Biology, Invasion Ecology, and Management of Palm Weevils

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Presentation Overview

- **What will we talk about?**
  - **Introduction to red palm weevil**
    - **The problem**
    - **Distribution**
    - **Life Cycle**
  - **RPW flight and dispersal capabilities**
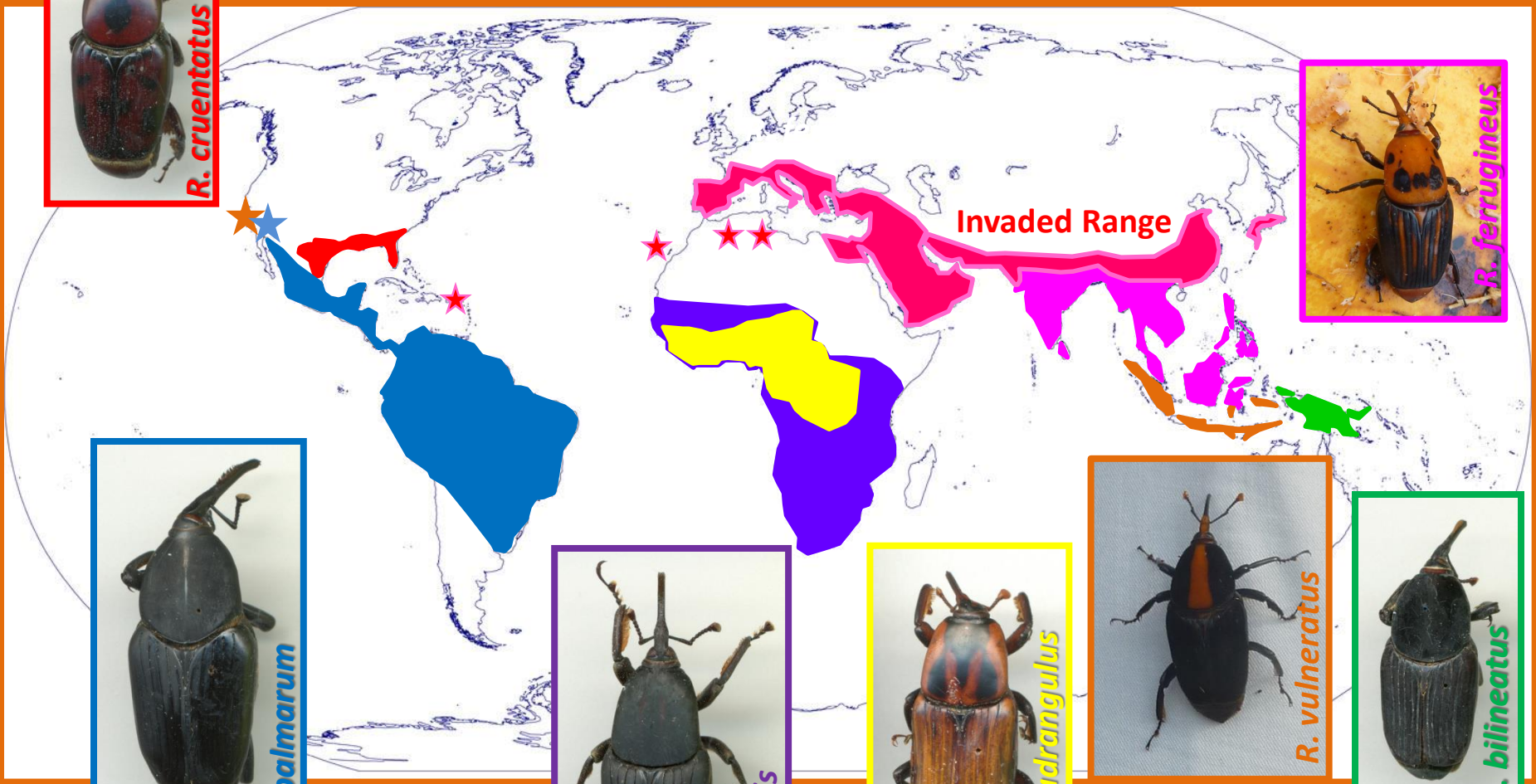 - **Monitoring and Control**
    - **Pheromone traps**
    - **Pesticides**
    - **Eradication**
  - **South American palm weevil invasion in California**
  - **Conclusions**

Global Distribution of *Rhynchophorus* spp.

