Food and Agriculture Organization of the United Nations

CIHEAM

DETECTION of RED PALM WEEVIL INFESTATION

Victoria Soroker

The Volcani Center,

Agricultural Research Organization,

Israel

Coauthors

University of Catania, Italy

POMPEO SUMA

ALESSANDRA LA PERGOLA

ARO, ISRAEL

AMOTS HETZRONI

YUVAL COHEN

VICTOR ALCHANATIS

YAFIT COHEN

OFRI GOLOMB

EITAN GOLDSHTEIN

Benaki Phytopathological Institute, Greece

DIMITRIS KONTODIMAS

PANOS MILONAS

Agriculture Research Center, Egypt

AEL MONEAM EL BANNA

Universitat Politècnica de València, Spain

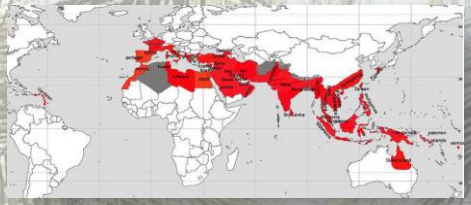
VICENTO NAVARRO LOPEZ

SANDRA VACAS

Outline

- The aims and challenges of RPW detection
- Main advances in RPW detection
  - Pros and Cons
  - Future directions

Aims and Constrains



Prevention

Introduction

Damages

At trade points

Spread

Palms are accessible for direct inspection

Monitoring

Infestation/damage levels in time & space

Treatment effectivity

In large open areas

Limited accessibility

Detection is half of the solution to RPW problem!

But is it possible to do it:

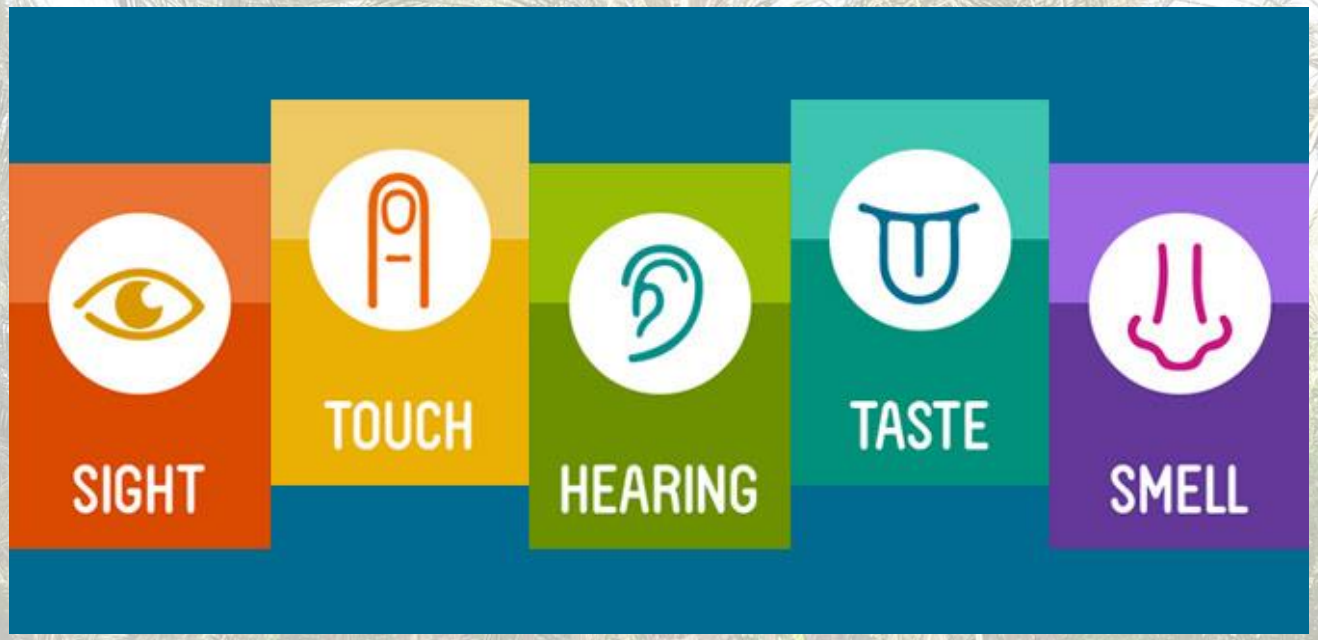
Precisely

Fast

Non-destructively

and

at affordable costs?


SIGHT
TOUCH
HEARING
TASTE
SMELL

SIGHT

Inspection of the palms for symptoms of damages and weevil presence:

- in the crown
- in the stipe
- among the offshoots
- around the palm base

TOUCH

Detection of visual symptoms of initial infestation stages

Mostly Canary palms	Holes in one or more leaves in canary palms	
	Extensive chewing symptoms of “>” shape	
	No new inner leaves	
Mostly date palms	Oozing holes in the stipe in date palm	
	Dry offshoot/s in date palms	

Shortcomings of direct visual detection

Detection of early infestation stages is impossible especially in date palms

Sensitivity and specificity are low

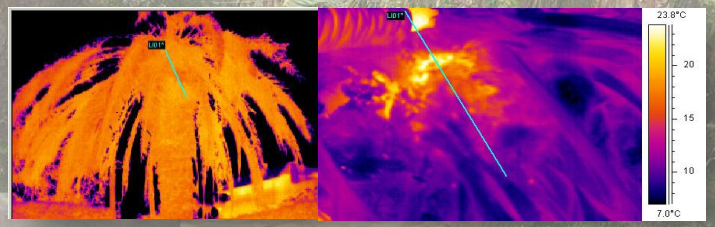
Unreliable, unless combined with other means!!!

