Sustainability, Application and Delivery of Biological Control Agents

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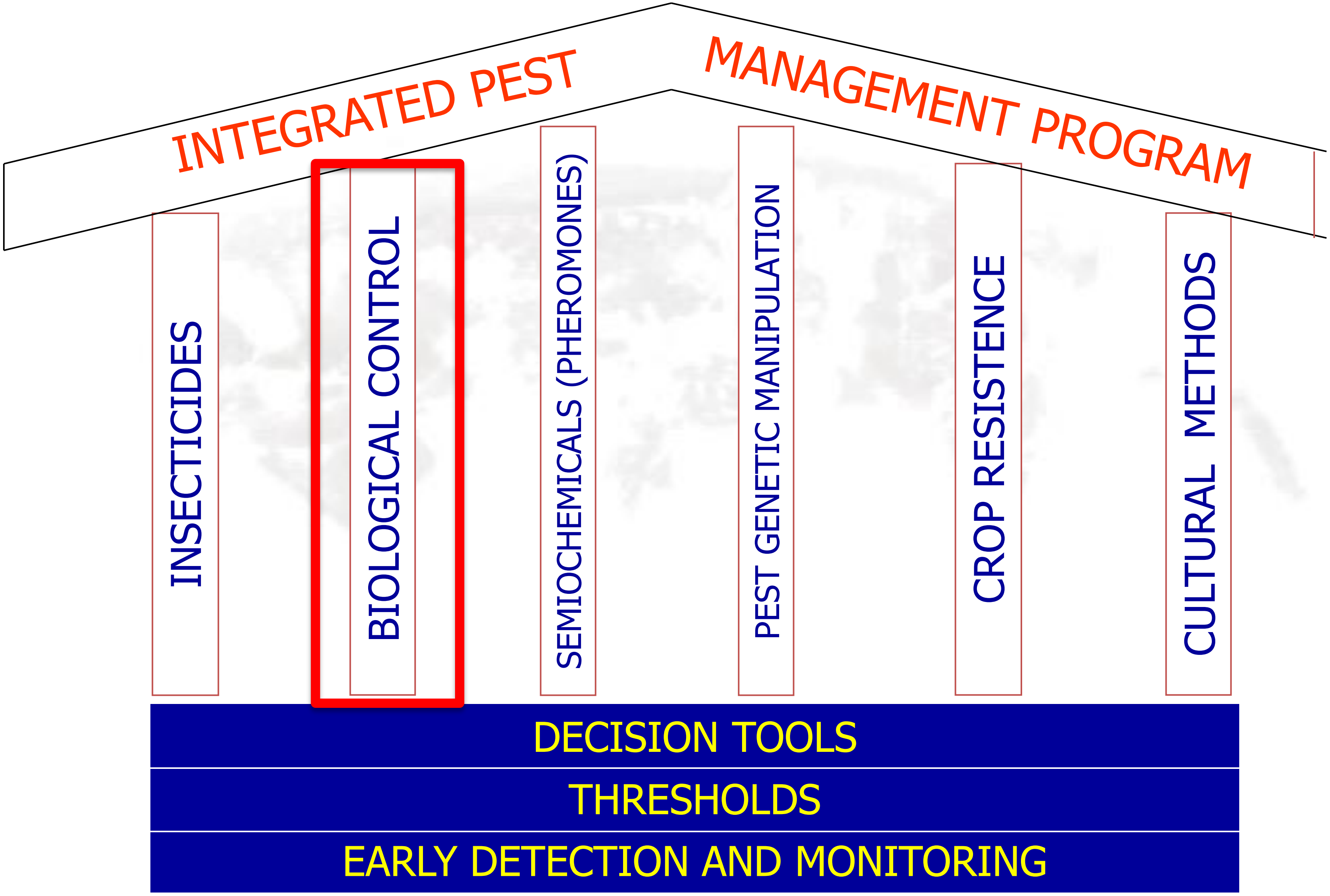
Information Note

Scientific Consultation and High-Level Meeting on Red Palm Weevil Management

29-31 March, 2017

FAO, Rome, Italy

The "house" of red palm weevil integrated pest management



Biological control is defined as the reduction of pest populations by using other organism, sometimes their own natural enemies (Van Lenteren, 2012)