R. cruentatus

R. ferrugineus

Invaded Range

R. palmarum

R. phoenicis

R. quadrangulus

R. vulneratus

R. bilineatus

There are ~10 species in *Rhynchophorus*

Male RPW have a "beard" on rostrum. Females lack this

Adult RPW can live 2-3 months

Females can lay 58-531 eggs; hatch in 1-6 days

Pupal period is 11 – 45 days

Life cycle can take 45 – 139 days

3-9 larval instars take 25-105 days to develop

Pupal cocoons made from chewed palm fibers

The Problem with RPW

- **Red palm weevil is considered to be the world's most serious palm pest**
  - Coconuts favored in native range
  - > 40 palm species recorded as hosts
- **This pest has killed millions of palms in countries it has invaded**
- **Palms in the genus *Phoenix* are very susceptible**
  - Date palms (*P. dactylifera*)
  - Canary Islands palms (*P. canariensis*)

Invasion History

- **RPW is native to northern areas of southern Asia (e.g., Vietnam)**
- **Movement of infested palms has transported the orange form of RPW to new areas**
  - **Iraq (1920)**
  - **Saudi Arabia & United Arab Emirates - 1985**
  - **Iran 1990**
  - **Egypt 1992 (> 1,000,000 palms killed(?) [not verified])**
  - **Spain 1995**
  - **China 1998**
  - **Israel/Palestine/Jordan 1999**
  - **France 2004 (officially declared present in 2006)**
  - **Italy 2004 (by 2009, > 13,000 palms killed)**
  - **Greece 2005 (infested palms imported for the Olympics; threatens endemic Cretan date palm, *Phoenix theophrasti*)**
  - **Turkey 2005**
  - **Cyprus 2006**
  - **Canary Islands 2006 (possibly eradicated from 3 islands. Canary Islands palms native here)**
  - **Portugal/Sicily 2007**
  - **Aruba-Curacao 2008 (infested palms from Egypt imported for hotels)**
  - **Slovenia/Georgia 2009**
  - **Maghreb region of north Africa started in Libya in 2009**

Invaded

Form

Orange

External Damage – Feeding Adults

Clipped end of frond. Young spear damaged by adult RPW before it expanded

Line of feeding holes caused by adult RPW

Figure "7" notch on underside of frond

External Damage

Internal Damage

Identification of Palm Weevils from SE Asia

- **There are multiple color morphs of *Rhynchophorus* weevils in SE Asia:**
  - *R. vulneratus*
    - **Detected in California in 2010**
    - **Eradicated Jan. 2015**
  - **The "orange" form of RPW that has invaded globally:**
    - *R. ferrugineus*
 - **And everything in between**

Eradication of *R. vulneratus* in California

- **Weevil infestation very small when first detected in 2010**
  - **< 15 infested palms**
  - **< 5% of urban area infested**
- **Rapid and aggressive program of**
  - **Trapping**
  - **Pesticide applications**
  - **Palm eradication**
- **January 2015 RPW declared eradicated after 3 yrs of no detections**
  - **Cooperation of UCR, CE, USDA, CDFA, Homeowners, palm enthusiasts**