Kontodimas et al., 2017

VISUAL/THERMAL IMAGING DETECTION

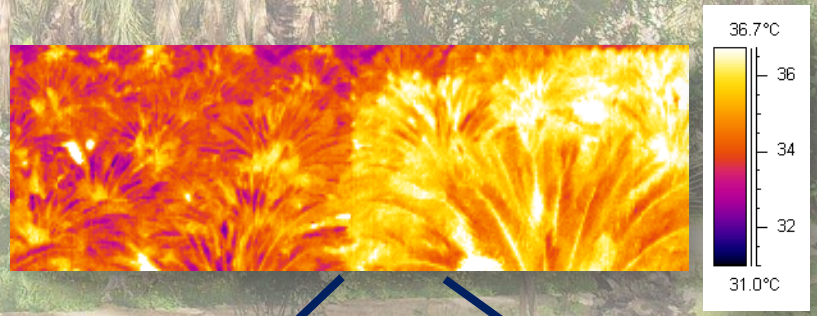
Direct effects of the weevil activity

RPW larvae create tissue fermentation raising trunk temperature up to 45oC



Indirect effects of the weevil activity

RPW larvae chew the fronds' bases or palm stem, reduce water availability in the fronds (water stress)

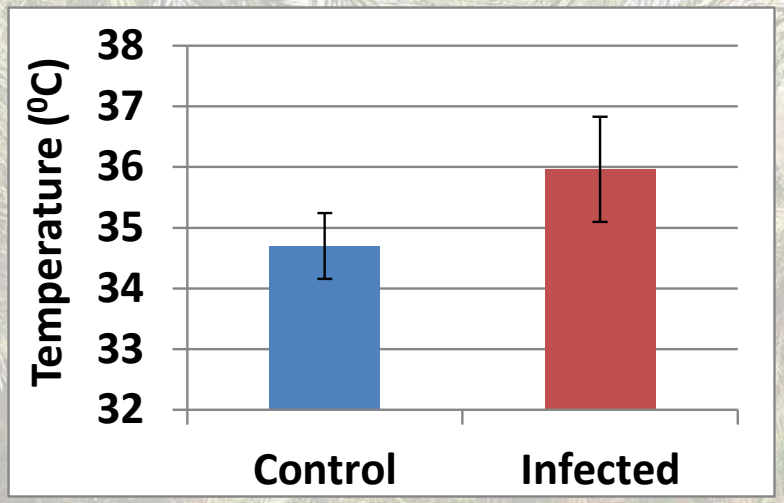


Decrease in stomatal conductance

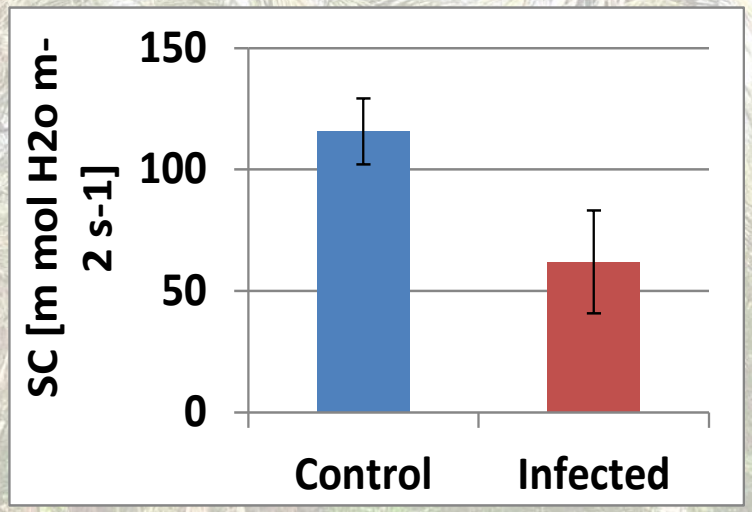
Increase in leaf temperature

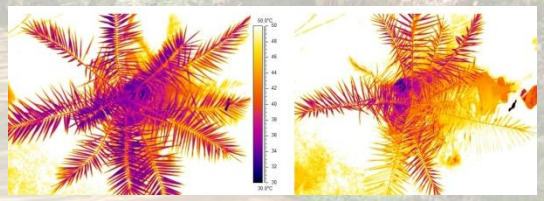
Thermal detection of infested Canary palms in quarantine