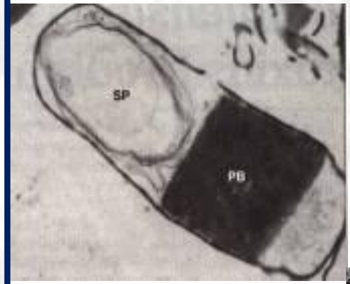
Parasitoids & predators

Macrobial Control

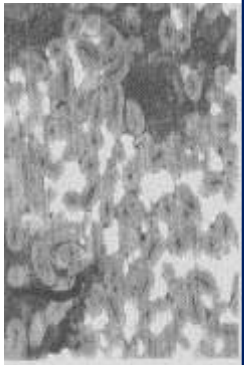
Entomopathogens

Microbial Control

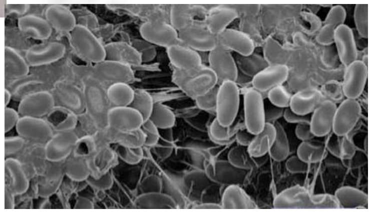
Bacteria



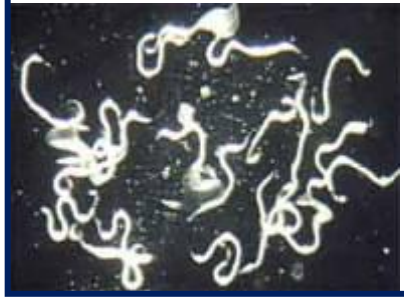
Viruses



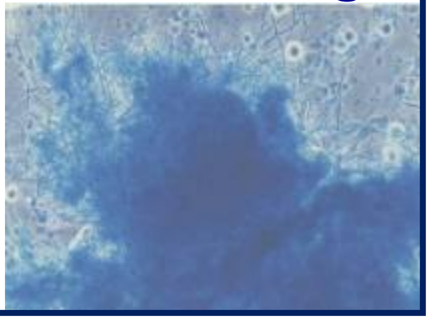
Protozoa



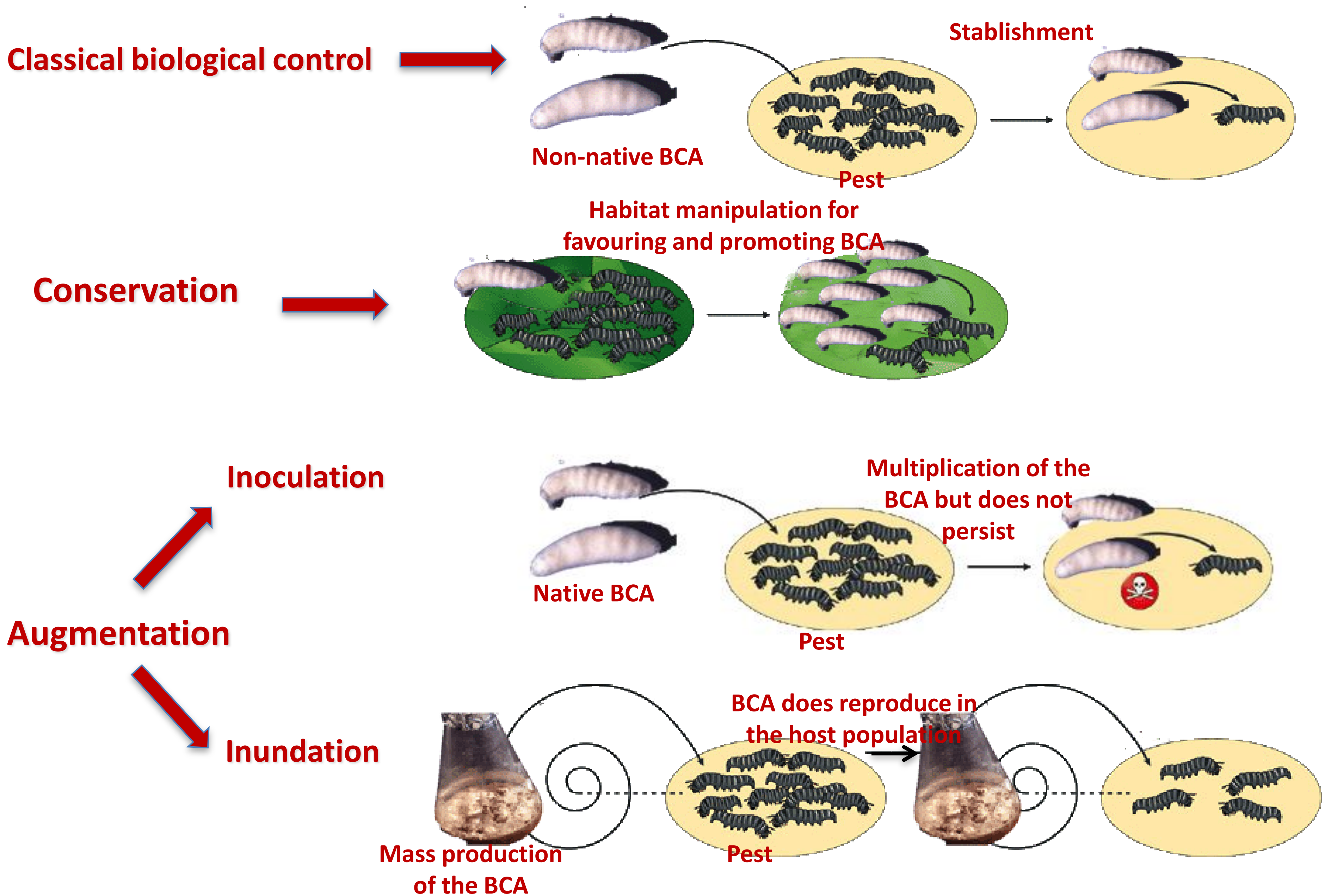
Nematodes



Fungi



Strategies for the use of microbial control agents for pest control



BCA: Biological Control Agent

Modified from: Roderick & Navajas. 2003. Genes in new environments: genetics and evolution in biological control. Nature Reviews Genetics 4, 889-899.

Biological control is defined as the reduction of pest populations by using other organism, sometimes their own natural enemies (Van Lenteren, 2012)

Parasitoids & predators

Macrobial Control

Ortega-García et al. 2016. Natural Enemies of *Rhynchophorus ferrugineus* and *Paysandisia archon*. Chapter 8. In: Handbook of Major Palm Pests: Biology and Management (Victoria Soroker and Stefano Colazza eds.). Wiley.

Red palm weevil control by Predators

- **Predators kill and eat many insects to complete their life-cycle** (i.e. mammals, birds, amphibians, reptiles, fishes and insects…..)
- The **earwigs** *Chelisoches morio* (Fabricius) (Dermaptera: Chelisochidae) and *Euborellia annulipes* (Lucas) (Dermaptera: Anisolabididae) haven been described as common predators of *R. ferrugineus* eggs and larvae in crowns of different palm species around the world
- Mites from the family **Uropodidae** (Acari: Mesostigmata) have also been observed in large numbers in association with red palm weevil in Israel

- These mites are not considered to play a role as biological control agents
- However, as they populate on each individual in huge numbers it is expected that they should significantly compromise red palm weevil flight abilities and thus the dispersion

Red palm weevil control by Parasitoids

- **Parasitoids are arthropods whose immature stages develop on or inside their host, causing its death, while adults are free living**
- The host-range of parasitoids is usually limited to one or few closely related species because their life-cycles must be very fine tuned
- The ectoparasitoid ***Scolia erratica*** **Smith (Hymenoptera: Scoliidae)** has been described naturally parasitizing red palm weevil larvae in several occasions, although it is not specific of the Curculionidae family
- 40-50% parasitism levels have been reported for the parasitic fly ***Billaea menezesi*** **(Townsend) (Diptera: Tachinidae) in** *Rhynchophorus palmarum* in palm orchards in Brazil

Ortega-García et al. 2016

It could be concluded that predators and parasitoids do not shown potential for RPW control apart from its natural activity that should be conserved

Biological control is defined as the reduction of pest populations by using other organism, sometimes their own natural enemies (Van Lenteren, 2012)