RPW Invasion into Maghreb
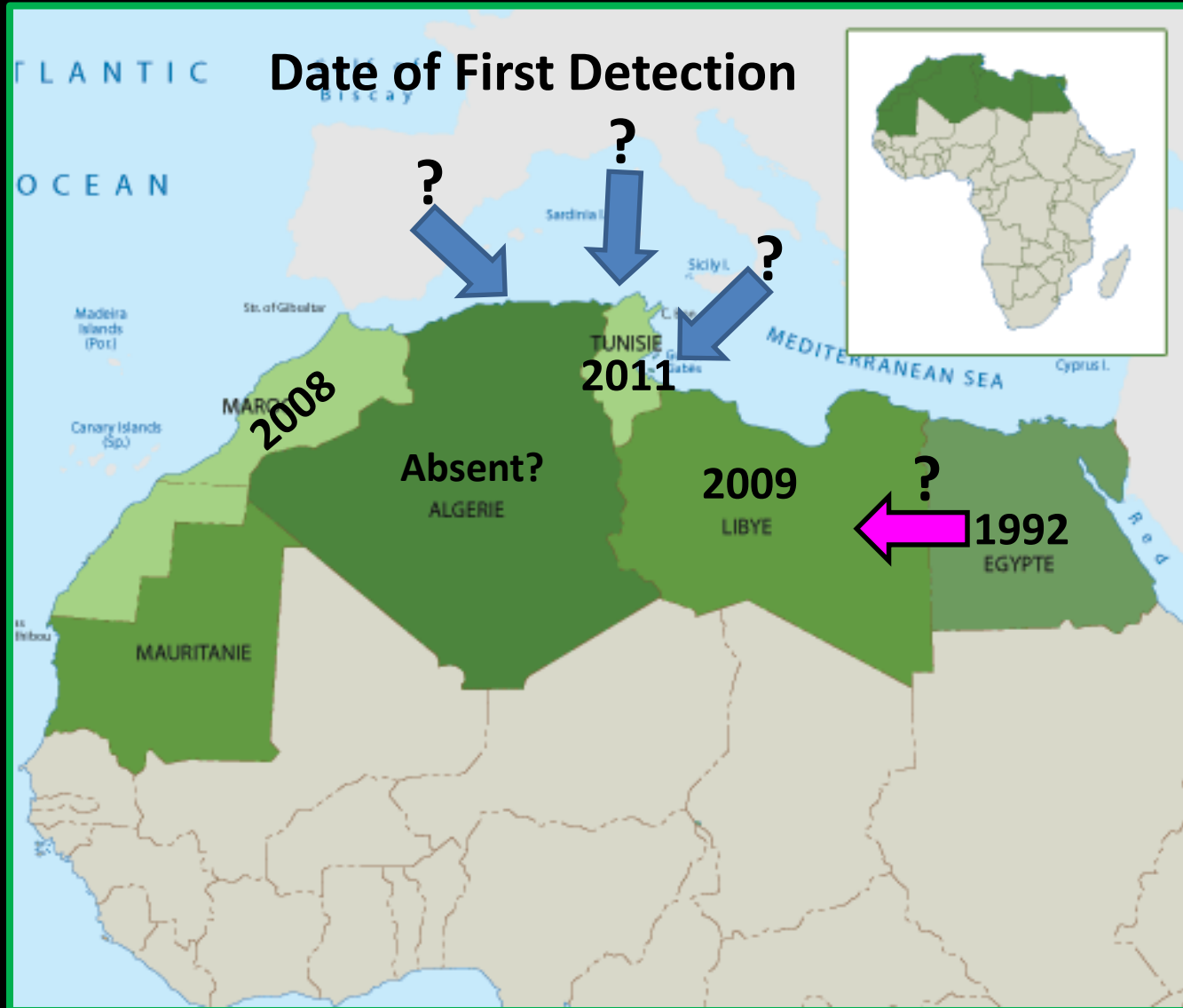
The Threat RPW Poses to Tunisia

- **Maghreb accounts for 15% of global date production**
  - **Madjoul & Deglet Nour important cultivars**
  - **12% of Tunisians depend on date farming**
- **Date palms < 20 yr of age susceptible to RPW attack**
  - **In 2007 Tunisia grew ~40,000 ha of dates**
  - **~50% (~2 million palms) of dates are < 20 yr old**
  - **120,000 tonnes of dates grown each year**

How Far Can RPW Fly?

Summary Data from Flight Mills

- **Trials conducted in Saudi Arabia with field collected weevils**
  - **139 weevils (73%) of 192 flew > 1 km in 24 h**
- **Average distances flown in 24 h**
  - **Winter (Dec):**   **Females: 15 km**   **Males not tested**
  - **Spring (Mar):**   **Females: 21 km**   **Males 25 km**
  - **Summer (May): Females: 35 km**   **Males 25 km**
- **55% flew > 10 km and 5% flew > 50 km in 24 h**
- **Summer ~30ºC and < 30% RH 80% weevils died**

Is Carthage Ground Zero for the RPW Invasion?

Photo by El Presidente Mafra-Neto, IscaTech

How Far Can RPW Fly?

