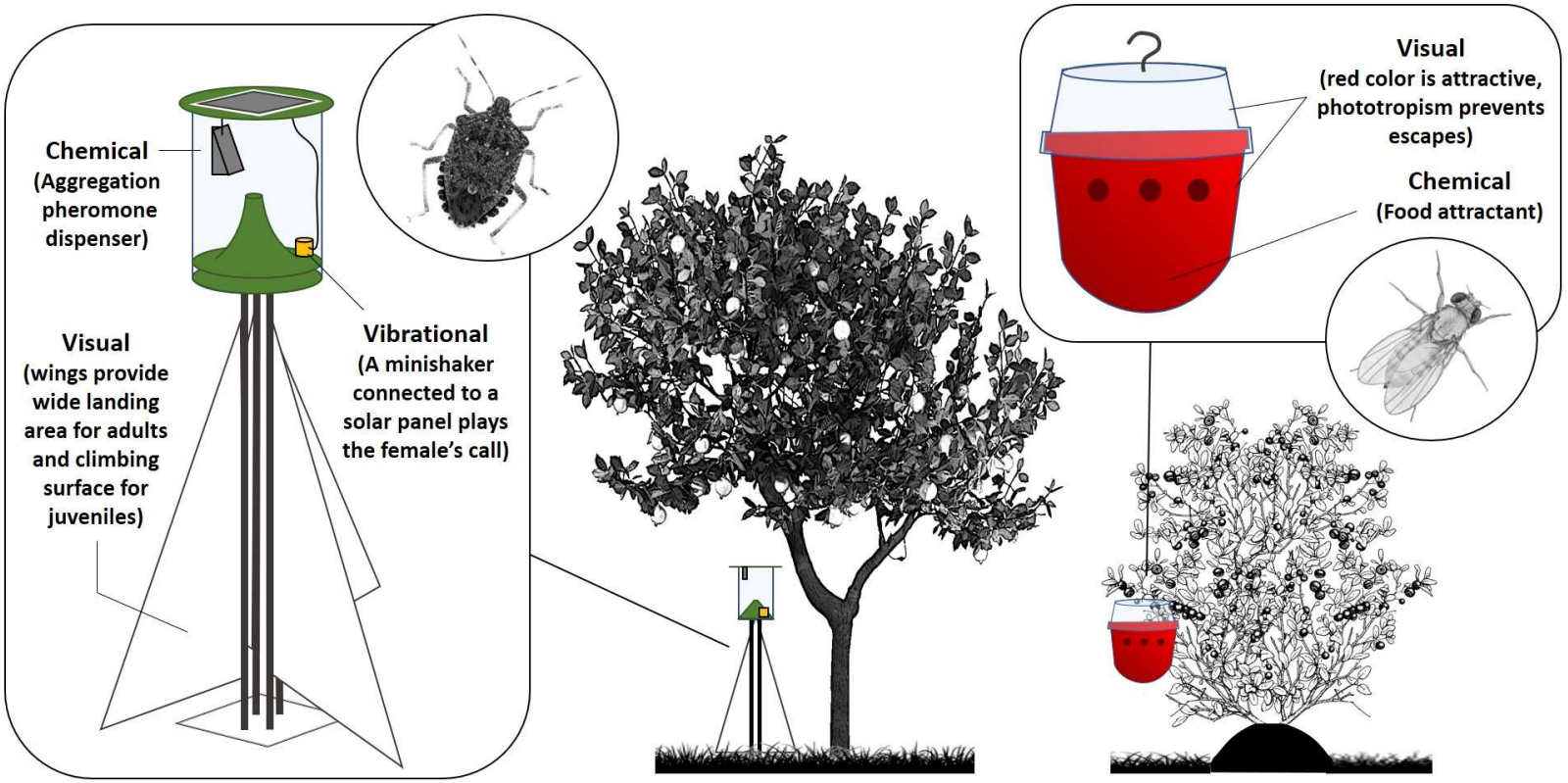
LED UV
Attract & Kill



Vibration
Repeller

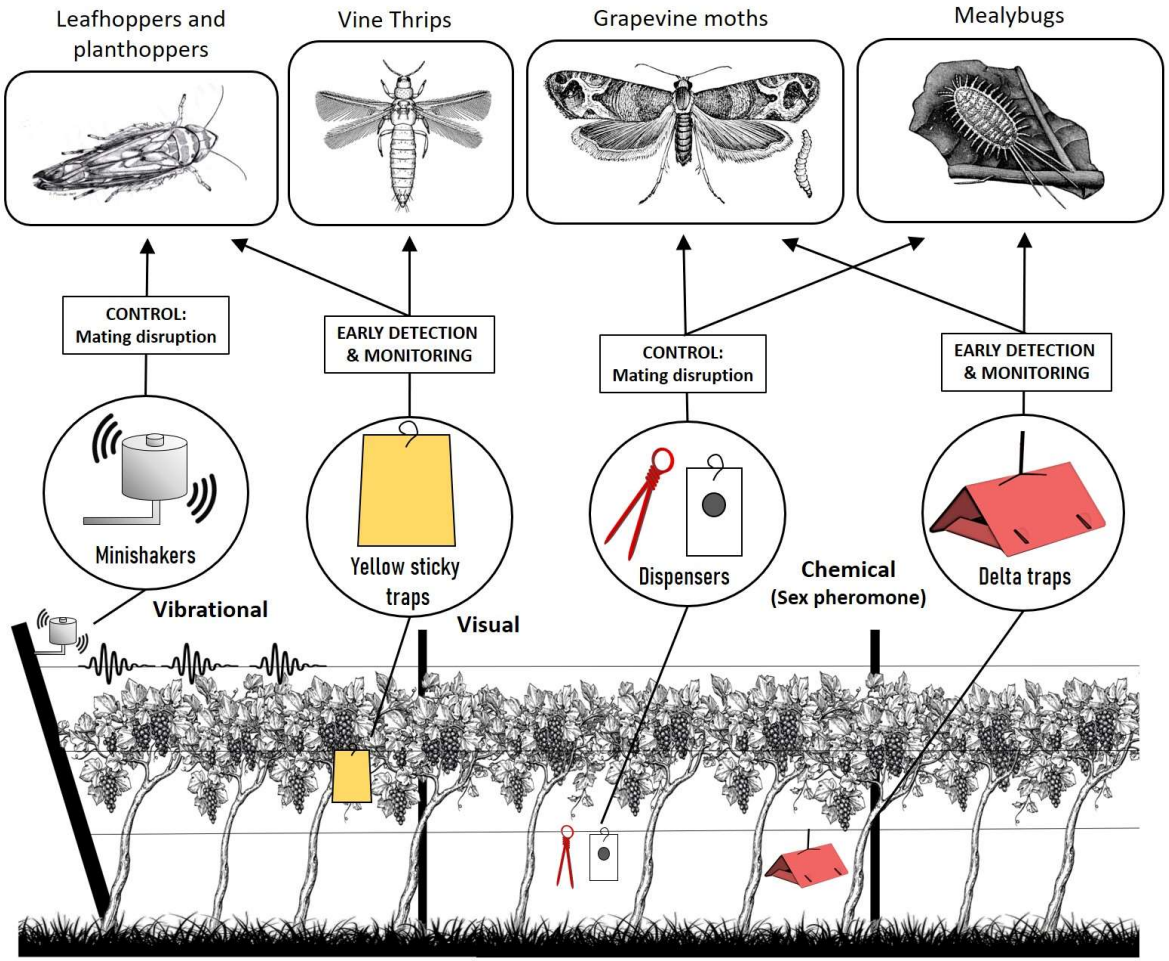
Ultrasound deterrent

Integration of semiochemicals &semiophysicals for Behavioral Manipulation



Nieri et al., 2021

Integration of semiochemicals & semiophysicals for Behavioral Manipulation



Nieri et al., 2021

Chapter 2

Biotremology

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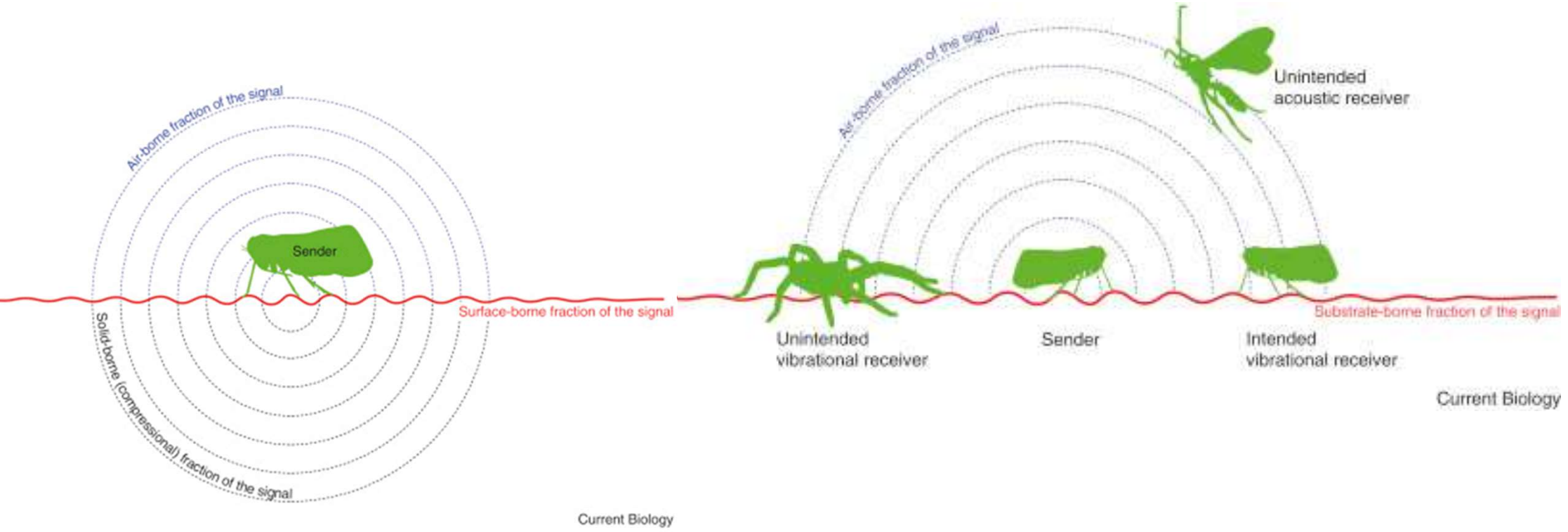
BIOTREMOLOGY

The discipline that studies **Animal Communication** by **Substrate-borne Mechanical Waves** (**VIBRATIONS**)