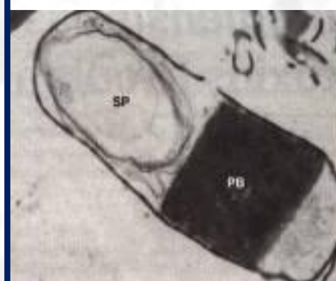
Parasitoids & predators

Macrobial Control

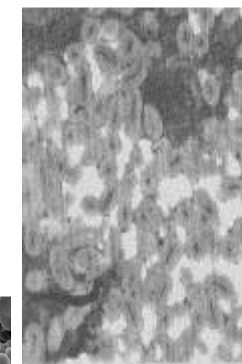
Entomopathogens

Microbial Control

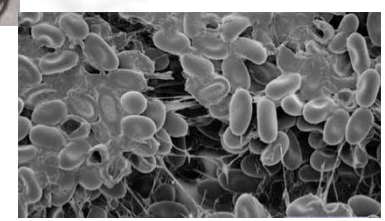
Bacteria



Viruses



Protozoa



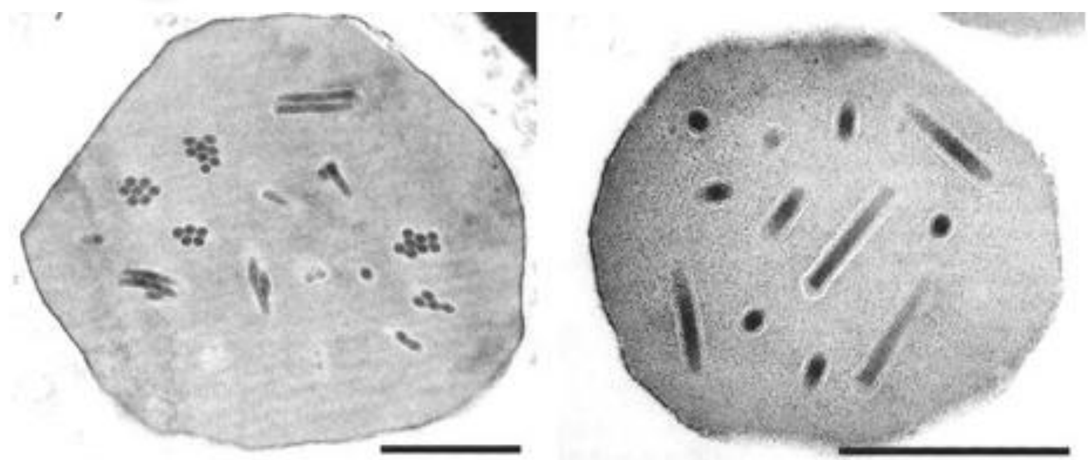
Nematodes

Fungi

Red palm weevil control by entomopathogenic microorganisms

Viruses

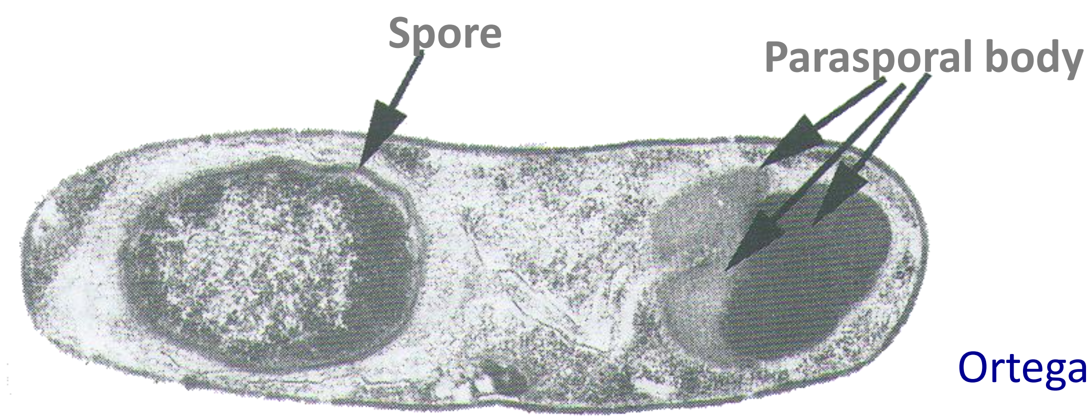
- Insect viruses are obligate pathogens that can only reproduce within a host insect. They have to be ingested by the insect host to start the infection process
- First case of a **cytoplasmic polyhedrosis virus** on RPW in India causing deformed adults and reducing their lifespan (Gopinadhan et al. (1990)
- Viruses have little use as biological control agents (BCAs) against RPW, except a report on their combination with nematodes (Salama and Abd-Elgawad, 2002)



Red palm weevil control by entomopathogenic microorganisms

Bacteria

- Entomopathogenic (entomotoxic) bacteria have to be ingested by the insect host to start the infection process
- Several pathogenic bacteria isolated from the red palm weevil have proved successful in laboratory conditions
- Among them, *Bacillus sphaericus* Neide has shown the highest activity, with low activities of *Bacillus thuringiensis* Berliner (Salama et al 2004; Manachini et al., 2009; 2011)

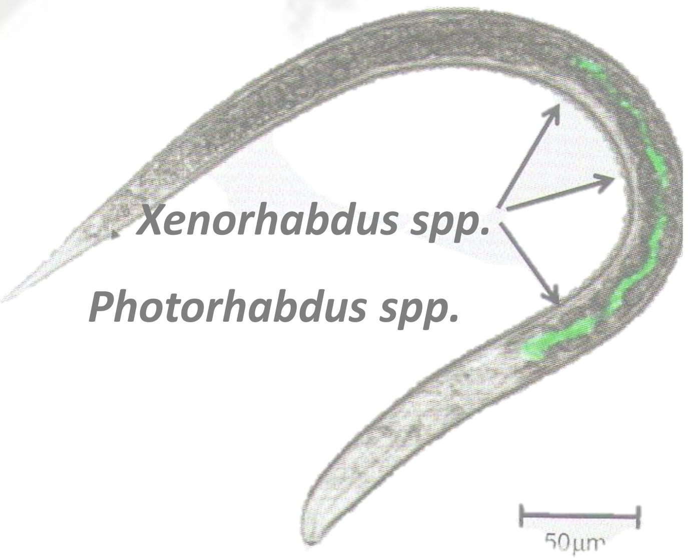


Ortega-García et al. 2016

Red palm weevil control by entomopathogenic microorganisms

Nematodes

- **Steinernematidae and Heterorhabditidae** families are the most interesting biocontrol species (among the 23 described) carrying specific pathogenic bacteria ***Xenorhabdus*** **and** ***Photorhabdus***
- These nematodes can actively find, penetrate, and infect the insect with their symbiotic pathogenic bacteria which are released into the insect hemocoel
- Natural infections of RPW by *Heterorhabditis* and *Steinernema* have been described
- Several tests conducted both in laboratory and field have evaluated the efficacy of EPNs



Ortega-García et al. 2016

Nematodes

- *Steinernema feltiae* Filipjev and *Heterorhabditis bacteriophora* Poinar have shown high infectivity to all developmental stages of *R. ferrugineus* in laboratory assays
- These nematodes have been also applied to red palm weevil-infested Canary Islands date palms, where they have been observed actively moving into the tree inner tissues, infecting larvae and adults
- However, in general, inconsistent results have been reported when EPNs are applied in field experiments due to high temperatures, high UV radiation, and low relative humidity that affect nematode survival

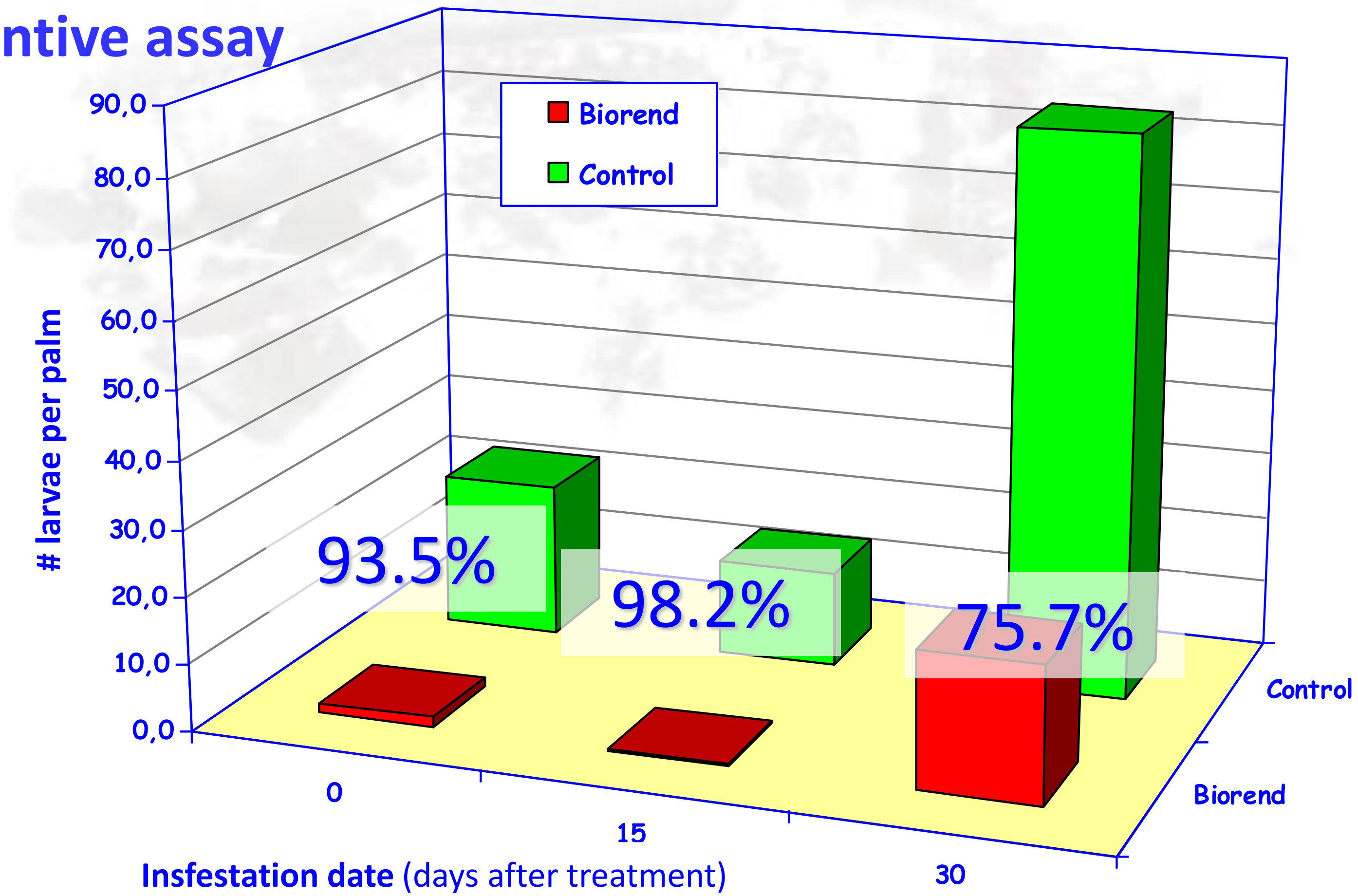
Ortega-García et al. 2016

Red palm weevil control by entomopathogenic microorganisms

Nematodes + chitosan

Llácer *et al*. (2009). Evaluation of the efficacy of *Steinernema carpocapsae* in a chitosan formulation against the red palm weevil in *Phoenix canariensis*. BioControl 54, 559–565 (doi: 10.1007/s10526-008-9208-3)