30% flew < 1 km

5% flew > 50 km

55% flew > 10 km
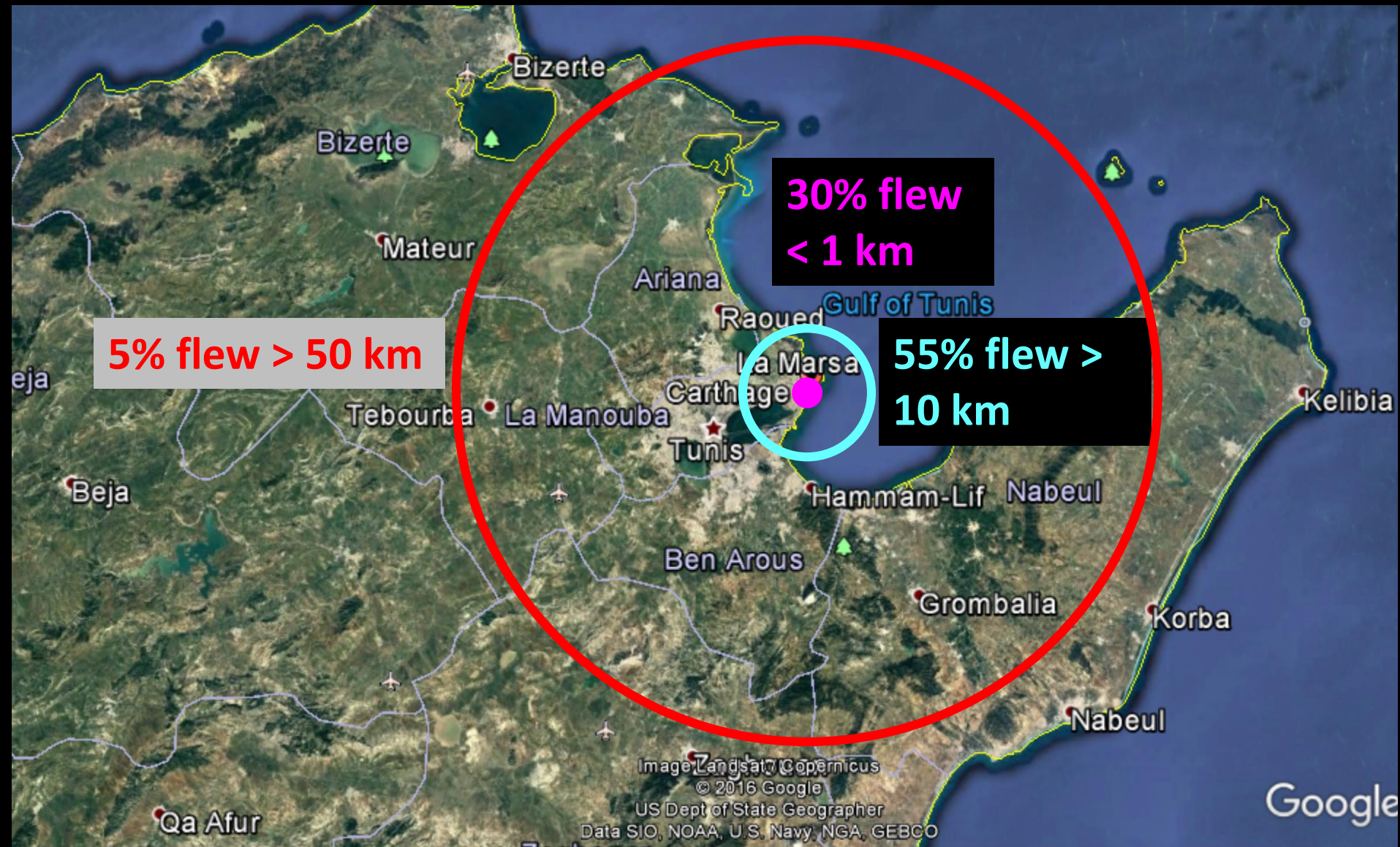
Flight Mill Data for Other Palm Weevil Species

- *R. vulneratus*
  - Females ~ 30 km/day
  - Males ~ 15 km/day

- *R. palmarum*
  - Trials still underway, but can easily fly on average > 10 km/day

Transportation of Live Infested Palms can Move Palm Weevils Long Distances very Quickly

RPW is Farmed in SE ASIA – California Invasion?