Temperature



Stomatal conductance



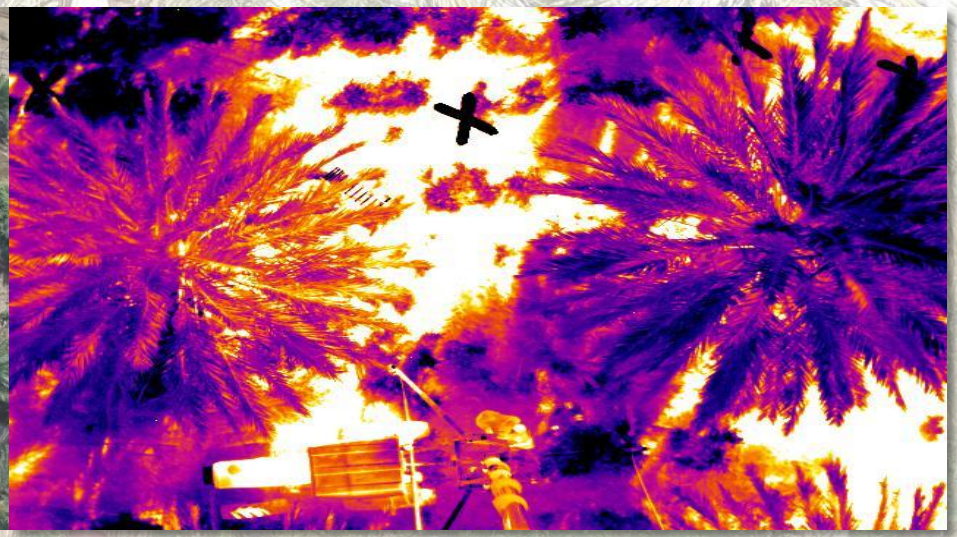


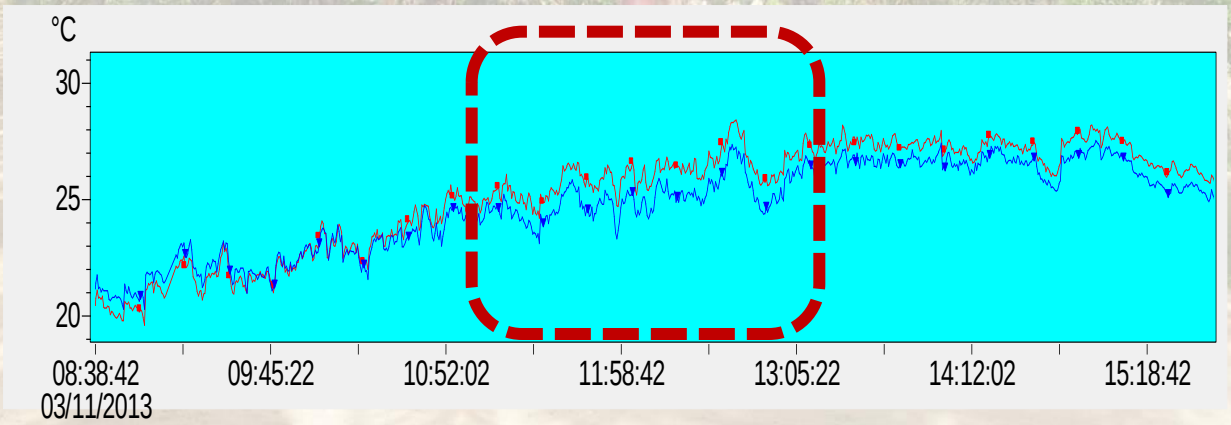
41 days PI

Thermal detection in plantation

RGB image

Thermal image

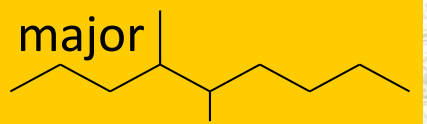




Traps are inspector's eyes!

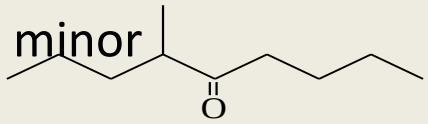
Aggelakopoulos *et al.*, 2012;
El Sebay, 2003;
Faleiro, 2006;
Nardi et al., 2011
Roda et al., 2011
Soroker et al. 2005; 2017