Preventive assay

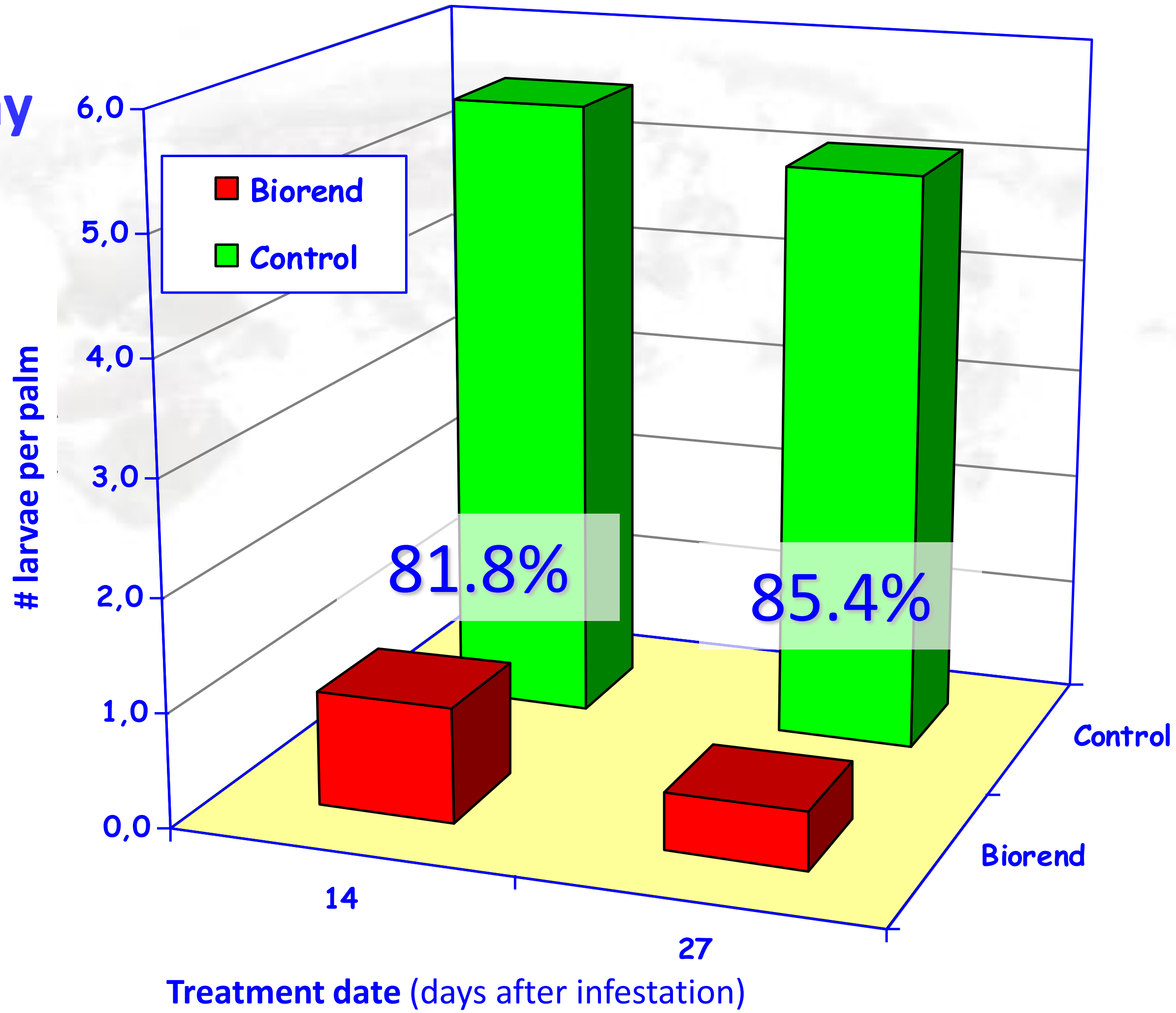


Red palm weevil control by entomopathogenic microorganisms

Nematodes + chitosan

Llácer *et al*. (2009). Evaluation of the efficacy of *Steinernema carpocapsae* in a chitosan formulation against the red palm weevil in *Phoenix canariensis*. BioControl 54, 559–565 (doi: 10.1007/s10526-008-9208-3)

Curative assay



Red palm weevil control by entomopathogenic microorganisms

Nematodes + chitosan+imidacloprid)

Dembilio *et al*. (2010). Field efficacy of imidacloprid and *S.carpocapsae* in a chitosan formulation against the red palm weevil in *P. canariensis*. Pest Manag. Sci. 66, 365-370 (doi: 10.1002/ps1882)

Field assay in a nursery (6-8 yr-old *P. canariensis*); 6 treatments:

Control

Biorend monthly (*S. carpocapsae* + chitosan)

Confidor (imidacloprid) drench in either:

March and May

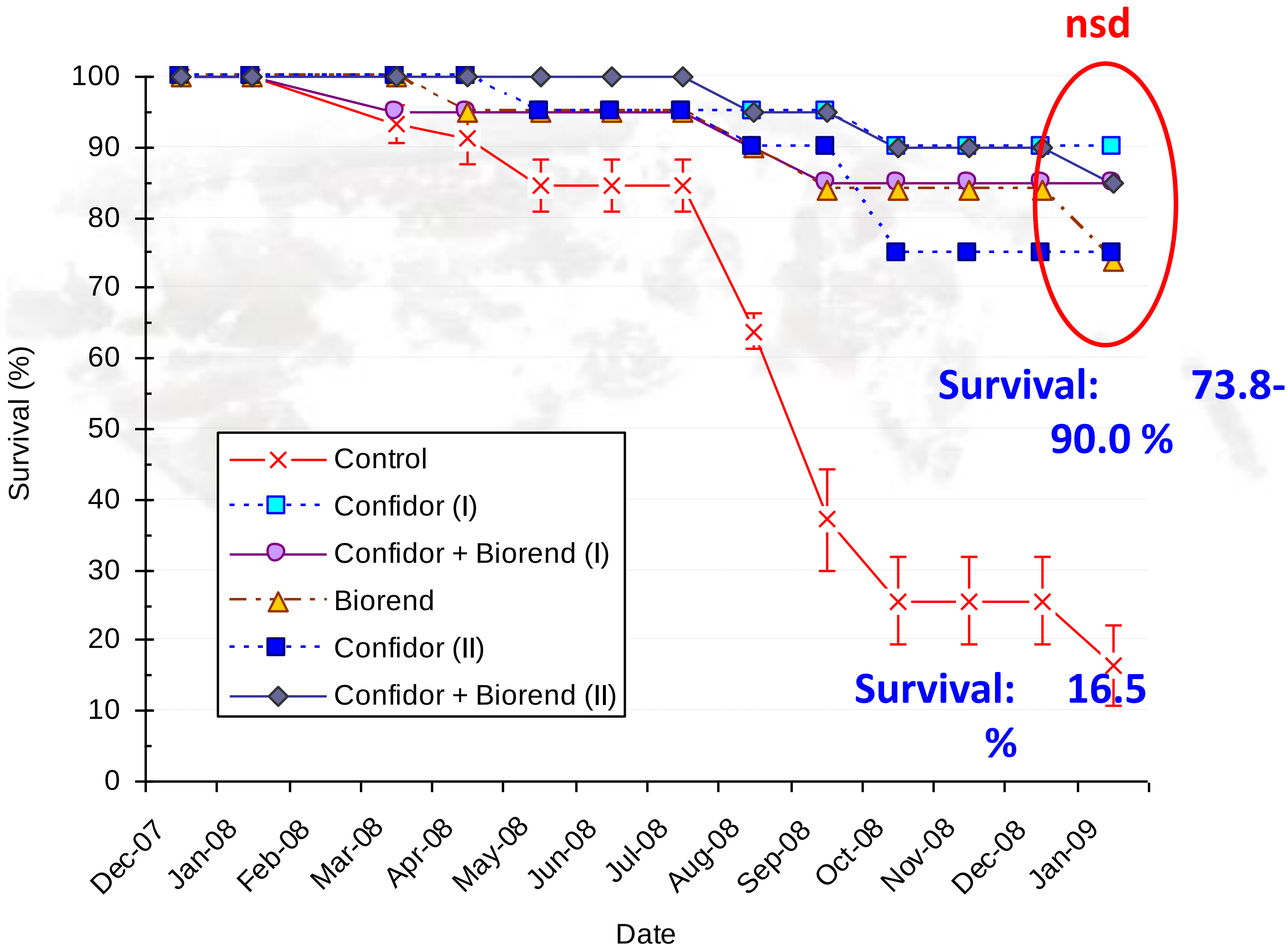
May and July.