FONDAZIONE EDMUND MACH

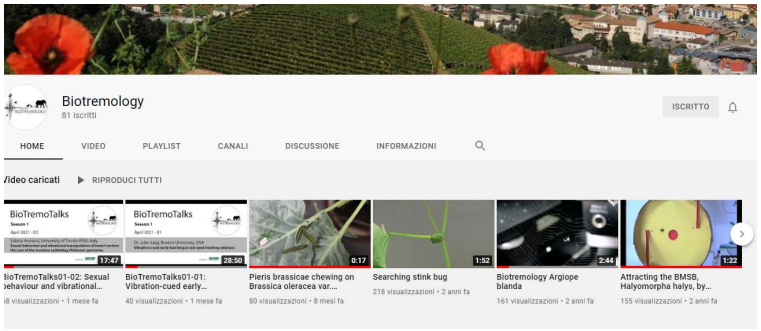
BIOTREMOLOGY

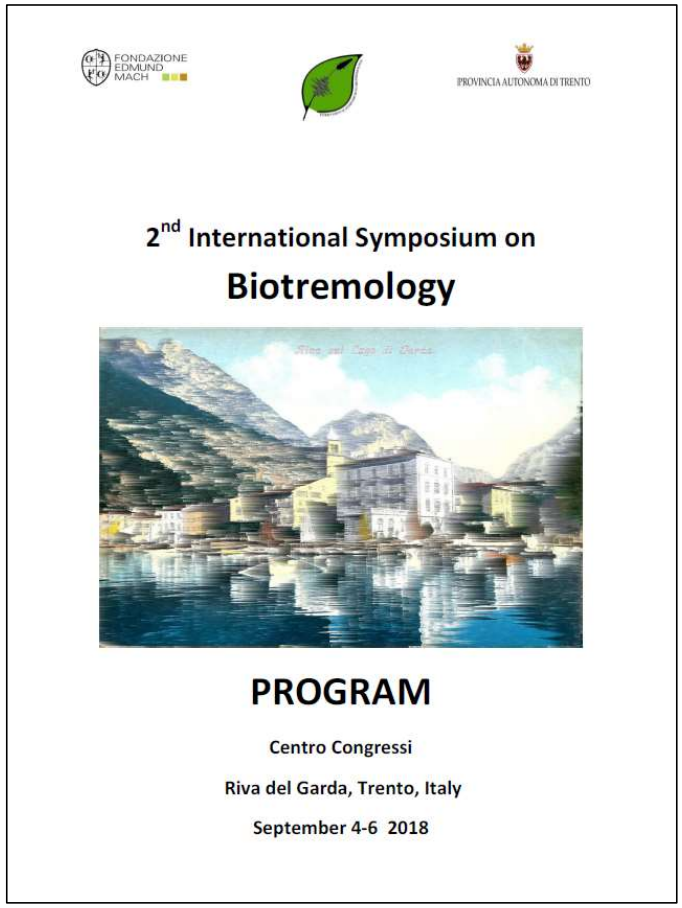
Official Logo

Books

Facebook page

Youtube channel





World Symposium (3° edition on 2022 in Slovenia)

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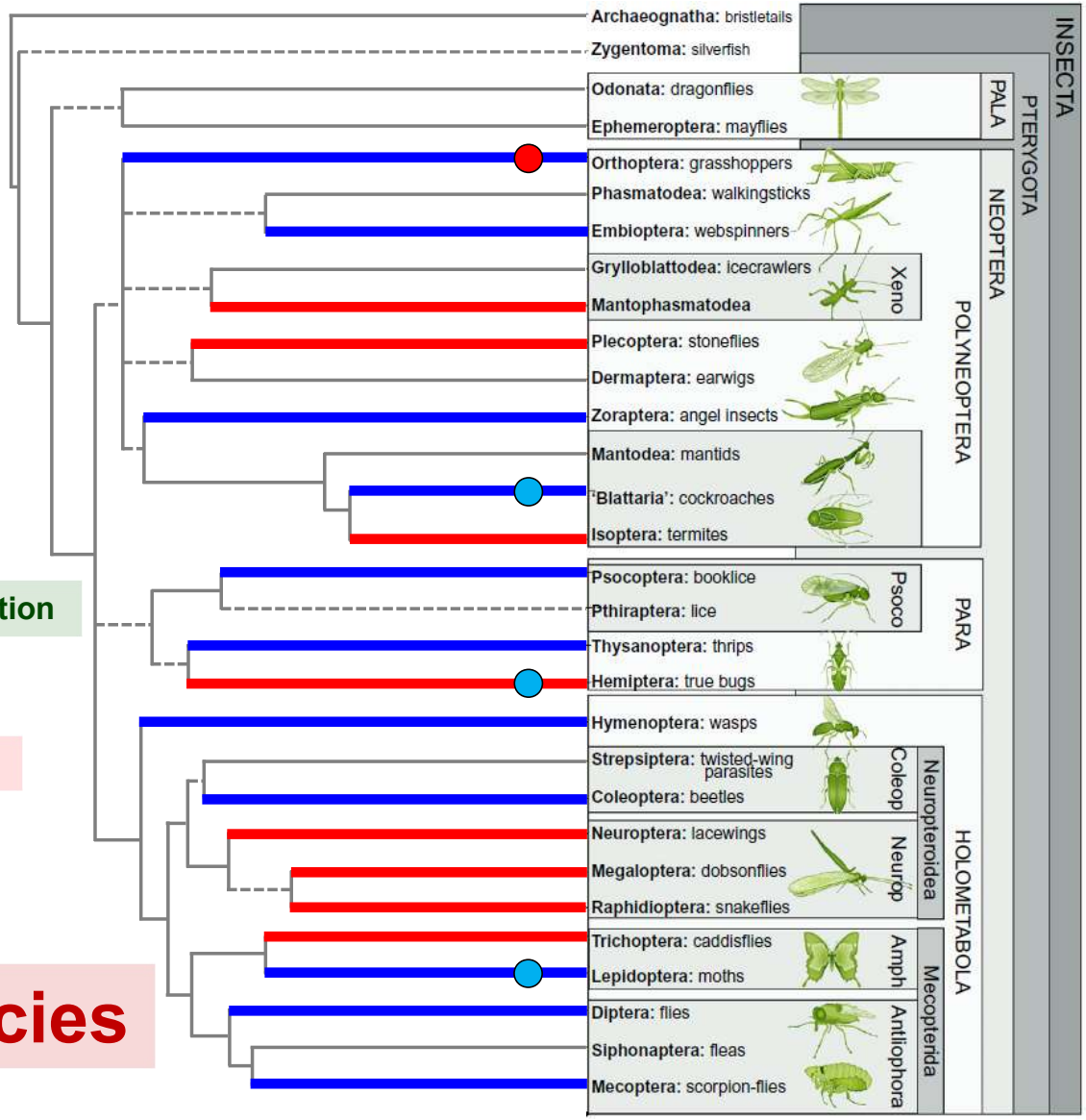
Insect phylogeny



Air-borne sound communication

- common
- present

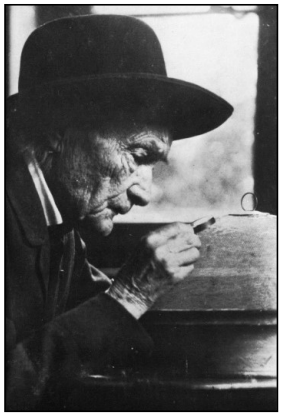
Vibrational communication

- common
- present
- not found (yet…)

> 200000 species

modified from Cocroft & Rodríguez (2005): BioScience 55, 323-334; insect phylogeny from Yeates et al. (2012): Austr J Entomol 51, 79-87

Mating Disruption with Pheromones



Jean-Henry Fabre
prime registrazioni
Comunicazione
chimica negli insetti

1879

Bruno Götz ipotizza
la Confusione
Sessuale

1940

Adolf Butenandt identifica
Bombicolo
da *Bombyx mori*

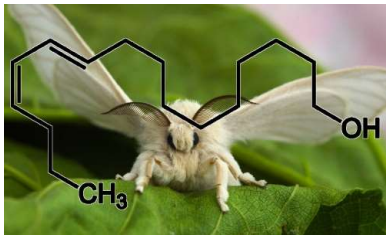
1959

Harry Shorey
prove in campo di
Confusione sessuale
su *Trichoplusia ni*

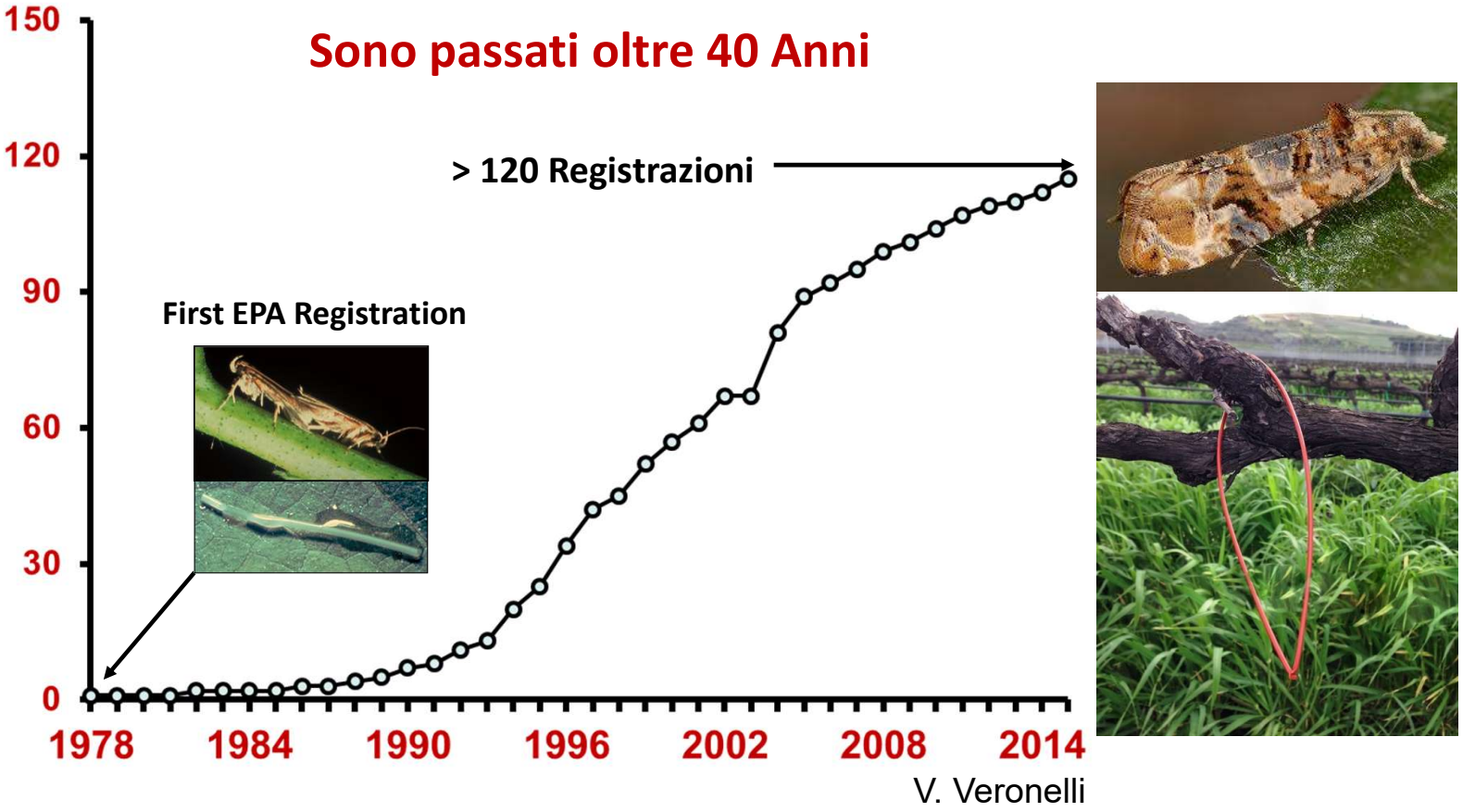
1967

Pectinophora gossypiella
Prima registrazione di
un prodotto
in USA

1978



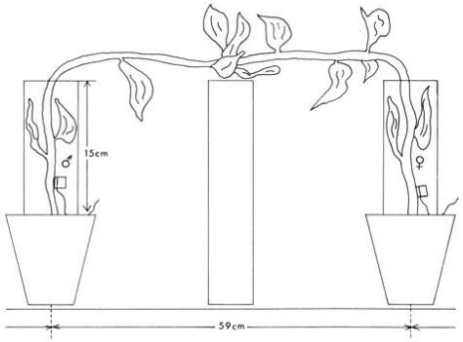
PHEROMONE Mating Disruption



Applicazione possibile se si conosce il
COMPORTAMENTO RIPRODUTTIVO della specie target!