Ferrugineol-major



4-methyl-5-nonanol

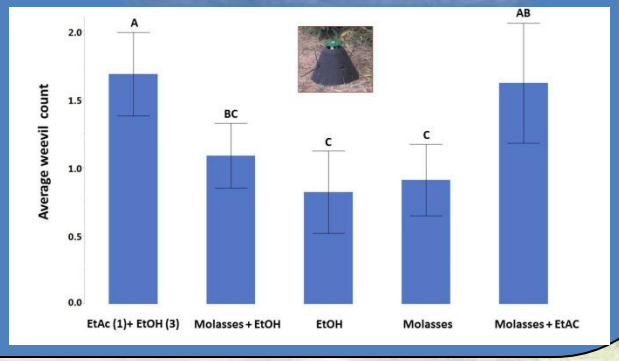
Ferrugineone - minor



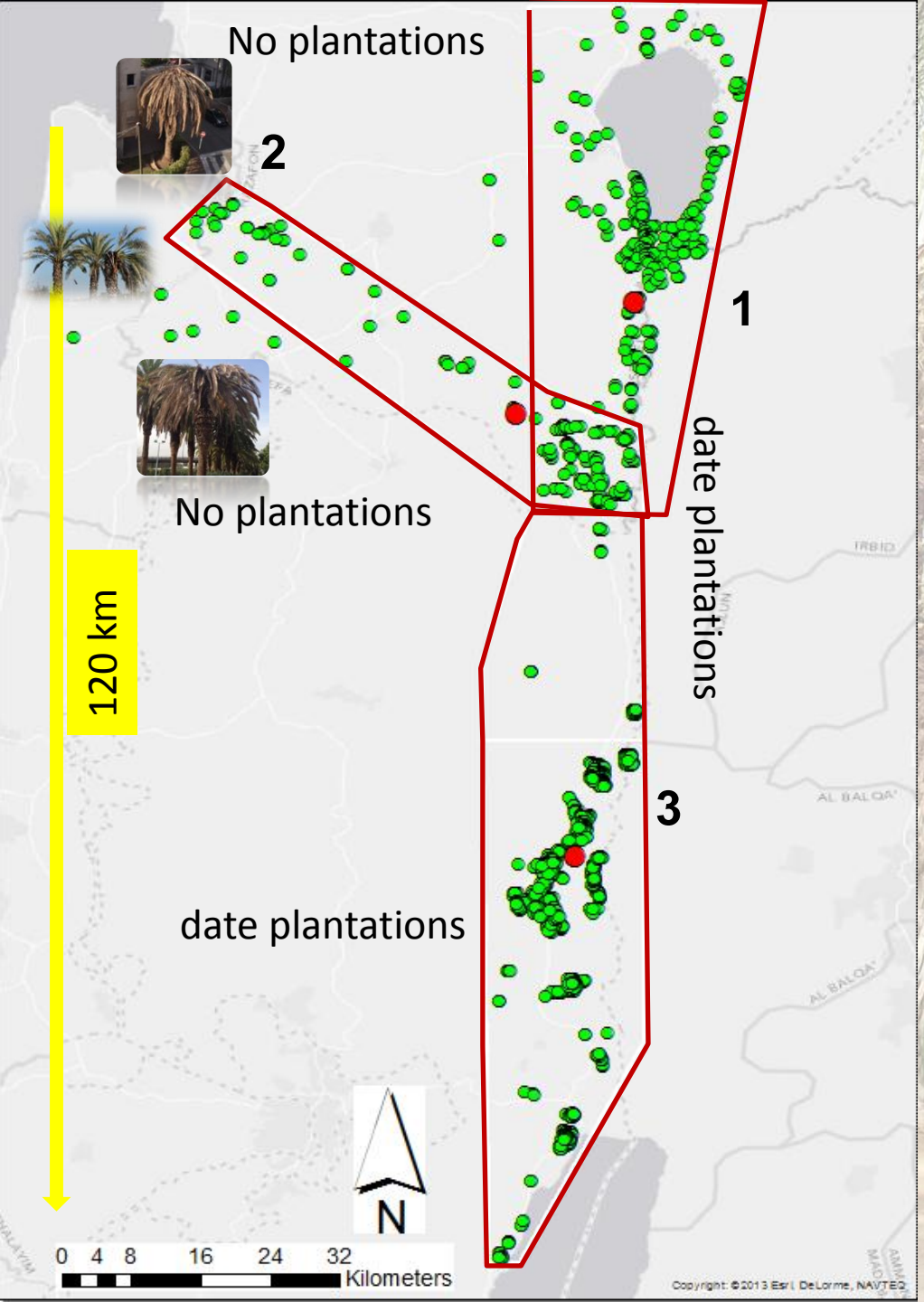
4-methyl-5-nonanone

Ferrugineol 4–5mg /day
+ ethyl acetate:ethanol (1:3) or ethyl acetate and sugar molasses
+ water;

Vacas et al..,2015



Vacas et al., 2016 Pest management science



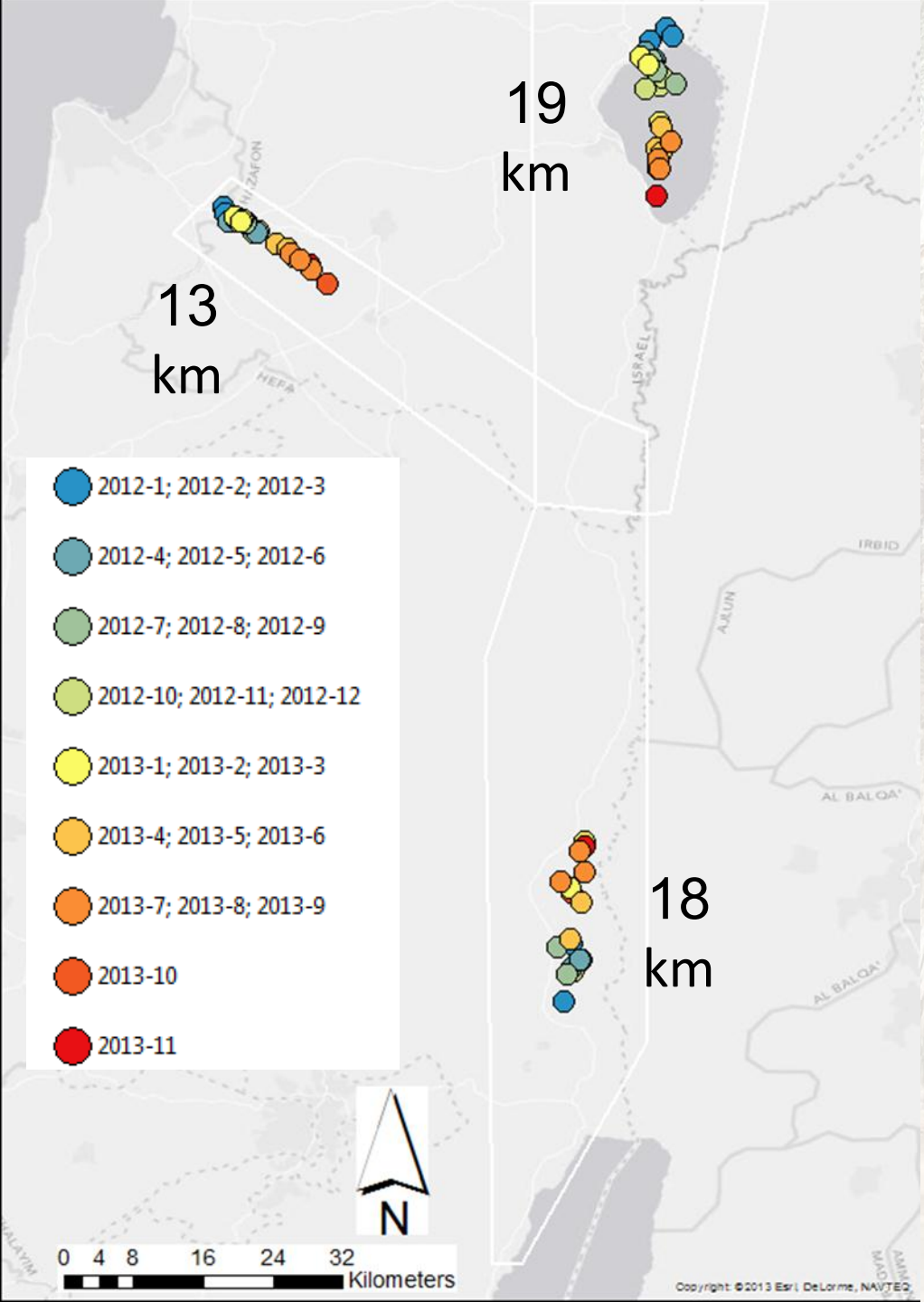
Monitoring dispersion

Data collection

- 1059 Traps
- Monitoring 1-2 times per month
- (22 month, 01/2012 and 11/2013)