Same as before + Biorend at 1st treatment and September

Red palm weevil control by entomopathogenic microorganisms

Nematodes + chitosan+ imidacloprid

Dembilio *et al*. (2010). Field efficacy of imidacloprid and *S.carpocapsae* in a chitosan formulation against the red palm weevil in *P. canariensis*. Pest Manag. Sci. 66, 365-370 (doi: 10.1002/ps1882)



Nematodes

- Therefore, the use of **chitosan** in the formulation has showed to protect entomopathogenic nematodes at field conditions by **increasing and stabilizing their efficacy**, which reached 98 and 80 % in preventive and curative assays, respectively (Llácer et al., 2009; Dembilio, et al. 2010)
- Compatible with insecticides (i.e. imidacloprid)
- The key concern with these nematodes is the **lack of reproduction of some species inside red palm weevils** which limits their commercial exploitation (Mazza et al., 2014) as frequent applications are still needed

Red palm weevil control by entomopathogenic microorganisms

Fungi

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

UNIVERSIDAD D CÓRDOBA

UNIVERSITAT JAUME•I

CEQA

Project KBBE-2011-5-289566. Strategies for the eradication and containment of the invasive pests *Rhynchophorus ferrugineus* Olivier and *Paysandisia archon* Burmeister (2011-2015) PALM PROTECT

PALM PROTECT

Entomopathogenic fungi for RPW control

- Natural incidence and environmental competence
- Laboratory and semifield trials
- Field evaluation
  - Leaf (crown) sprays
  - Lure and kill
- Insecticidal compounds from EPF

Fungi

Project KBBE-2011-5-289566. Strategies for the eradication and containment of the invasive pests *Rhynchophorus ferrugineus* Olivier and *Paysandisia archon* Burmeister (2011-2015) PALM PROTECT

Entomopathogenic fungi for RPW control

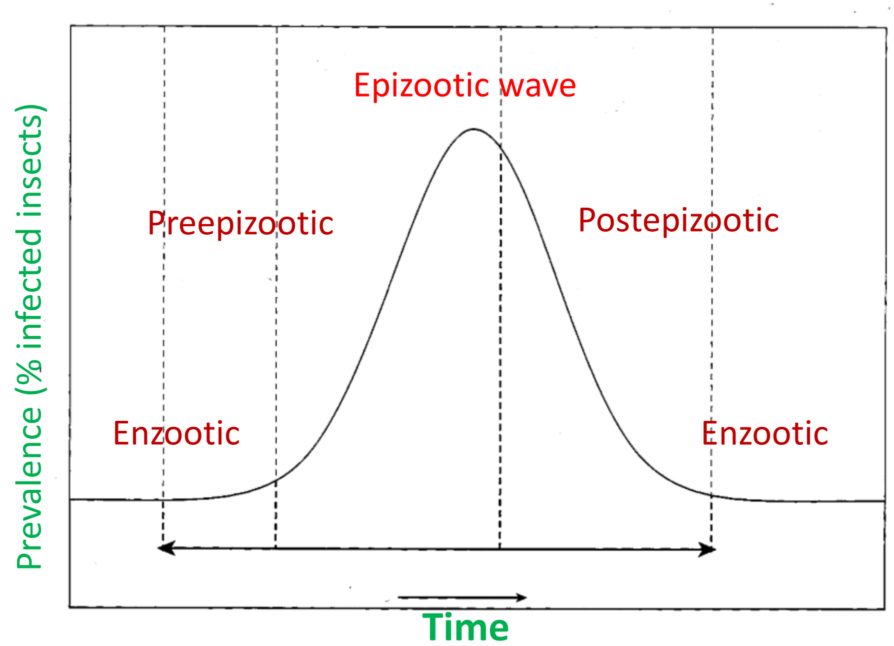
Natural incidence and environmental competence

Red palm weevil control by entomopathogenic microorganisms

Fungi

Project KBBE-2011-5-289566. Strategies for the eradication and containment of the invasive pests *Rhynchophorus ferrugineus* Olivier and *Paysandisia archon* Burmeister (2011-2015) PALM PROTECT

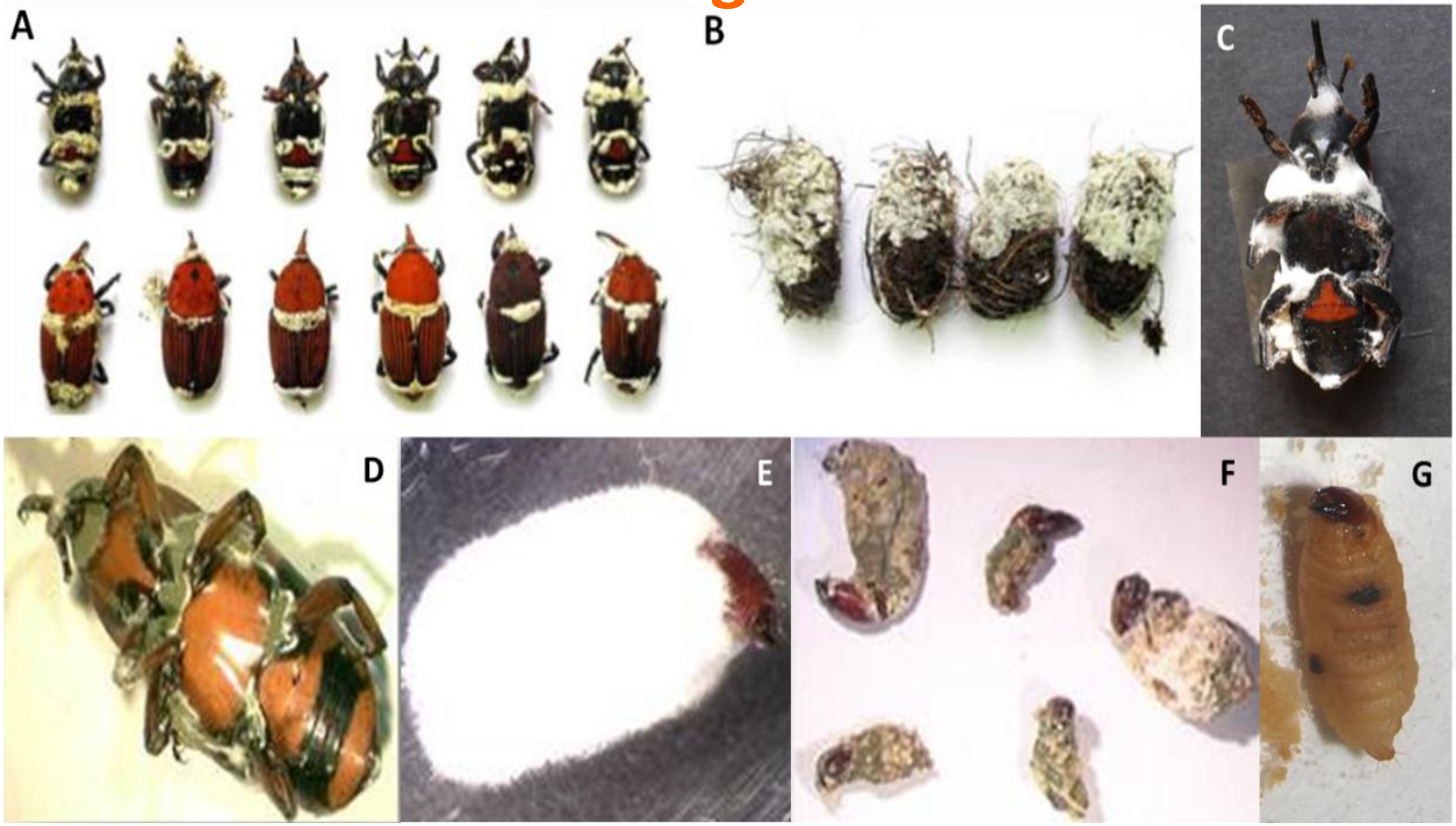
One of the main findings of PALM PROTECT regarding microbial control of RPW is that entomopathogenic mitosporic ascomycetes are the main natural regulators of RPW populations in the Mediterranean basin, with several reports of natural infections close to epizootic levels