Mating Disruption with Vibrations

Frej Ossianilsson: hypothesis of Vibrational Communication



1st demonstrations of insect vibrational communication by Gogala and Ichikawa

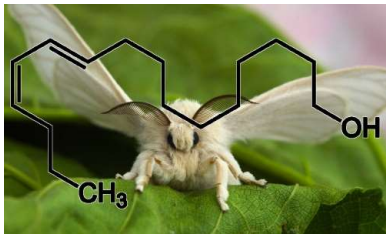
First tests of MD with vibrations (Eriksson et al)

1879

1940

1949

1959



1967

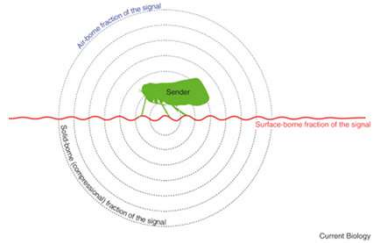
1974

1978

2012

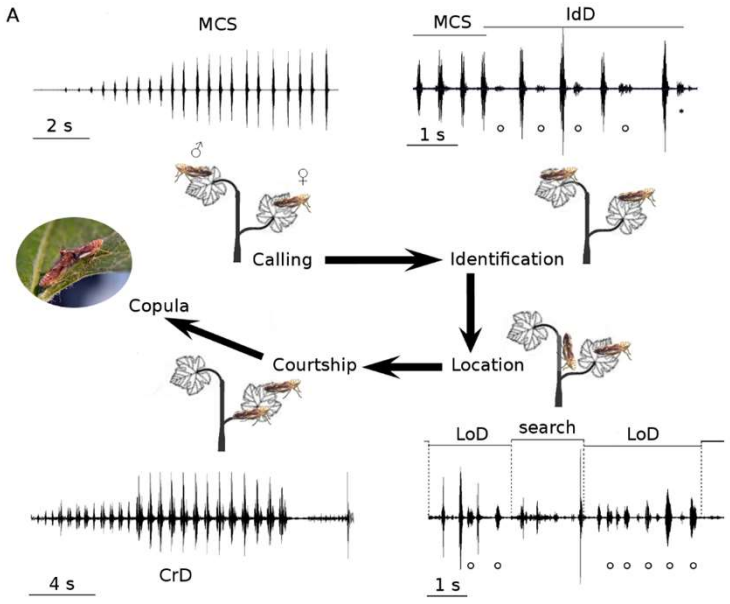
2015

Definition of Biotremology as a scientific Discipline (Wessel and Hill)



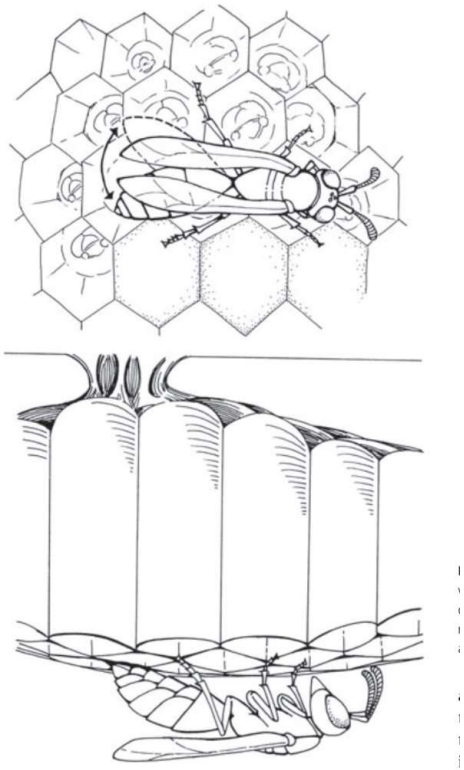
SEMIOPHYSICALS: Examples of Intraspecific Signals

Mating Behavior



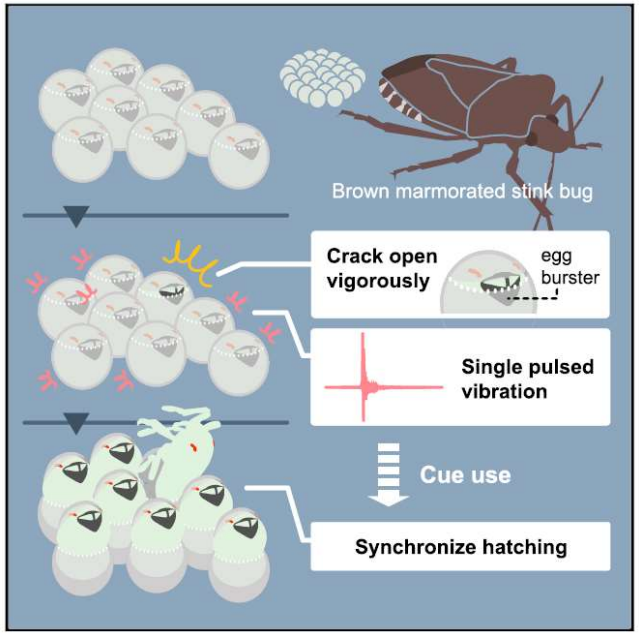
Mazzoni et al. (2009): Bull Ent Res 99

Parental Care



Brennan (2007): Ethology 113

Synchronize Egg hatching



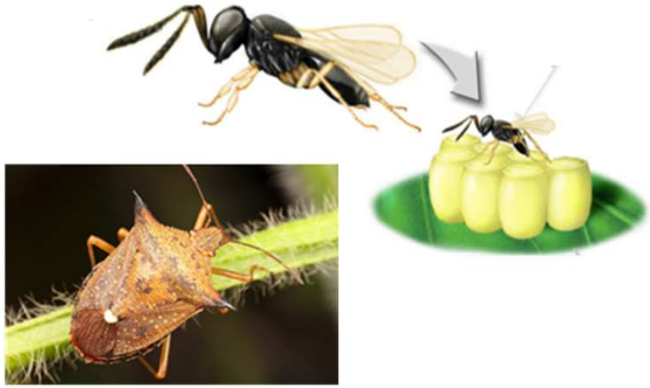
Endo et al. (2019): Curr Biol 29

SEMIOPHYSICALS: Examples of Interspecific Signals

Harmful for the Sender; **Benefit for the Receiver**

Predators eavesdropping incidental vibrations to find preys

Pfannenstiel et al. (2019):
J Insect Behav 8, 1-9



Parasitoids using specie-specific vibrations to find the Host

Laumann et al. (2011):
Anim Behav 82, 1175-1183

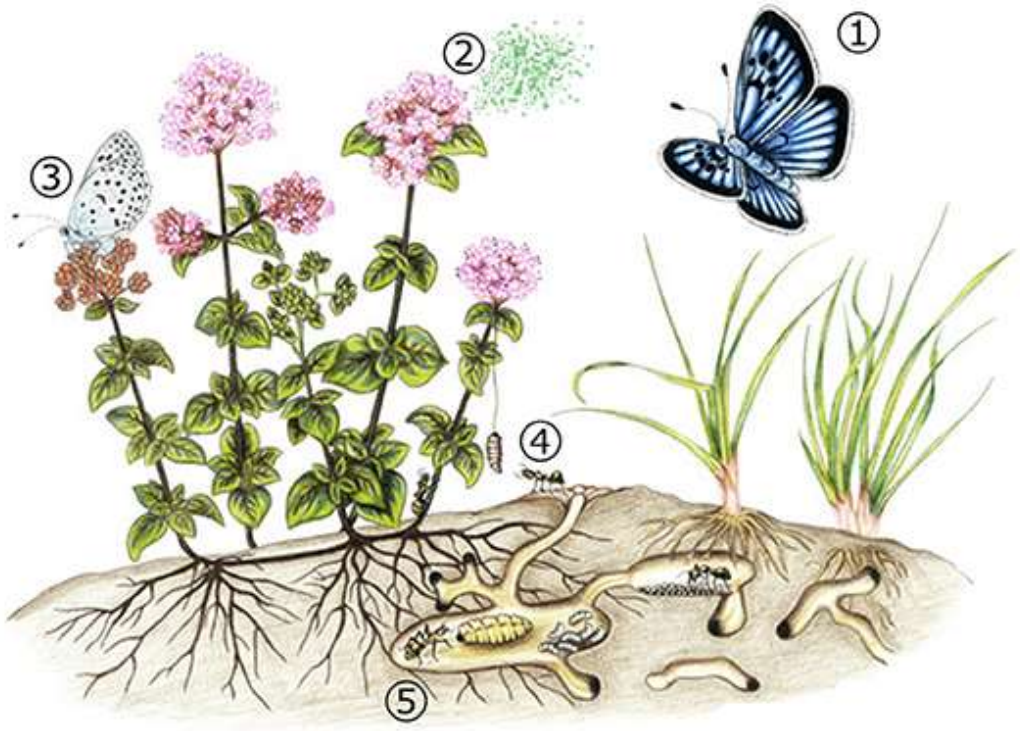
Predators using specie-specific vibrations to find the Prey