Data analysis

- % of catching traps
- number of RPW trapped per trap
- geographical center

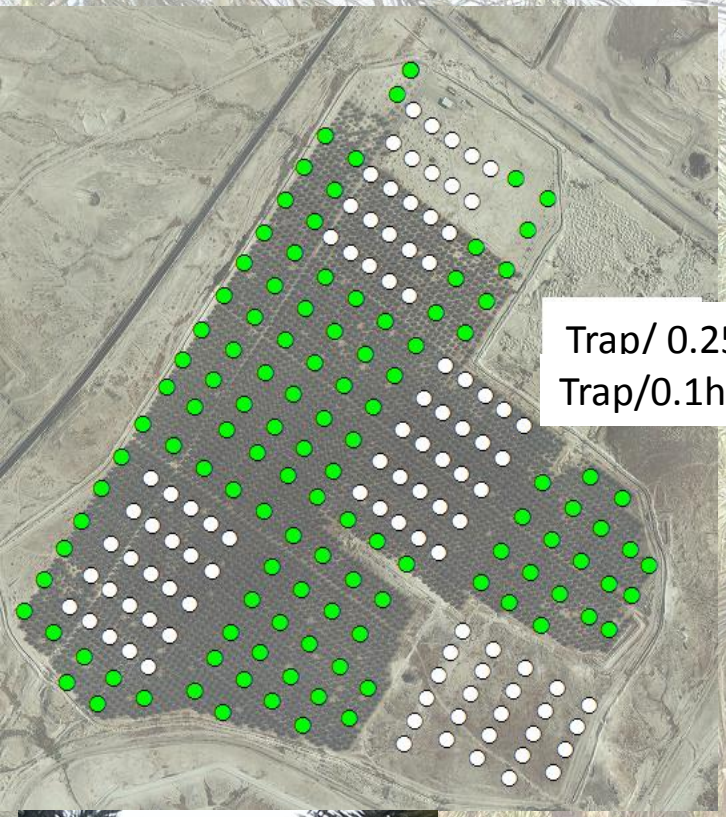


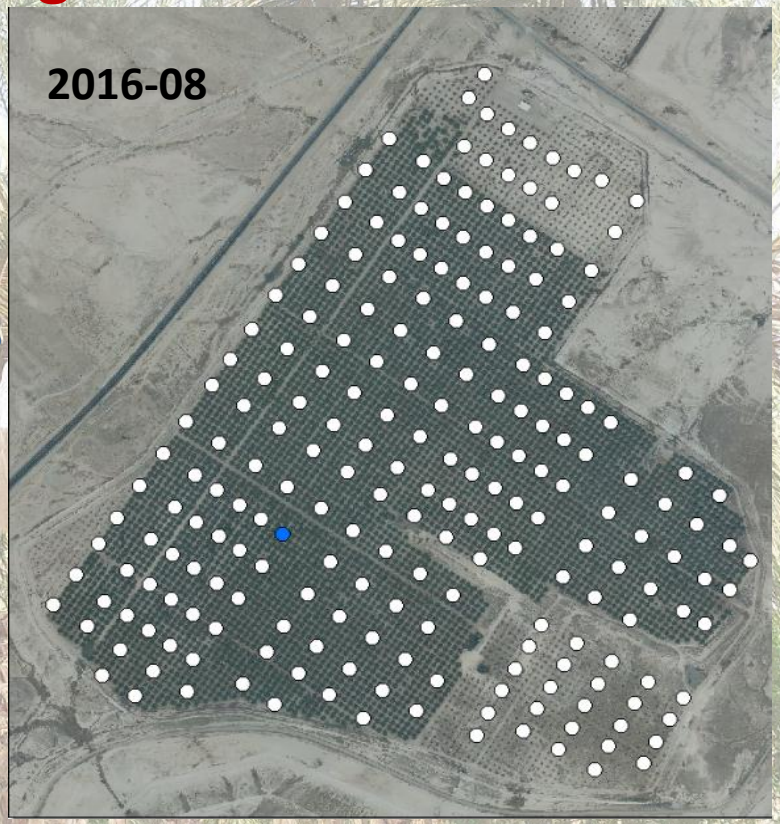
Mapping temporal changes in geographical center of catching traps