Quarantine of RPW

- **RPW is a very strong flier**
- **RPW has the potential to spread long distances on its own**
- **Humans can move RPW accidentally via infested palms that are planted in new areas**
- **Strict quarantines are needed to slow or prevent spread of RPW**
  - **Ban importation/movement of palms from infested areas**
  - **Set large boundaries around new outbreak areas**
  - **Palms need to be inspected 3 months prior to movement and then for 6 months post-movement for RPW activity**
    - **No RPW activity they can be certified clean and released**

Monitoring Programs

- **Monitoring and detection programs for RPW rely heavily on bucket traps**

- **Bucket traps are loaded with commercially-available aggregation pheromone, ethyl acetate synergist, and baited with fermenting dates**

- **Traps set into soil or excavated palm logs**

Bucket Traps Deployed

How To Use Bucket Traps

- **Pheromone trapping important RPW management tool**
  - **Servicing**
    - **Need to be serviced every 2 weeks**
      - **Replace baits/water**
    - **Lures replaced every 6 weeks (more often when hot)**
    - **Deploy traps in shade if possible**
  - **Deployment rates**
    - **1 trap per Ha good for monitoring**
    - **Mass trapping at 3-10 traps per Ha has been successful for reducing RPW numbers**

Smart Traps for RPW

- **Smart traps monitor RPW entering traps and send count data in real time to computer**
- **No need to monitor traps for weevils as frequently**
- **Very low error rate in counts**
  - **Will count other insects entering traps**
  - **Can't sex weevils**
- **Potential reduces labor associated with trapping**
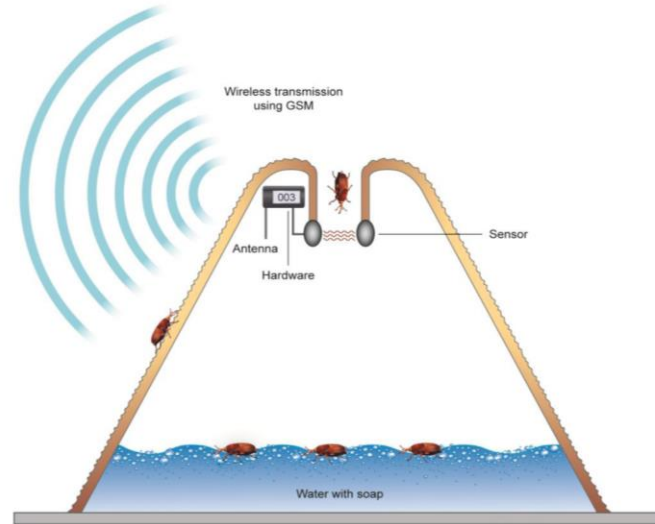- **Pheromone/bait/water need to be replaced**

Figure 1. A typical plastic Picusan type trap with the optoelectronic detector embedded.
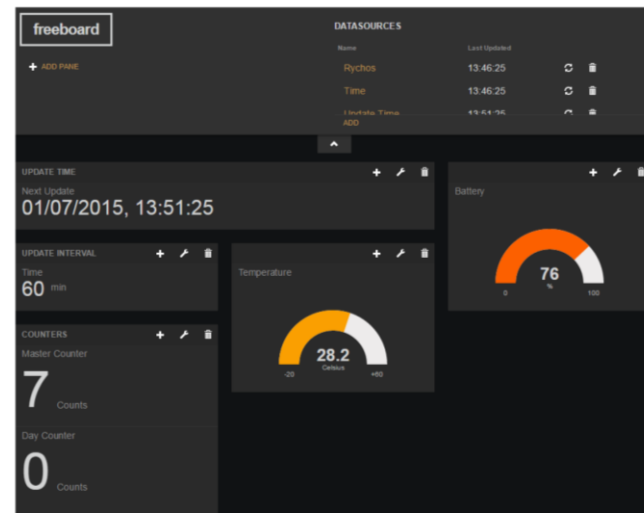

Figure 4. Detection and recognition results received from the GPRS module. The figure shows the online web interface that presents detected counts of pests.