Virant-Doberlet et al. (2011):
Mol Ecol 20, 2204-2216

SEMIOPHYSICALS: Examples of Interspecific Signals

Benefit for the Sender; **Harmful for the Receiver**

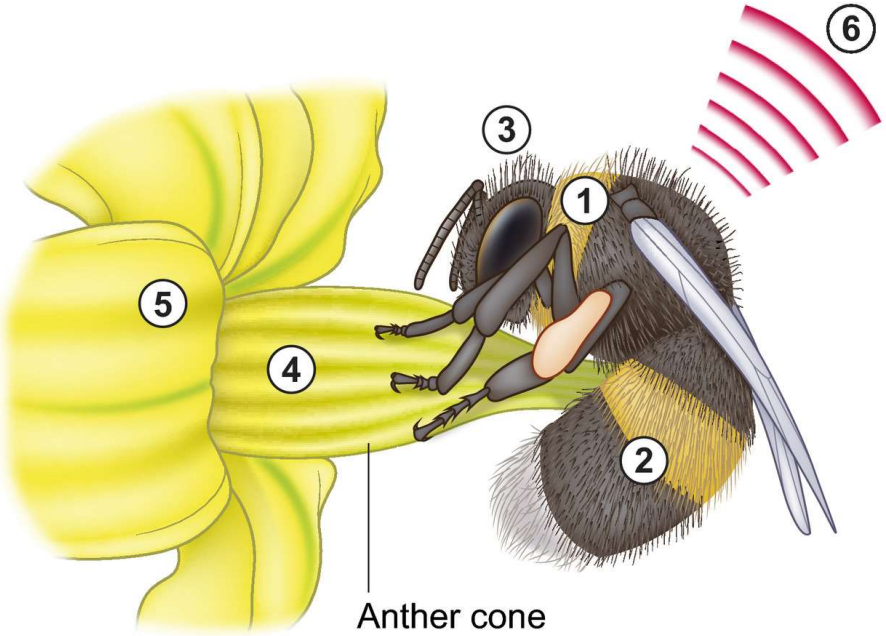
MYRMECOPHILA BUTTERFLIES



Casacci et al (2019) Front. Ecol. Evol. 29

Benefit for both Sender and Receiver

BEES and FLOWERS (Buzz Pollination)

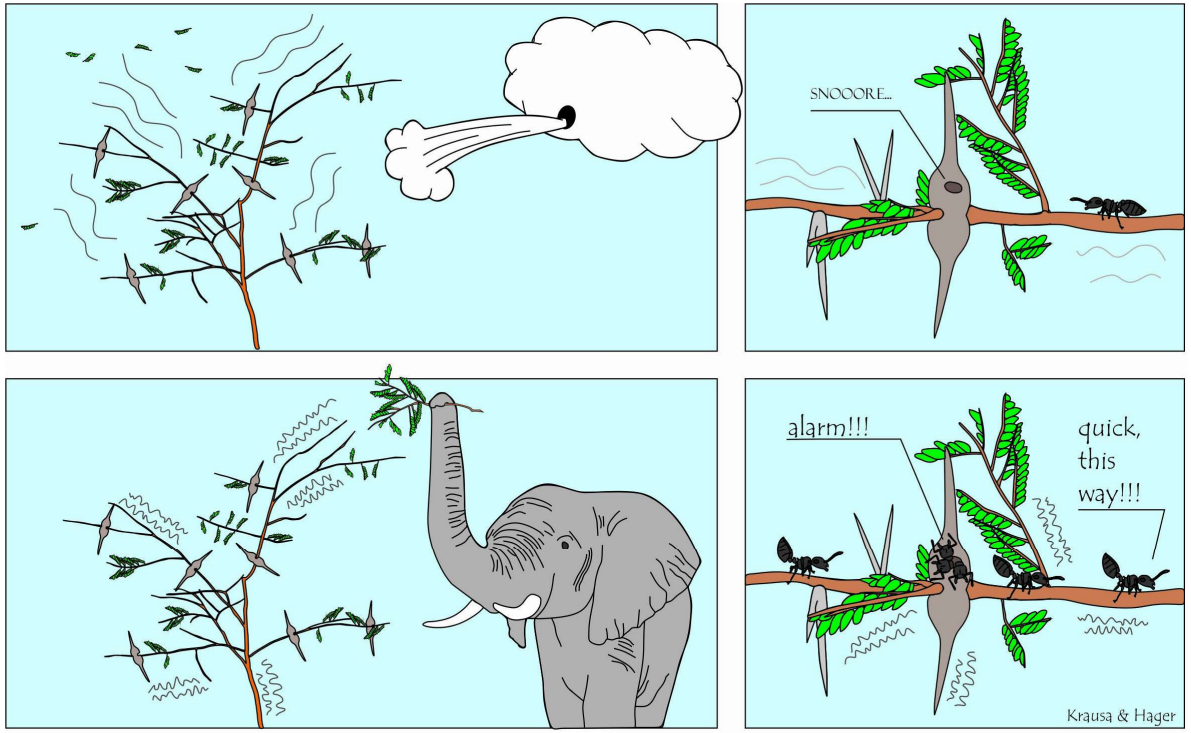


Vallejo-Marin (2018) New Phytologist 224

SEMIOPHYSICALS: Examples of Interspecific Signals

Signals with 3 actos: Benefit for 2; harmful for the third one

ANTS e ACACIA: Protection from Elephants



Hager & Krausa (2019), Curr. Biology 29

Chapter 3

Applied Biotremology

Applied Biotremology: Vibrational Mating Disruption

FONDAZIONE EDMUND MACH

Vibrational Communication mediates Mating Behavior

Nome scientifico:

Scaphoideus titanus Ball

Nome comune:

Cicalina americana della vite

Ordine: **Homoptera**

Famiglia: **Cicadellidae**

Nell'agroecosistema: **Vettore di una malattia della vite, la Flavescenza dorata**

Piante ospiti: **Vite**

Distribuzione: **America, Europa meridionale**

FONDAZIONE EDMUND MACH

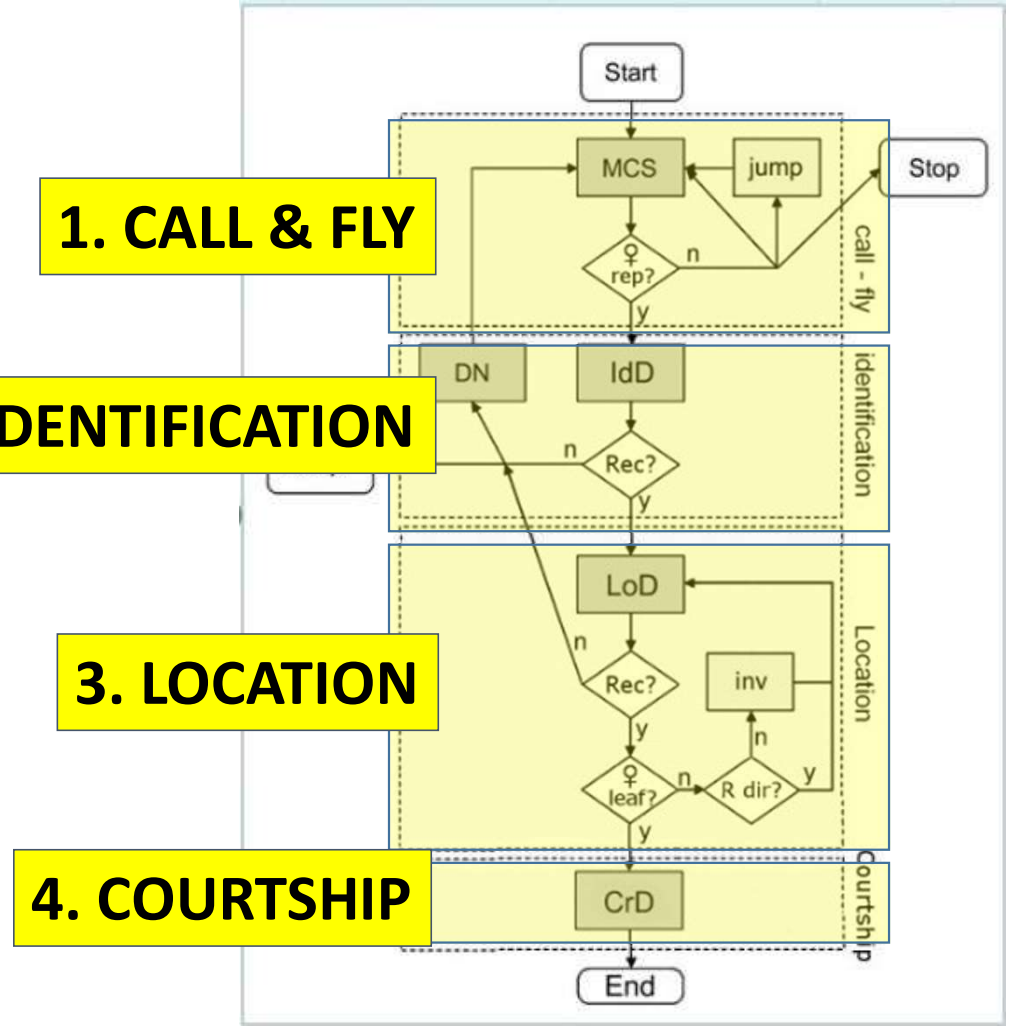
Scaphoideus titanus: Ethogram

1. Each Step is Mediated by a Phase-Specific Vibrational Duet

2. Male and Female must respect a strict Temporal Pattern

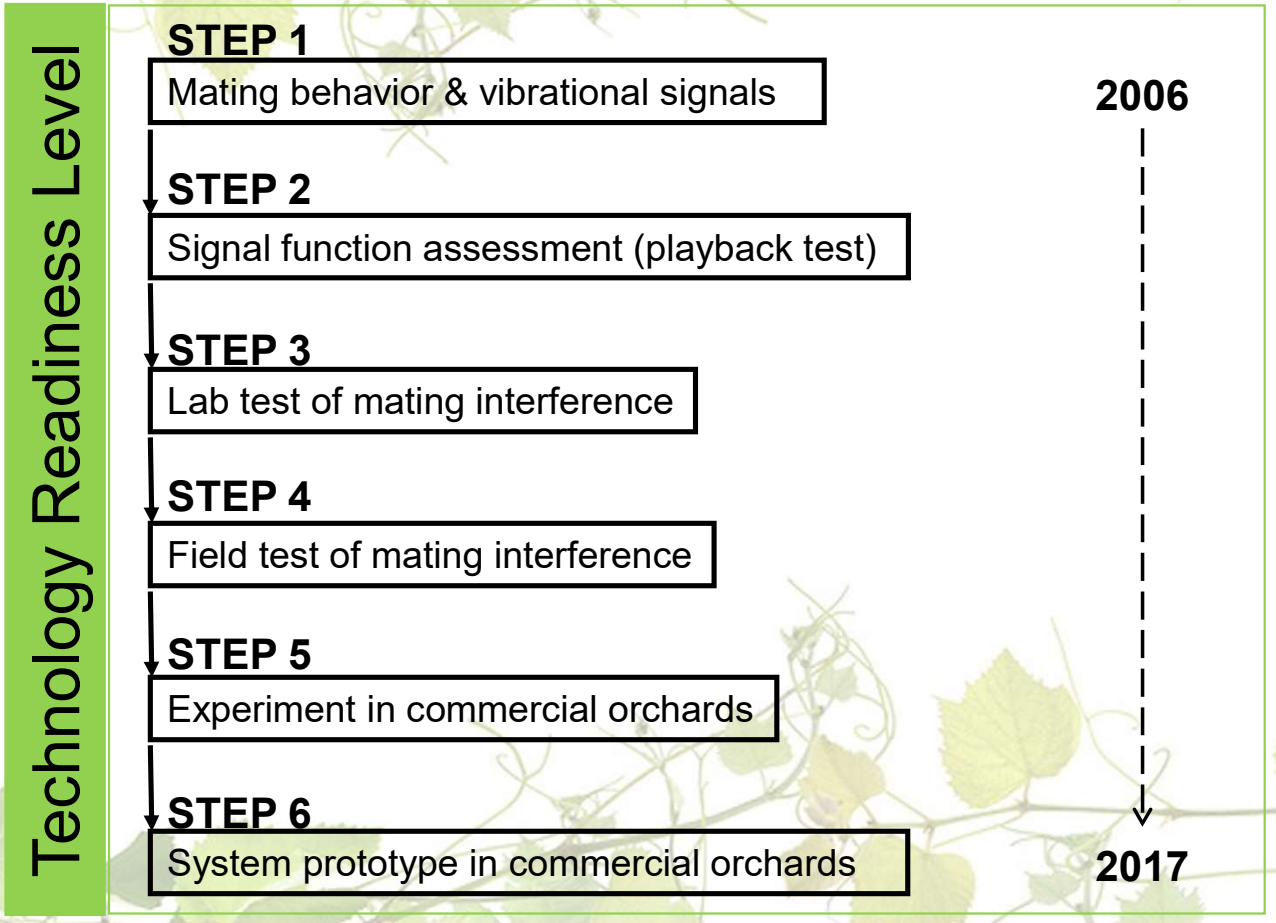
3. The temporal pattern but also the type of signals used change with the behavioral step