Modificado de Shapiro-Ilan et al. 2012

Red palm weevil control by entomopathogenic microorganisms

Fungi

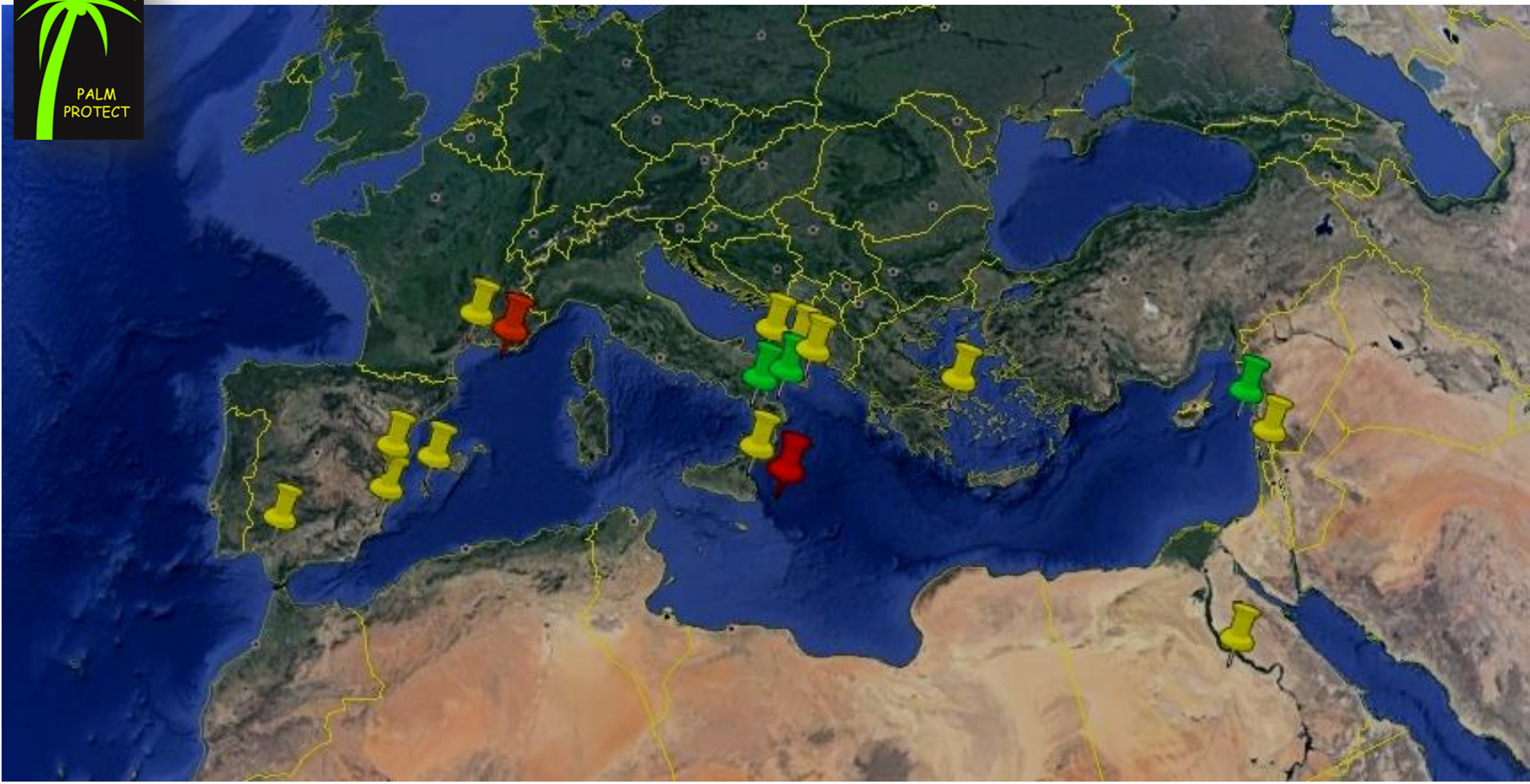


A) Natural epizootic of *Beauveria* and *Metarhizium* spp. in RPW population in Israel. Adults infected with *Metarhizium* spp. ventral and dorsal views. B) Cocoons infected with *Beauveria* spp. C, D) Adults and E, F) larvae infected with *Beauveria* and *Metarhizium* spp. respectively. G) Entry points due to fungal invasion.