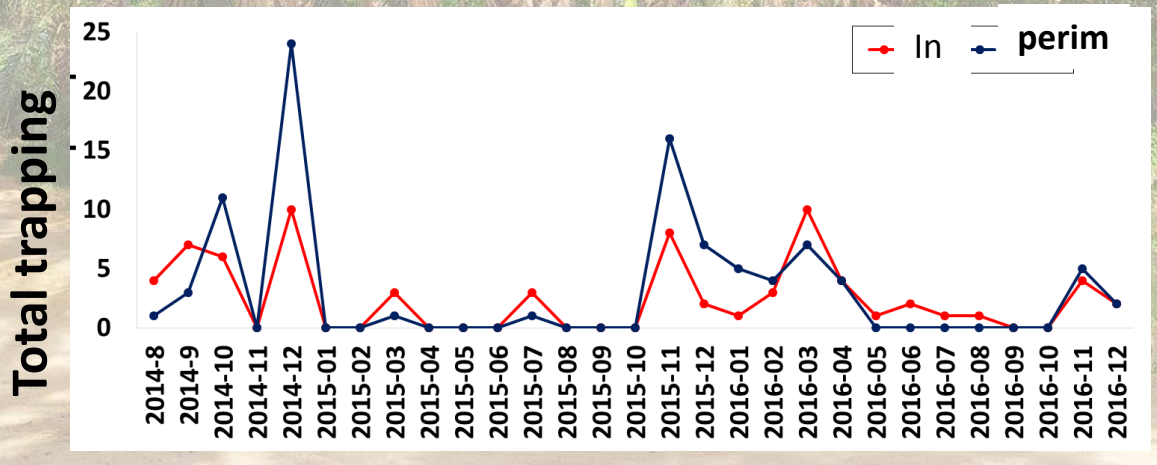
blue & green – 2012's

yellow & red – 2013's

Monitoring in organic orchard







How many traps to set?

- The potential area covered by each trap is still unknown.

- Geostatistical analysis of trapping distribution and abundance suggested for monitoring:
  - In date palm plantation: 1 trap per 0.35 ha (60X60m)
  - In urban areas: 1 trap per 0.5 ha

Chemical detection

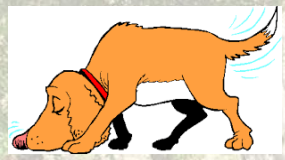
Rational:

Weevil infested palms emit characteristic volatile cues

The sources of the volatile cues

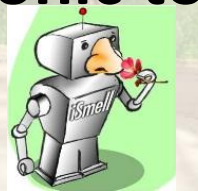
Palm tissue	weevils	weevil's frass
wound or weevil induced		

Sniffer dogs



Electronic nose

Electronic tongue



Littardi *et al.* 2013; Rizzolo *et al.* 2013

Nakache et al., 2000; Suma et al, 2013

Sniffer dogs at work

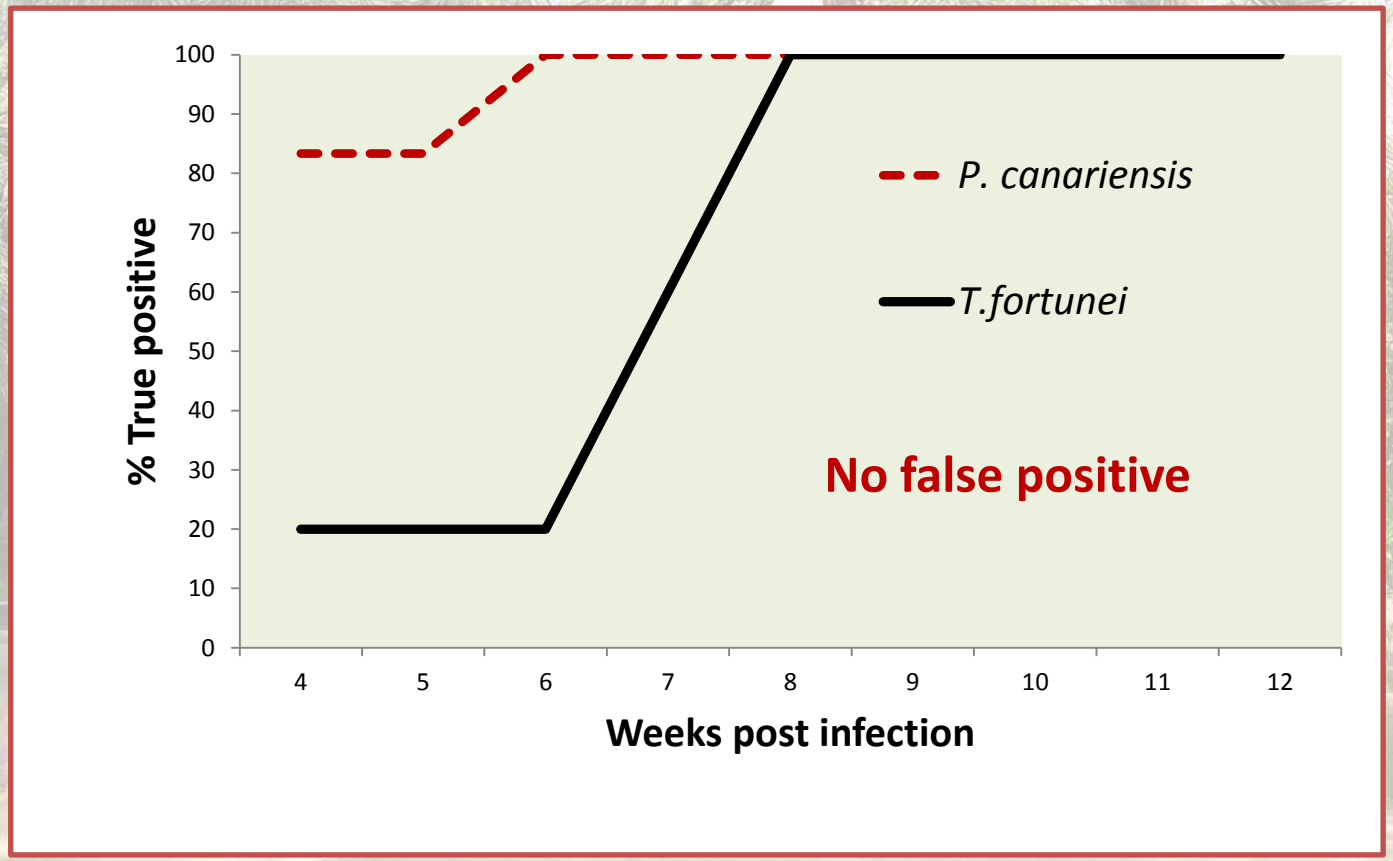
The ability Labrador Retriever to discriminate between Canary palms infested with one young RPW larva and uninfested palms