4. Any «mistake» causes the immediate Stop of the mating process



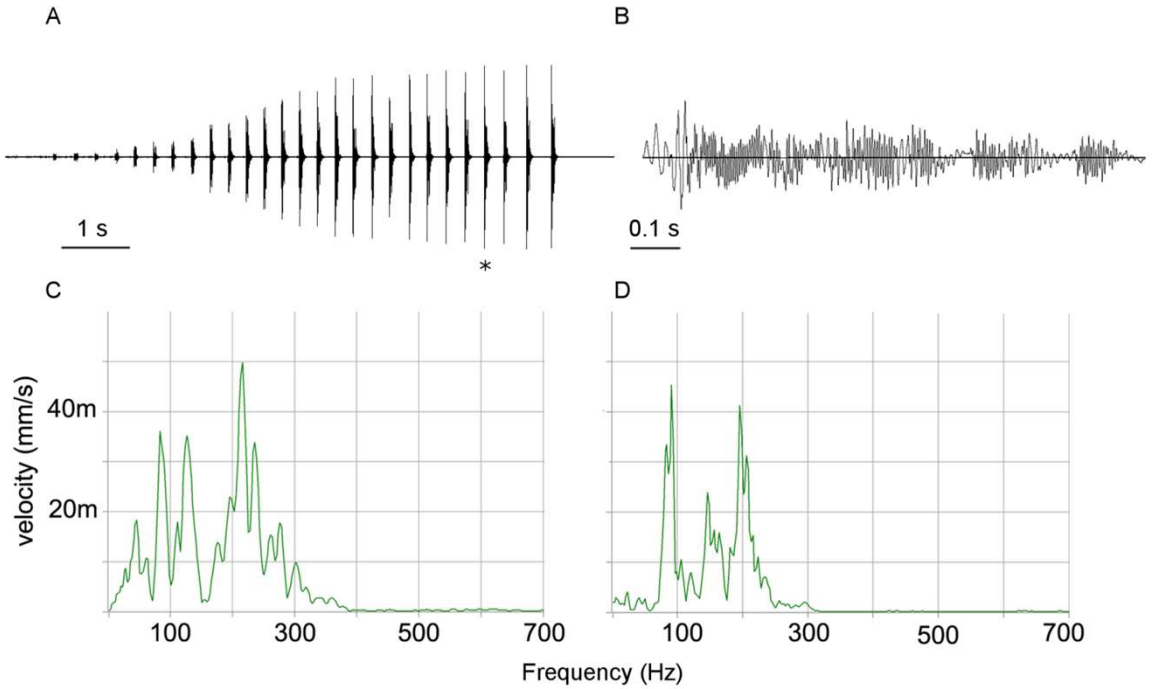
FONDAZIONE EDMUND MACH

Vibrational Mating Disruption in *Scaphoideus titanus*



FONDAZIONE EDMUND MACH

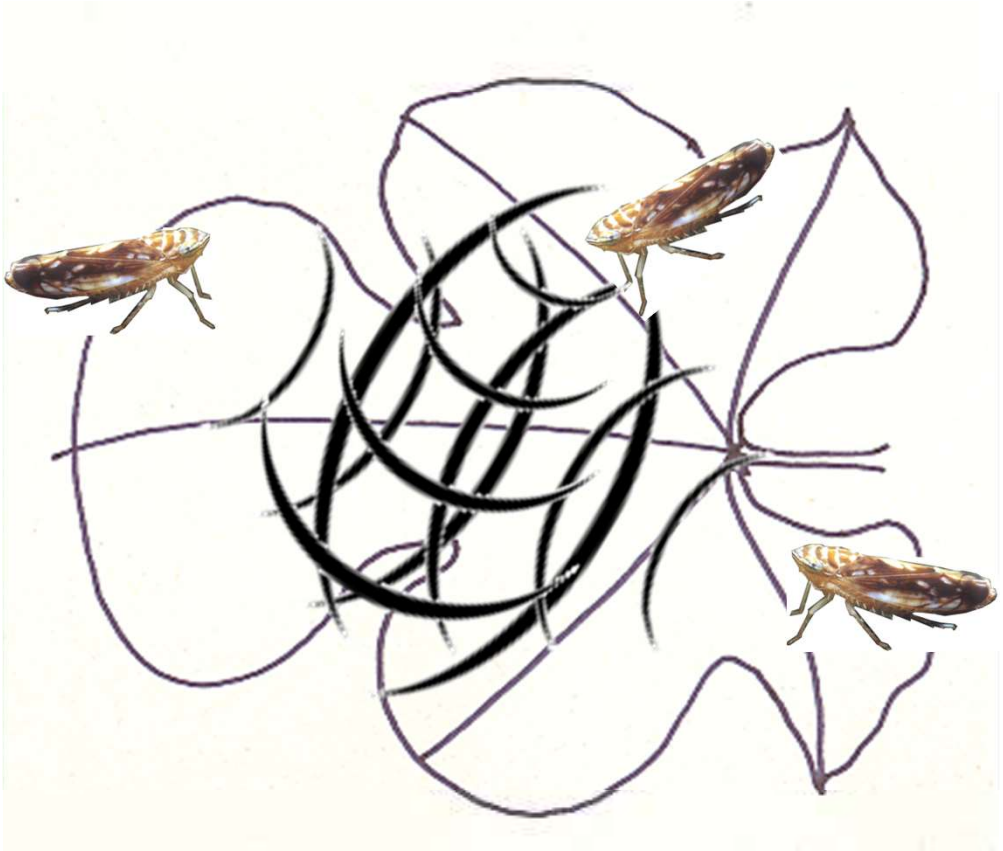
Disturbance Noise (DN)



DN

FONDAZIONE EDMUND MACH

Let’s exploit the Rivalry



FONDAZIONE EDMUND MACH

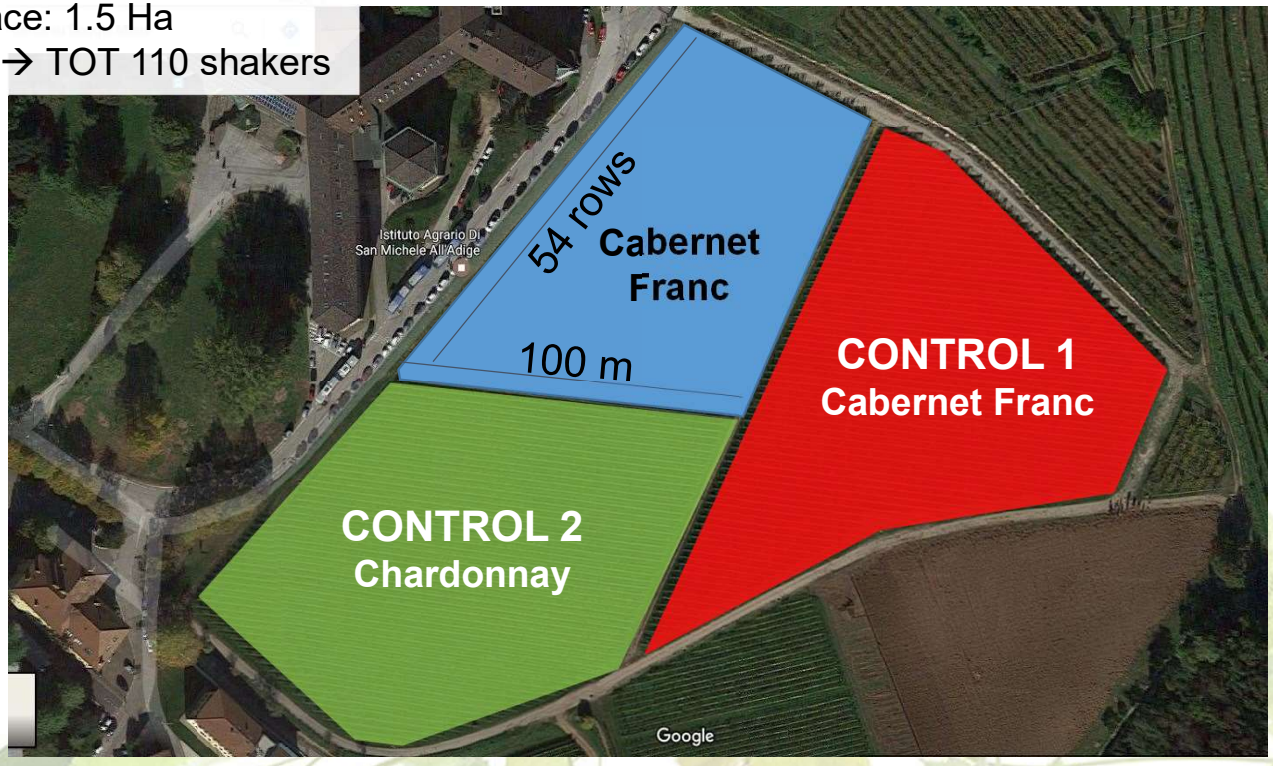
Let’s exploit the Rivalry

FONDAZIONE EDMUND MACH

The first «vibrational vineyard»

Loc: San Michele all'Adige (Italy)
Management: Organic
Guyot trellis system
Surface: 1.5 Ha
2 shakers/row → TOT 110 shakers