Early Detection of Infestations

- **A very important area of RPW research that is very difficult to solve adequately**
  - **Trained dogs to sniff out infested palms**
    - **Expensive**
    - **Require training/re-training**
    - **May give false positives for rewards**
    - **Hard to get to crowns of trees where infestations may be located**
  - **Acoustic monitoring**
    - **Listen for weevils "feeding" inside palm**
    - **Difficult to detect when larvae are small**
    - **Need to filter out background noise**
  - **Metabolomics?**
  - **Thermal sensing?**
  - **Emission of volatile odors?**

Biological Control of RPW

- **Natural enemies of RPW poorly understood**
  - Identification, biology, ecology, impact in native range
- **Some reports suggest entomopathogenic fungi can kill pre-pupae/pupae/adults(?)**
  - Demonstrated in lab – easy to do in a Petri dish
  - Field-level impacts not demonstrated
- **Artificial applications of nematodes in drenches can kill larvae**
- **Highly unlikely biocontrol can provide adequate pest suppression to save trees**

Pesticides for RPW Control

- **Two groups of pesticides are used for RPW control in palms**
  - **Contact insecticides**
    - **Applied to palm trunks and foliage to <u>kill adult beetles</u> that land on trees**
      - **Pyrethroids (a couple of weeks?)**
    - **Heavy drenches poured into crowns of infested palms**
  - **Systemic insecticides**
    - **These pesticides move within the palm**
      - **Applied as drenches to soil**
        - » **Imidacloprid (few months?)**
      - **Injected into trunks under pressure or the palm pulls the pesticide from a reservoir inserted into the trunk, or trunk spray**
        - » **Dinotefuran (a couple of weeks?)**
      - **<u>Kill larvae and adults</u> feeding within the palm**

Spray Program in Saudi Arabia

- **Contact pesticides used:**
  - **Synthetic pyrethroids** (7 different products with 3 different AI [e.g., beta-cyfluthrin, cypermethrin])
  - **Organophosphates** (4 different products with 3 AI [e.g., chlorpyrifos, dimethoate)
  - **Carbamates** (1 product with 1 AI [e.g., carbaryl])
- **Systemic pesticides used:**
  - **Imidacloprid**
- **Resistance suspected:**
  - **No resistance management plan**
  - **No rotation program for pesticides with different modes of action**
  - **IRAC website EXCELLENT!** http://www.irac-online.org/

Eradicating Infested Palms

- **Removal and destruction of heavily infested palms is recommended**
  - Burning is not adequate – often infested trunk is not completely destroyed and weevils survive
  - Complete grinding of the trunk is recommended and drying of the ground palm trunk material
 - Infested palms can be buried a least 2 meters underground