Red palm weevil control by entomopathogenic microorganisms

Fungi

24 fungal isolates from diverse locations of the Mediterranean Basin



Metarhizium *Beauveria* *Lecanicillium*

Red palm weevil control by entomopathogenic microorganisms

Fungi

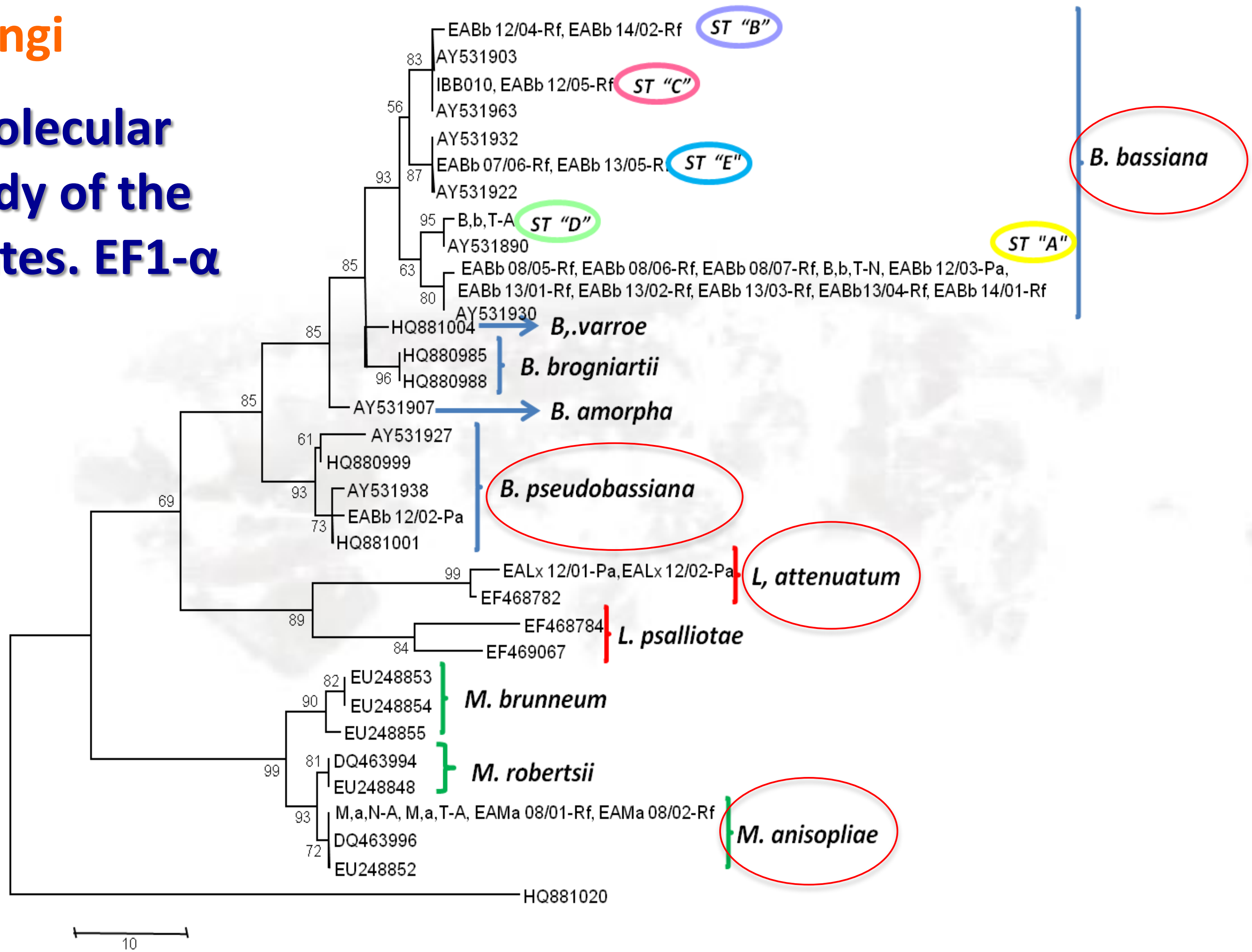
- Molecular study of the isolates:
  - Elongation factor (EF1-α)
  - Combined analysis (EF1-α–BLOC)
  - ISSR
- Effect of humidity, temperature, and UV
- Pathogenicity and virulence against *R. ferrugineus* pupae and adults

Quesada-Moraga et al. 2014, 2015

Red palm weevil control by entomopathogenic microorganisms

Fungi

Molecular study of the isolates. EF1-α

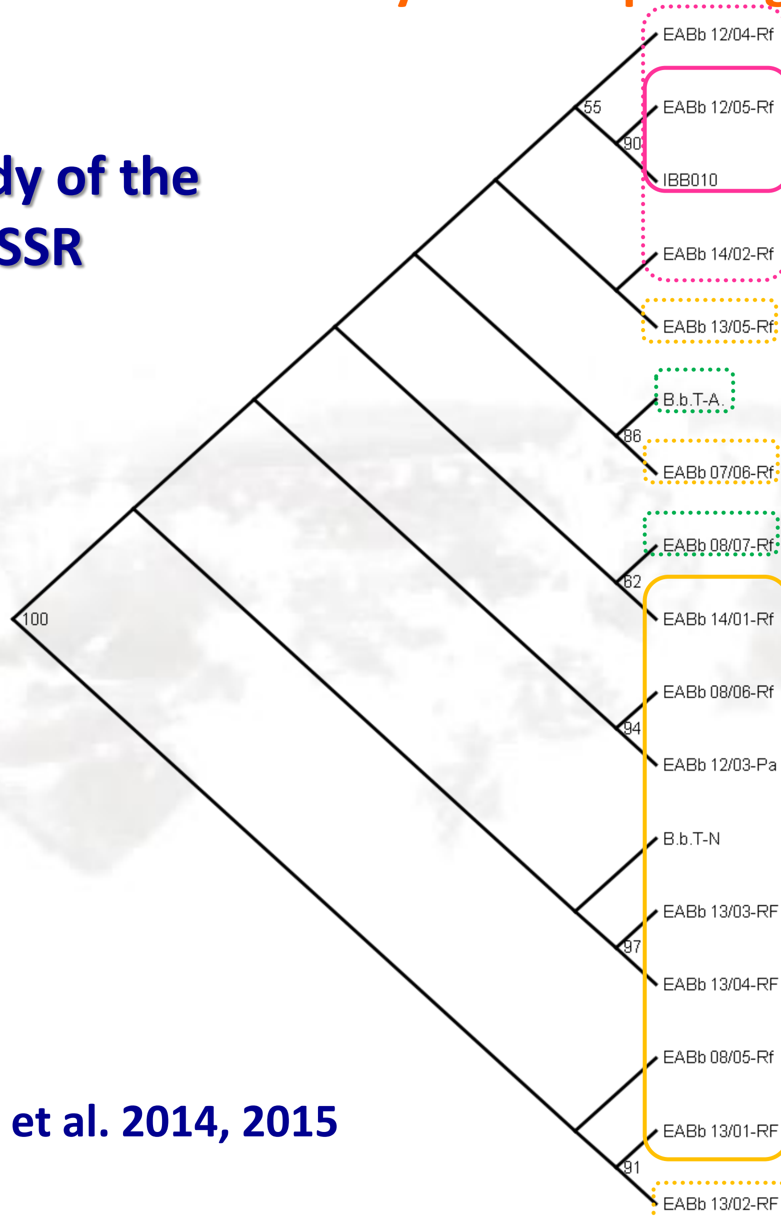


Phylogenetic analysis of entomopathogenic fungi isolates obtained from *R. ferrugineus* and *P. archon* inferred from Maximum Parsimony analysis of EF1-α gene sequences. Bootstrap values (based on 500 replicates) when above 50% are indicated in the branches. Species clades are indicated by vertical bars. Type sequences of *B. bassiana* are defined with the letters "A", "B", "C", "D", and "E", marked in yellow, purple, pink, blue and green respectively.