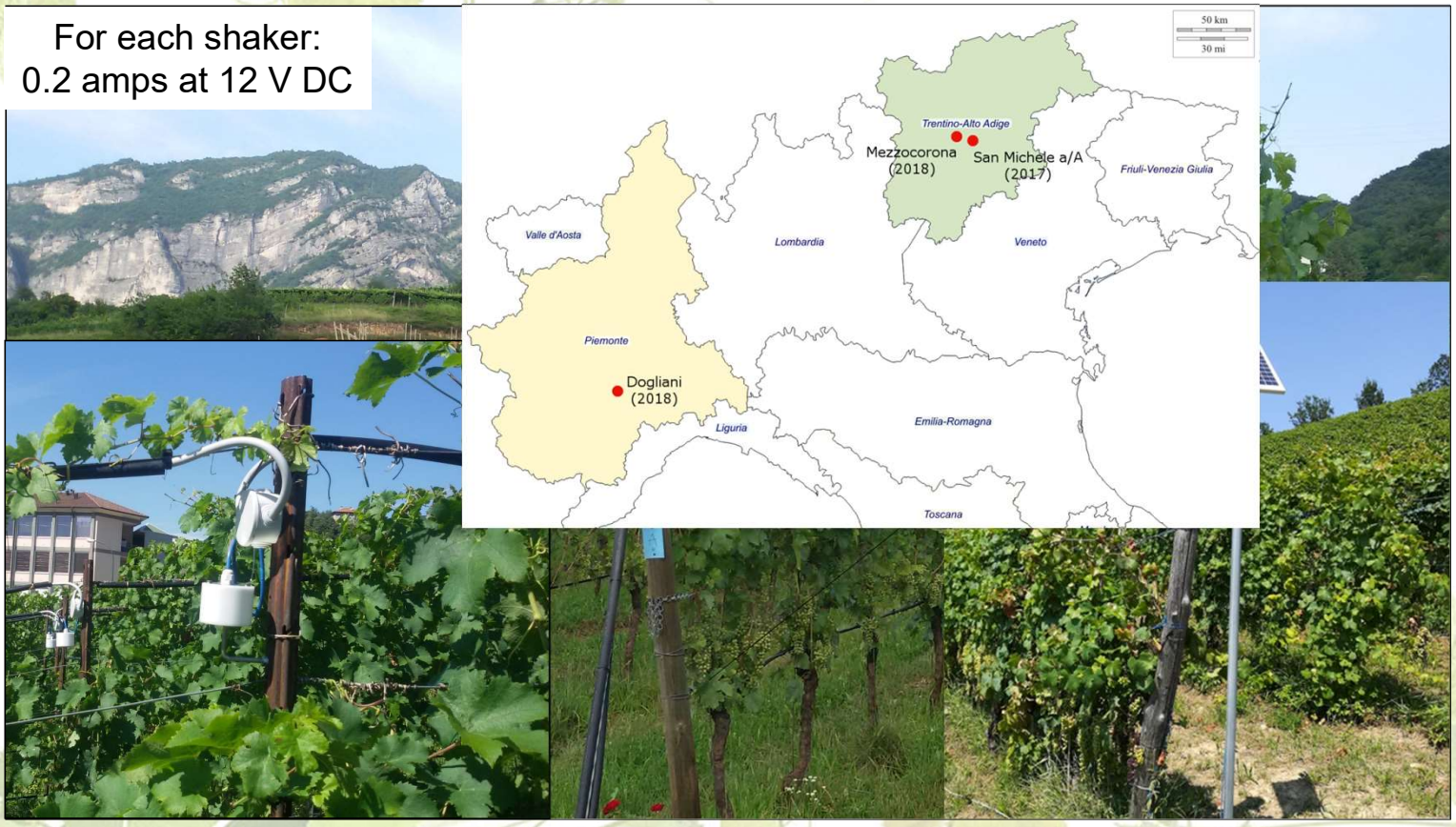
BIOGARD biological First.



FONDAZIONE EDMUND MACH

The first «vibrational vineyard»
Electrical wiring

For each shaker:
0.2 amps at 12 V DC



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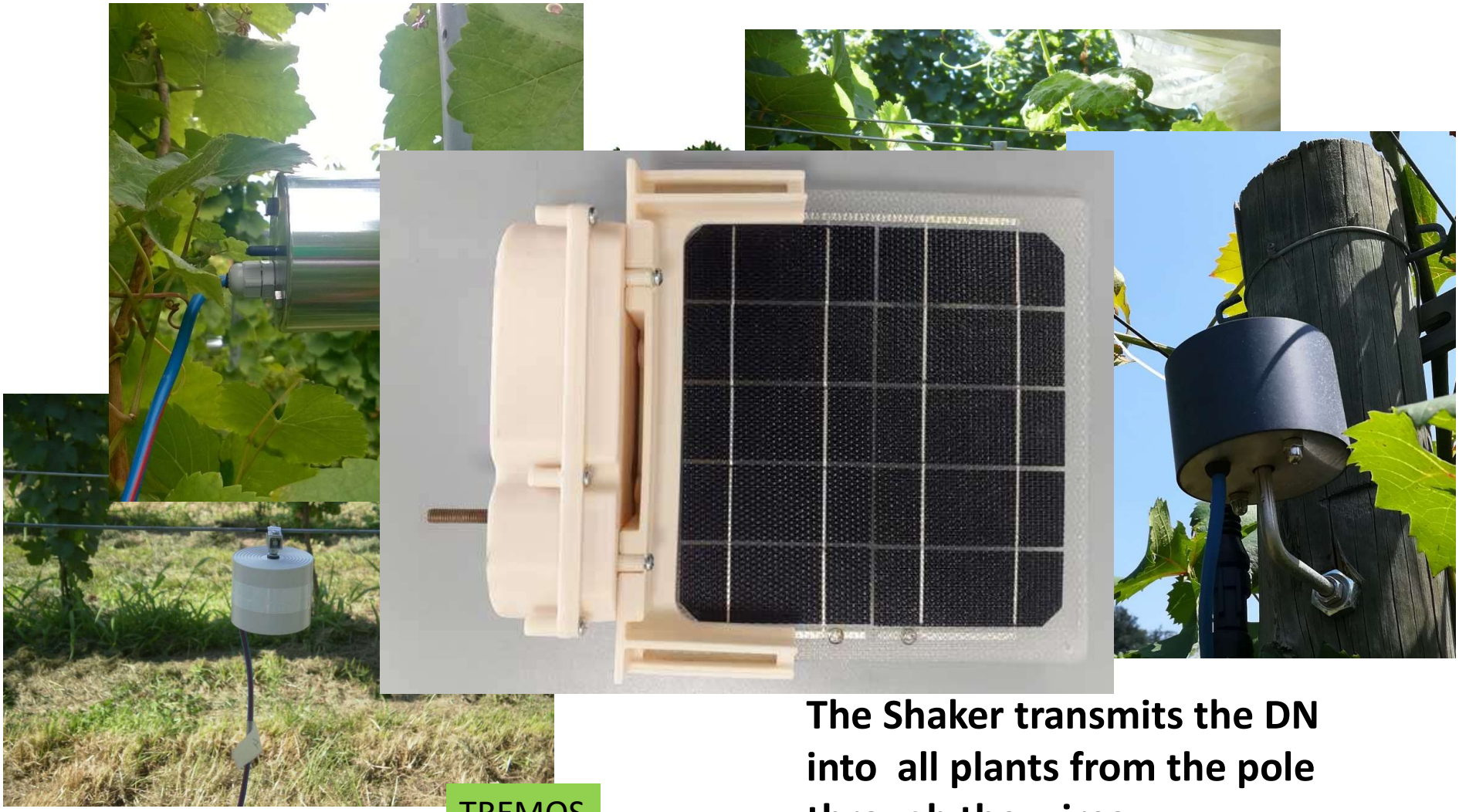
Tremos Emitter Evolution

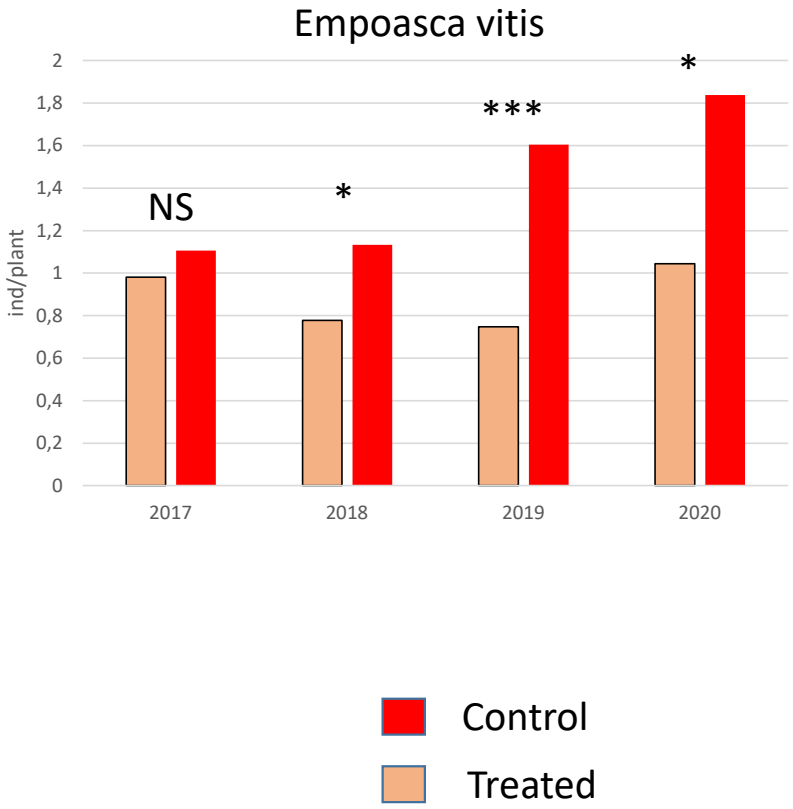


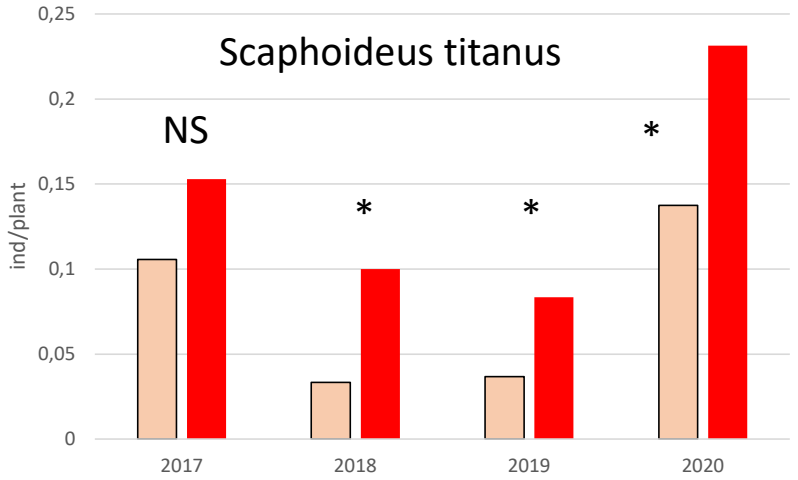
TREMOS

The Shaker transmits the DN into all plants from the pole through the wires

FONDAZIONE EDMUND MACH

Vibrational Mating Disruption (VMD)