SAPW Invasion into Southern California

Red Ring Nematode

- **Adult weevils can spread a nematode that causes red ring disease in palms**
  - **Nematode infections can kill palms**
- **Adults are infected with nematodes and spread them when they defecate or lay eggs**
- **Uninfected adults acquire nematodes when they feed on palm material infected with nematodes**
  - **Larvae growing inside infected palms become inoculated and retain nematodes as they develop into adults**
- **Kill off with weevil infestation with insecticides, nematode infection may kill palm in the absence of weevils**
- **Nematode not recorded from the USA**
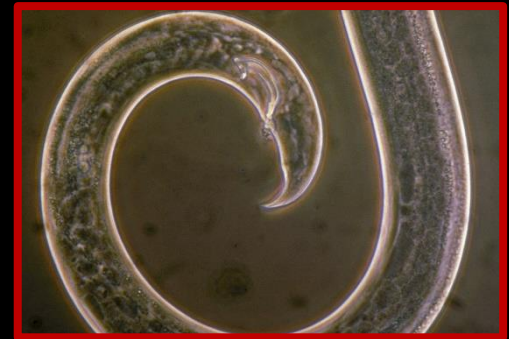
Drone to Monitor Rate of Infestations
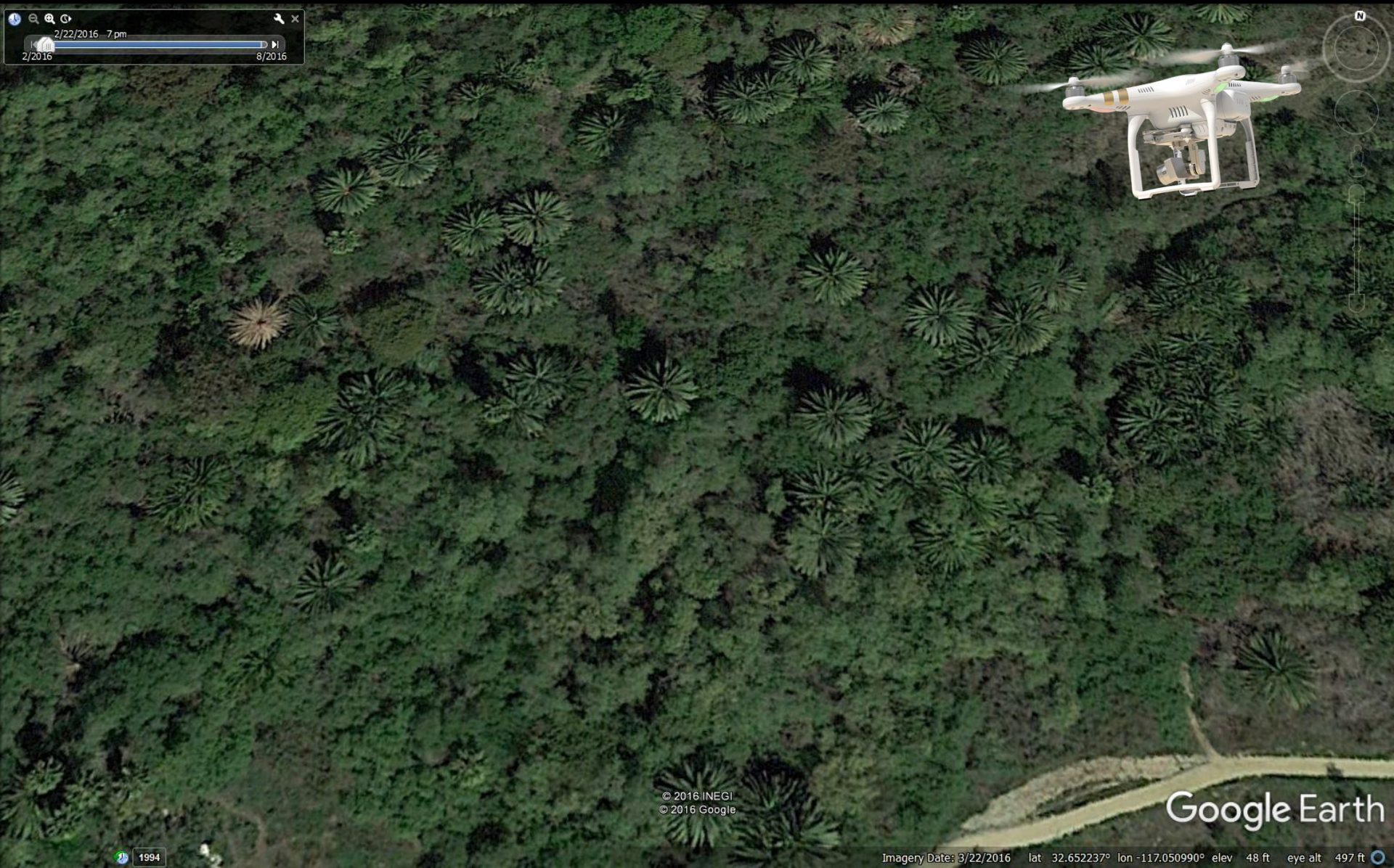
Using Drones for Palm Weevil Monitoring

Use Waypoints to Fly the Drone to Map Palms

0 250 FT

Legal

N

Speed
N/A MPH

LAT: N/A
LON: N/A

Altitude
N/A FT

S

Mission 3 ✏

📦 Mission Type	🕐 Flight Time est.
Waypoint Flight - Route	12 MIN 37 SEC
📏 Flight Length	⚓ Waypoints Qty.
7456 FT	100 PTS