Response categories	Time interval after infestation (hours)			
	2 h	24 h	48 h	120 h
TP	**90%**	77%	90%	87%
FN	10%	23%	10%	13%
FP	2%	1%	1%	0%
TN	**98%**	99%	99%	100%

True positive (TP); False negative (FN); False positive (FP); True negative (TN)

Dog detection precision in different the palm species

Phoenix canariencis and Trachycarpus fortunei



Detection is specific

On leash

Potted palm trees / Plastic pots

Free search

Rice weevil *Sitophilus oryzae*

Indian meal moth *Plodia interpunctella*

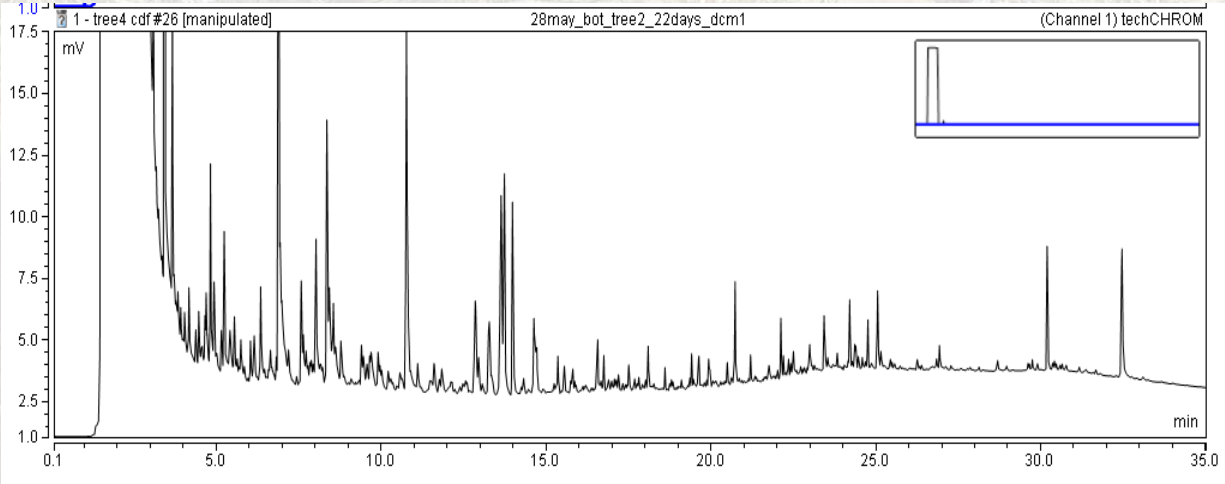
Rusty grain beetle *Criptolestes ferrugineus*

Scents- station tested

response categories	accuracy (%)
TP	100%
FN	0%
FP	10%
TN	90%

A few open questions:

- What are the specific chemical cues emitted by RPW infested palms?
- What are the cues the trained dogs use to identify the infested palm?



- From what distance the infestation can be chemically detected ?

Acoustic detection

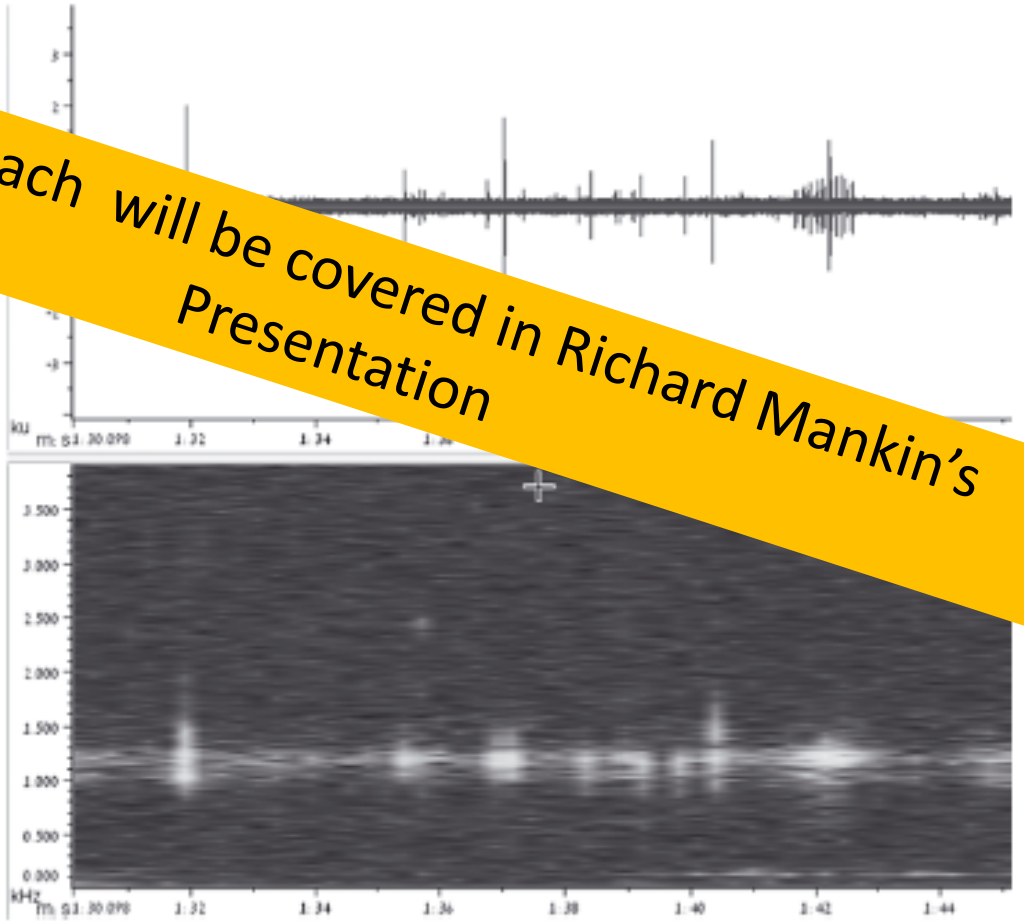
This approach will be covered in Richard Mankin's Presentation