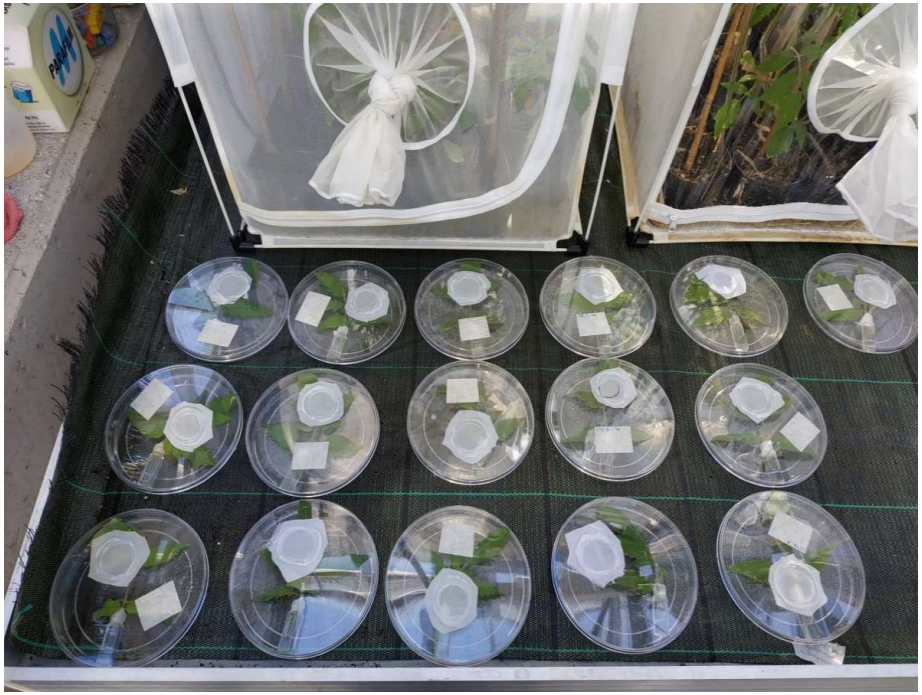
Chapter 4

Other Ongoing Research

FONDAZIONE EDMUND MACH

Applied Biotremology: Ongoing research

Whitefly in the Greenhouse (*Trialeurodes vaporariorum*)

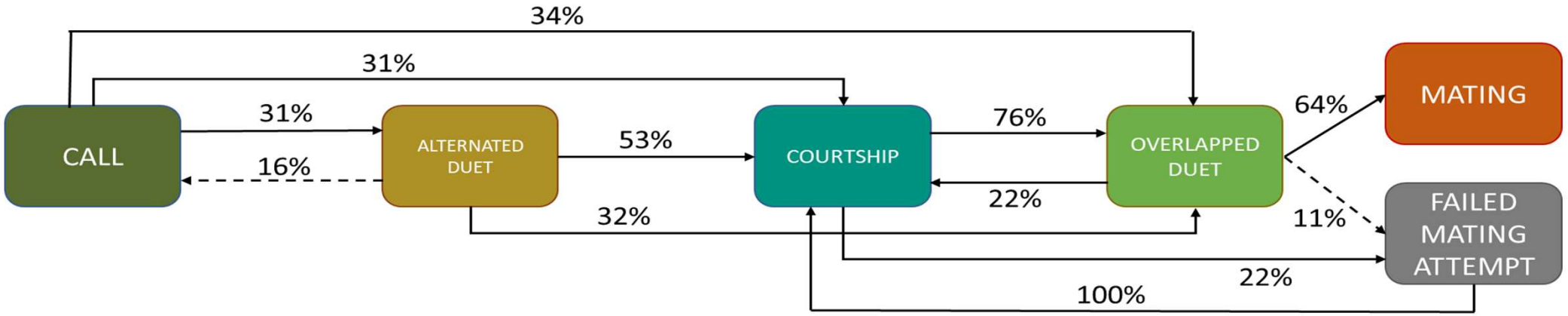


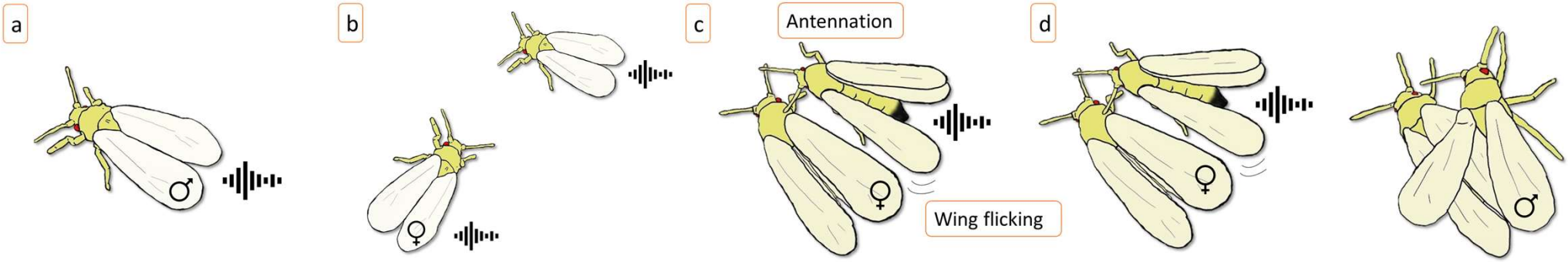
Replicates: 4 per each treatment
Mortality assessment: after 4 days

30-60/petri

FONDAZIONE EDMUND MACH

Mating Behavior: Ethogram of the Whitefly





	n	%
NO F. RESPONSE	112	71,79
FAILED	10	6,41
MATING	34	21,79
TOT.	156	100,00

Dashed lines:
nonsignificant transitions (P>0.05),
Solid lines:
significant transitions (P<0.05)
N= 38

Nome scientifico:

Trialeurodes vaporariorum Westwood

Nome comune: **Mosca bianca delle serre**

Ordine: **Homoptera**

Famiglia: **Alurodidae**

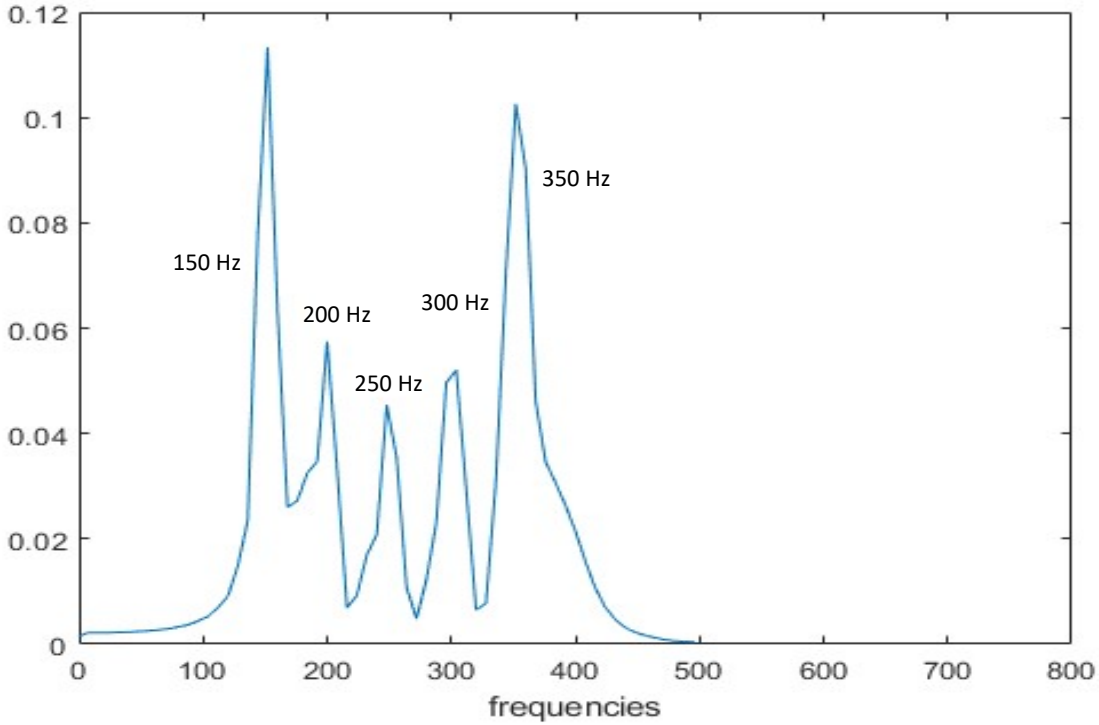
Nell'agroecosistema: **Parassita**

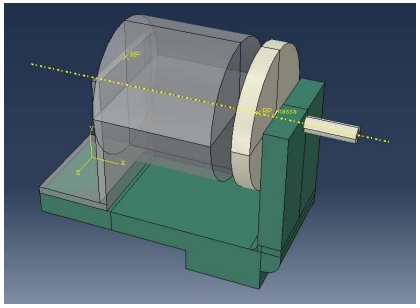
Piante ospiti: **Pomodoro, Tabacco, varie colture orticole e floricole ornamentali.**