All Points	Each Point

↗ Speed

11.2 MPH

⤢ Altitude

164.0 FT

↗ Aircraft Heading   Course Aligned ›

📷 Gimbal Pitch Angle

Manual	Defined Per Point

🏁 End-Mission Action   Return To Home ›

LAT   32.652444

LON   -117.051859

🗑 ⬆⬇
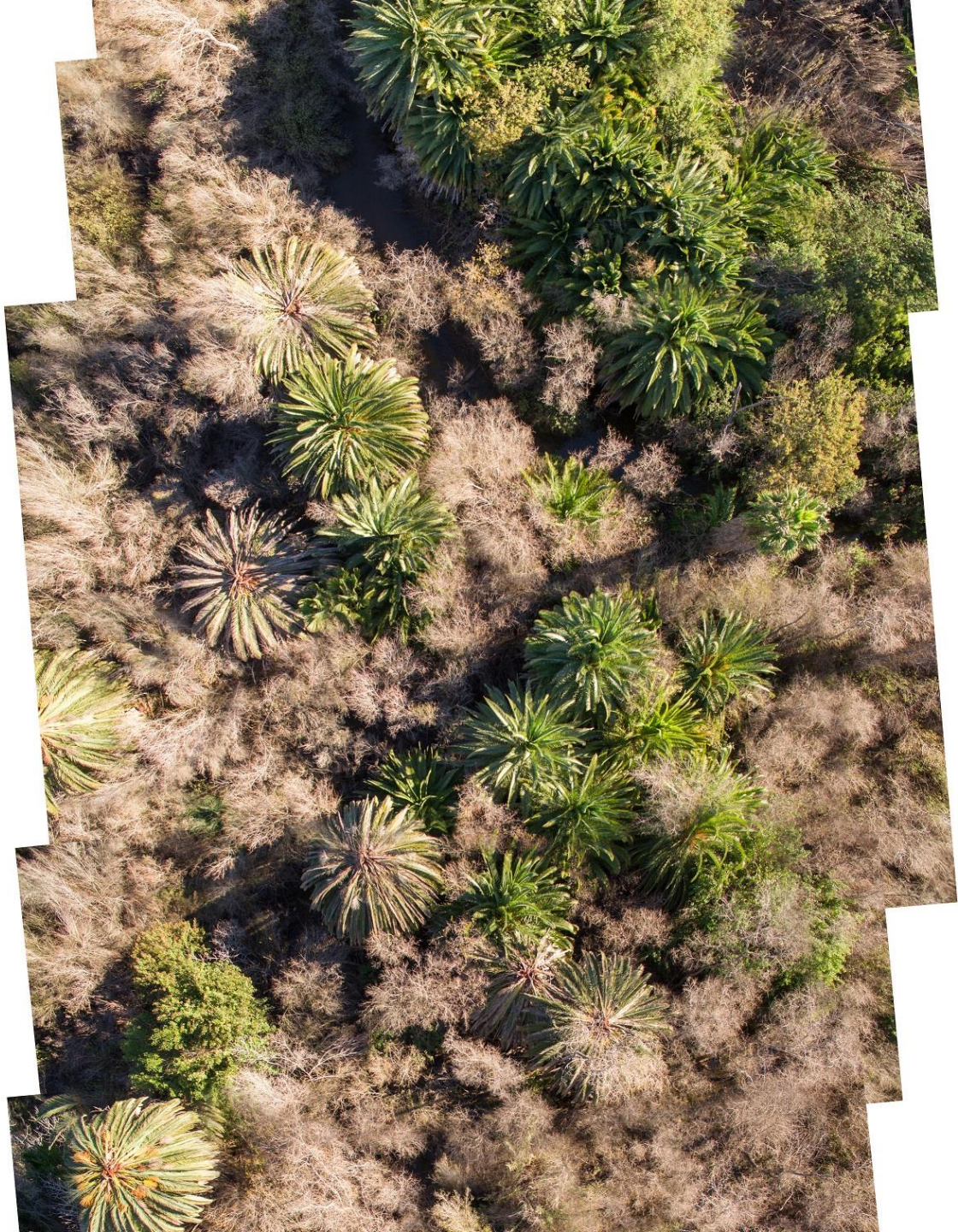
Conclusions

- **RPW is a devastating palm pest**
- **Very hard to control**
  - No good/efficient/cheap early detection technologies
  - No good biocontrol agents
  - Pesticides, trapping, palm removal – areawide management
- **Spreads fast**
  - Strong flier & movement of infested palms
- **New approaches needed?**
  - Smart traps
  - Drones
- **Need to monitor in areas with no confirmed infestations for early detection**
  - Small infestations that are highly localized may be eradicated

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