a. Y

- move
- secreting
- spinning

b. Palm-derived:

- Air bubbles
- Water movement
- Fiber friction
- Tear of fibers



Typical acoustic signal acquired from RPW-infested palm tree. Top: signal energy (kU – signal intensity); bottom: signal frequency (kHz); horizontal axis: time (s)

Pos and Cons of main detection techniques

Parameter	Acoustic	Olfactory-trained dogs	Thermal remote sensing & GIS	Monitoring traps
Individual examination	Required	Required	Not necessary	Required
Special equipment	Yes	Trained dog	Yes (not yet operational)	and lures
Labor	Low if automated	Medium	Low if automated	Medium
Trained labor	No	Yes	Yes	Not much
Sensitivity	80–95% under controlled environment	64–75% Depends on breed and training	Still unknown	High
Cost	Affordable	Affordable	Not yet	Affordable
Suitability	**Quarantine** Open areas	Mostly for local detection	Open areas	Quarantine and open areas

More considerations:

Means	Preferable techniques for detection of :			
	Infestation risk assessment (early detection) **Area wide**	Active infestation **Area wide**	RPW damaged palm	palm with active RPW infestation
Traps	+	+	+?	+?
Manual visual inspection	+?	+	+	--
Thermal	+?	+?	+	–
Dogs	–	+?	+	+?
Acoustic	–	+?	+	+

Summary & Conclusions about detection tools

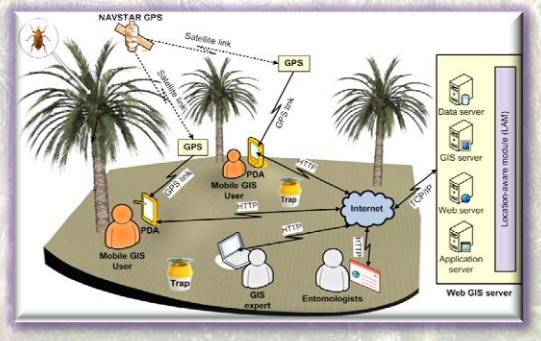
Quarantine detection

Acoustics and trained dogs currently appear to be the preferred means for early detection of RPW in quarantine and are also applicable to other quarantine borers

But traps are also vital for general assessment of infestation risk at quarantine area!

Area wide detection

1. Baited traps are still an essential monitoring tool
2. Regular visual monitoring is essential
3. Systematic GIS linked data collection is indispensable



http://gis.agri.gov.il/mobile

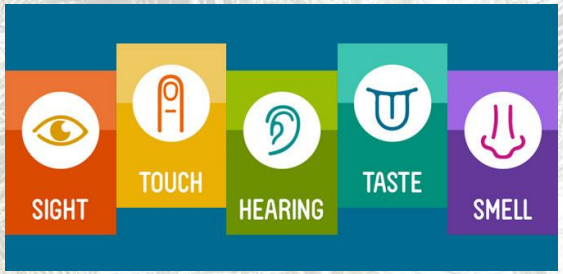
C-plas phoenix©

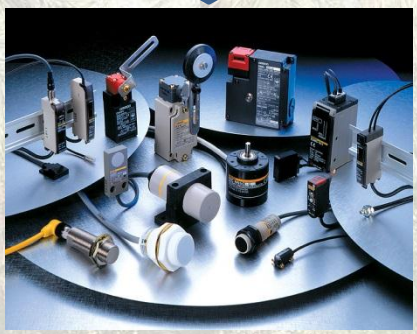
Pontikakos et al, 2017

4. Thermal imaging detection of palm damage symptoms is feasible, yet the methodology is still at initial stages of development.

Future challenges

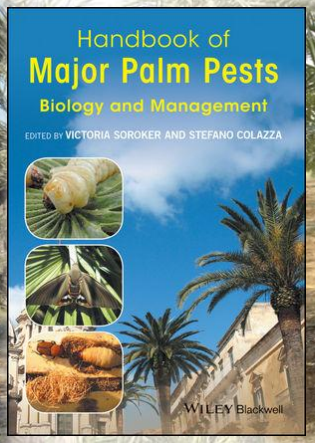
- Automatic detection by reliable & affordable electronic equipment.
- Aerial and satellite area wide detection.
- GIS and Cloud technologies operating info from a number of sensors for risk assessment at real time.





Acknowledgments

Members of EU project “Palm Protect”



"Q-detect"

Funding sources:

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SEVENTH FRAMEWORK

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SALVATORE GUARINO

EZIO PERI

Benaki Phytopathological Institute, Greece

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Thank you for the attention!!!