Distribuzione: **Mondiale**

FONDAZIONE EDMUND MACH

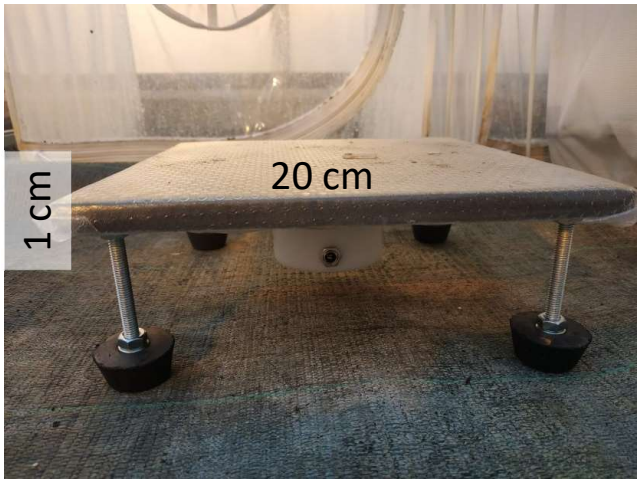
GW Playback Signal and Device





PbS Audio

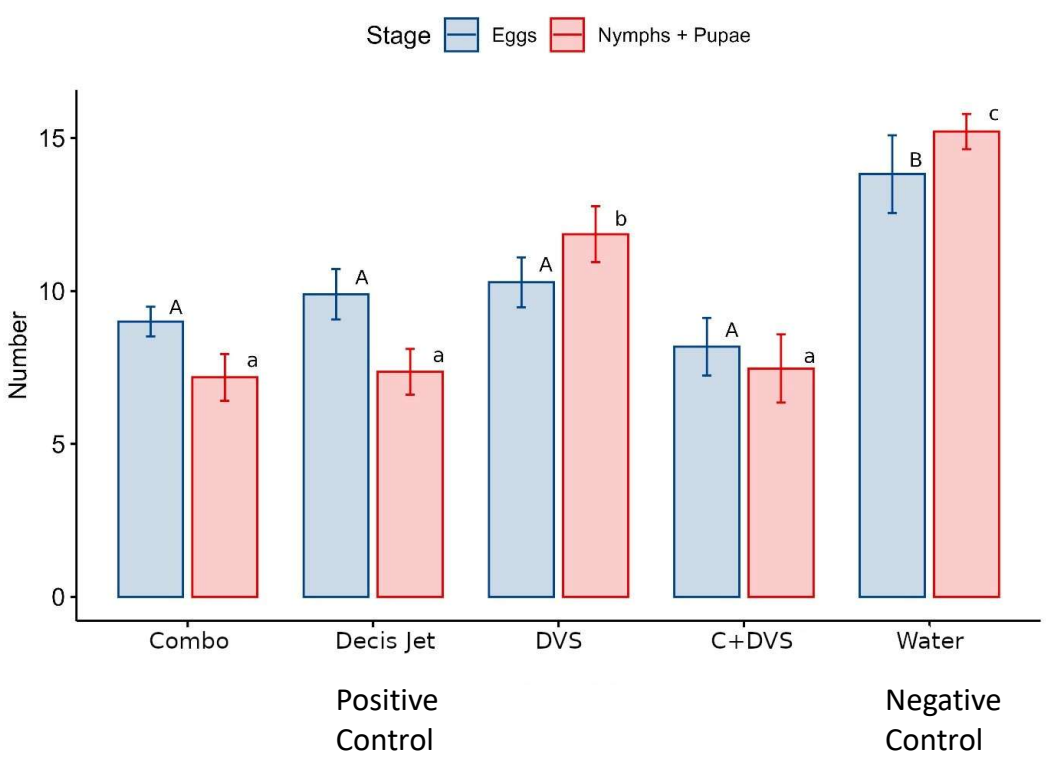
Vibro-Plate

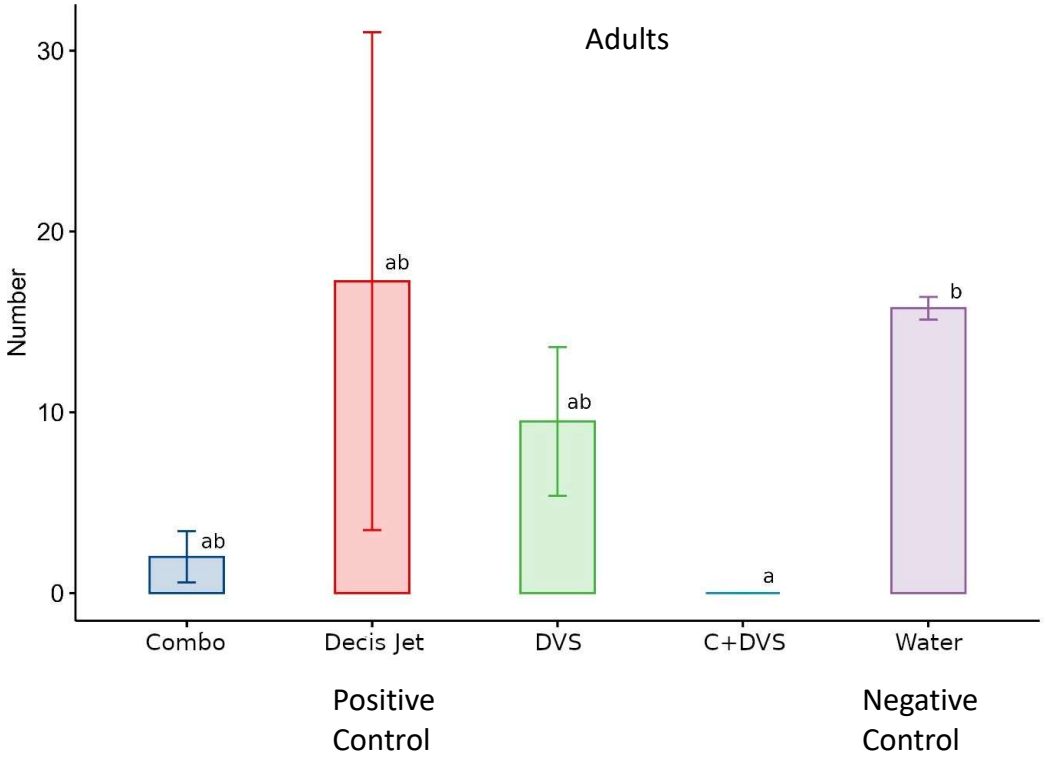


FONDAZIONE EDMUND MACH

The shaking plate/devices

Results


Stage
Eggs
Nymphs + Pupae
Number
15
10
5
0
A
a
A
a
A
b
A
a
B
c
Combo
Decis Jet
DVS
C+DVS
Water
Positive Control
Negative Control


Adults
Number
30
20
10
0
ab
ab
ab
a
b
Combo
Decis Jet
DVS
C+DVS
Water
Positive Control
Negative Control

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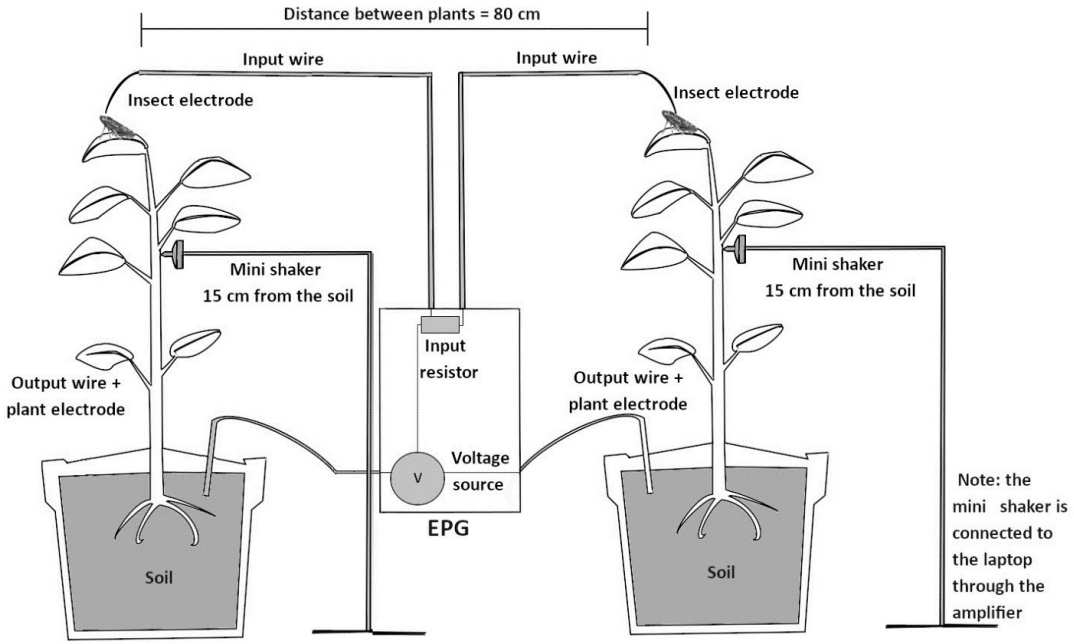
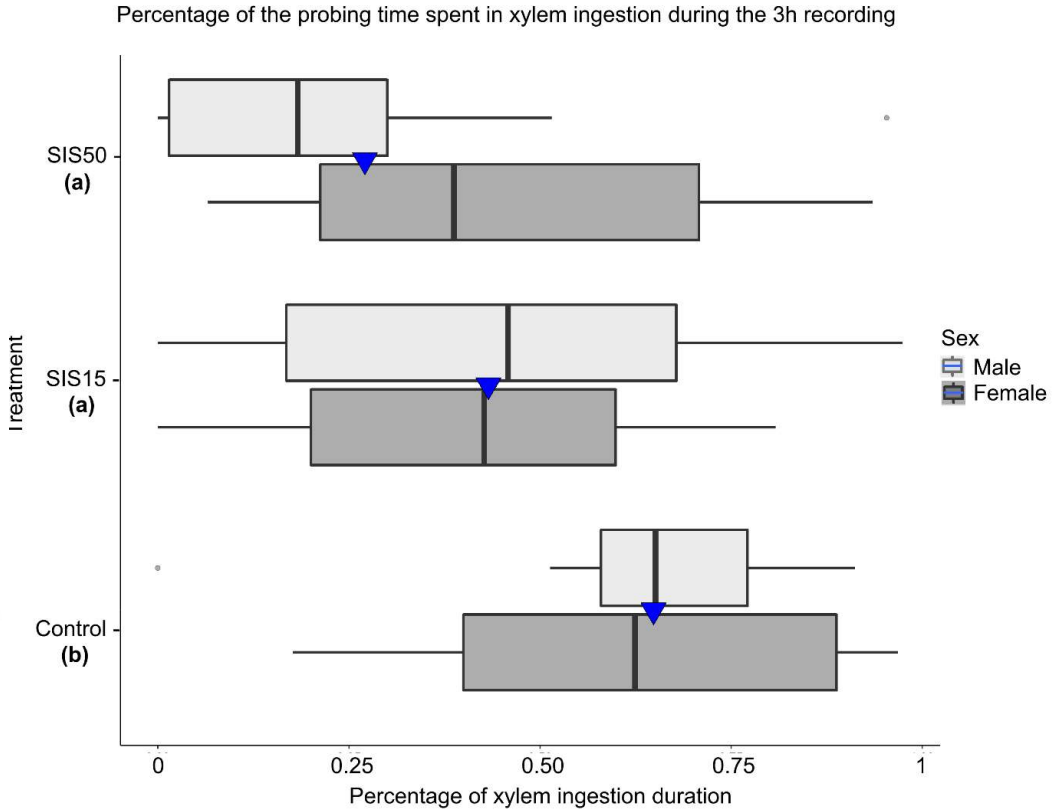
Feeding Disruption: *PHILAENUS SPUMARIUS - EPG applied to Biotremology*





Avosani et al., 2021 Entomol. Generalis (in Press)

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Cerambicidae
(T. Takanashi, Forestry and Forest Products Research Institute, Tsukuba, Japan)

Bark beetles
(R. Hofstetter, School of Forestry, Northern Arizona University, USA)

***Bactericera cockerelli**, the Potato Psyllid*
(Candidatus Liberibacter solanacearum – Zebra Chip)
(M. Suckling Plant&Food, NZ)

Diaphorina citri
the Asian Citrus Psyllids
(Dr. R. Mankin USDA-FL)

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