Red palm weevil control by entomopathogenic microorganisms

Fungi

Molecular study of the isolates. ISSR



Quesada-Moraga et al. 2014, 2015

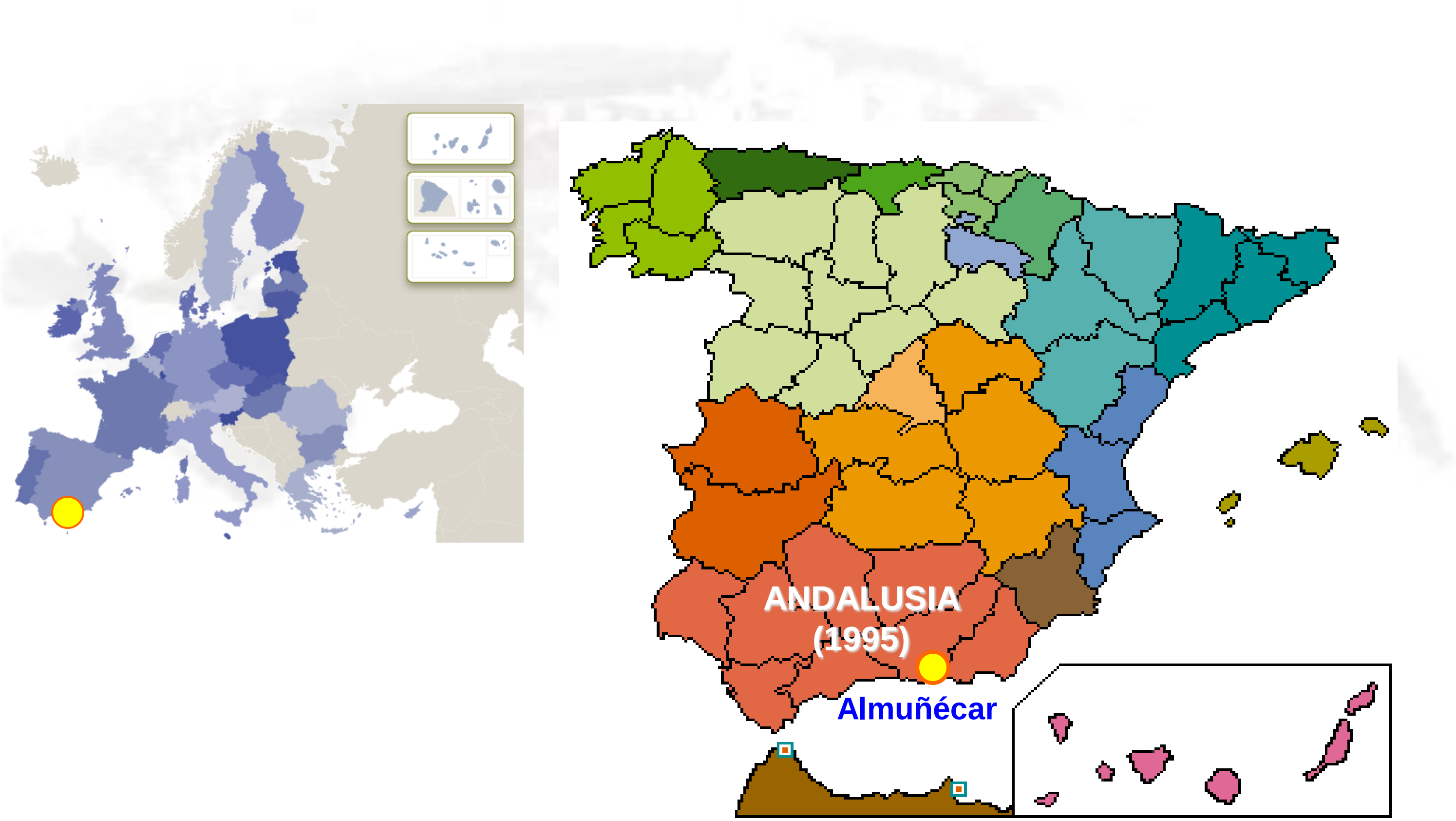
Phylogenetic tree of genetic relationship between the *B. bassiana* isolates obtained from *R. ferrugeneus* and *P. archon* with base on ISSR makers. Same color and continuous line indicate the same type sequence in the EF1-α and BLOC analysis. Same color and discontinuous line indicate same clade in the EF1-α and BLOC phylogenetic tree.

This diversity and phylogeny tree can be explained only by considering that the original RPW specimens from Egypt reaching Europe (Spain) were probably infested by *B. bassiana*, and also specimens of later invasions ….

Red palm weevil control by entomopathogenic microorganisms

Fungi

In 1995 *R. ferrugineus* is first detected in the EU: Almuñécar (Andalusia, Spain) very probably coming from palms from Egypt



Red palm weevil control by entomopathogenic microorganisms

Fungi

Rapid spread starting in 2004

Red palm weevil control by entomopathogenic microorganisms

Fungi

Red palm weevil control by entomopathogenic microorganisms

Fungi

First detection of *B. bassiana naturally infecting R. ferrugineus* pupae in 2007 (Dembilio *et al.*, 2010)

From 1995 to 2007 original *B. bassiana* genotypes evolved in Spain……and them……

Red palm weevil control by entomopathogenic microorganisms

Fungi

Rapid spread starting in 2004

Red palm weevil control by entomopathogenic microorganisms

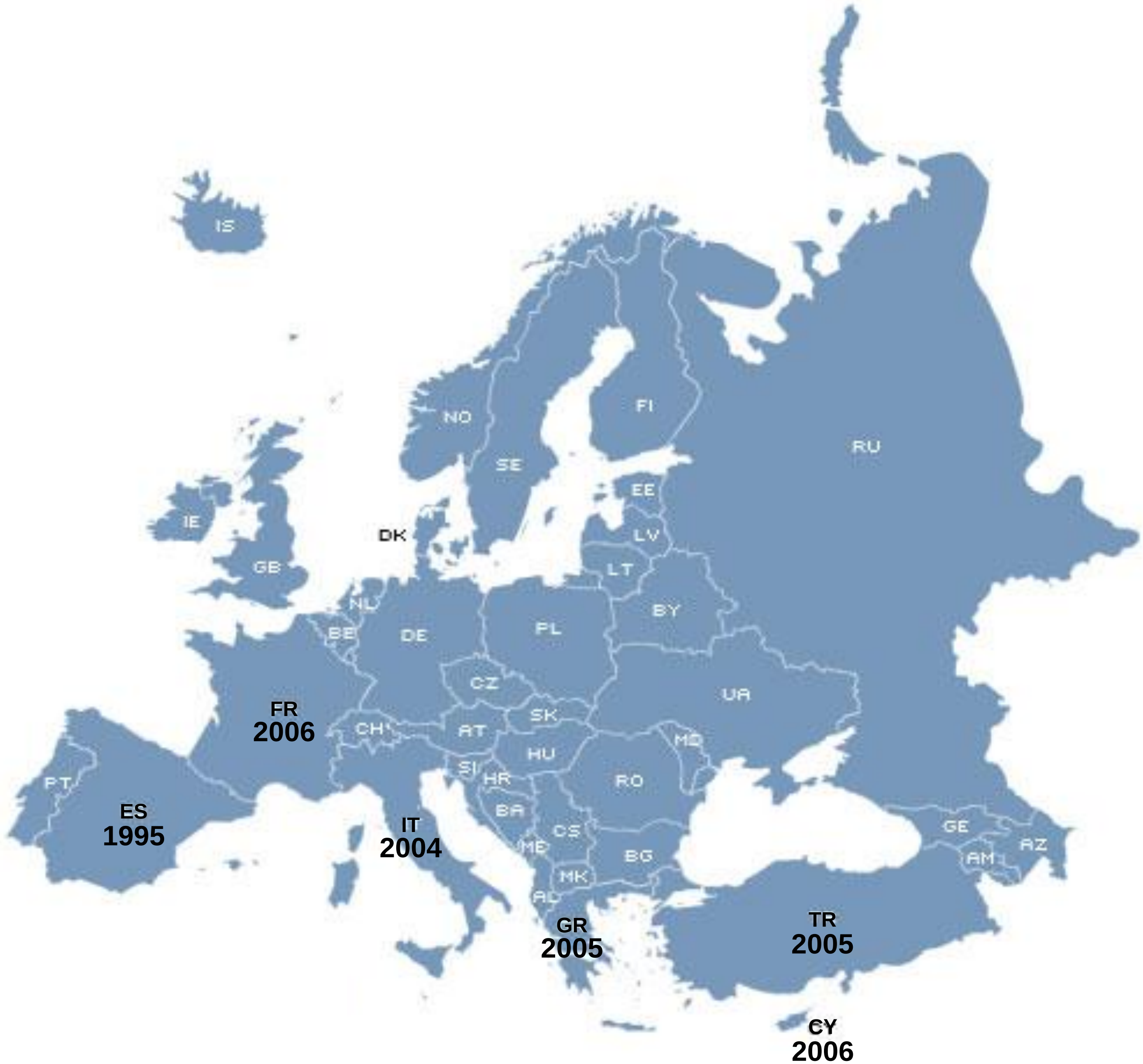
Fungi

2005

Red palm weevil control by entomopathogenic microorganisms

Fungi

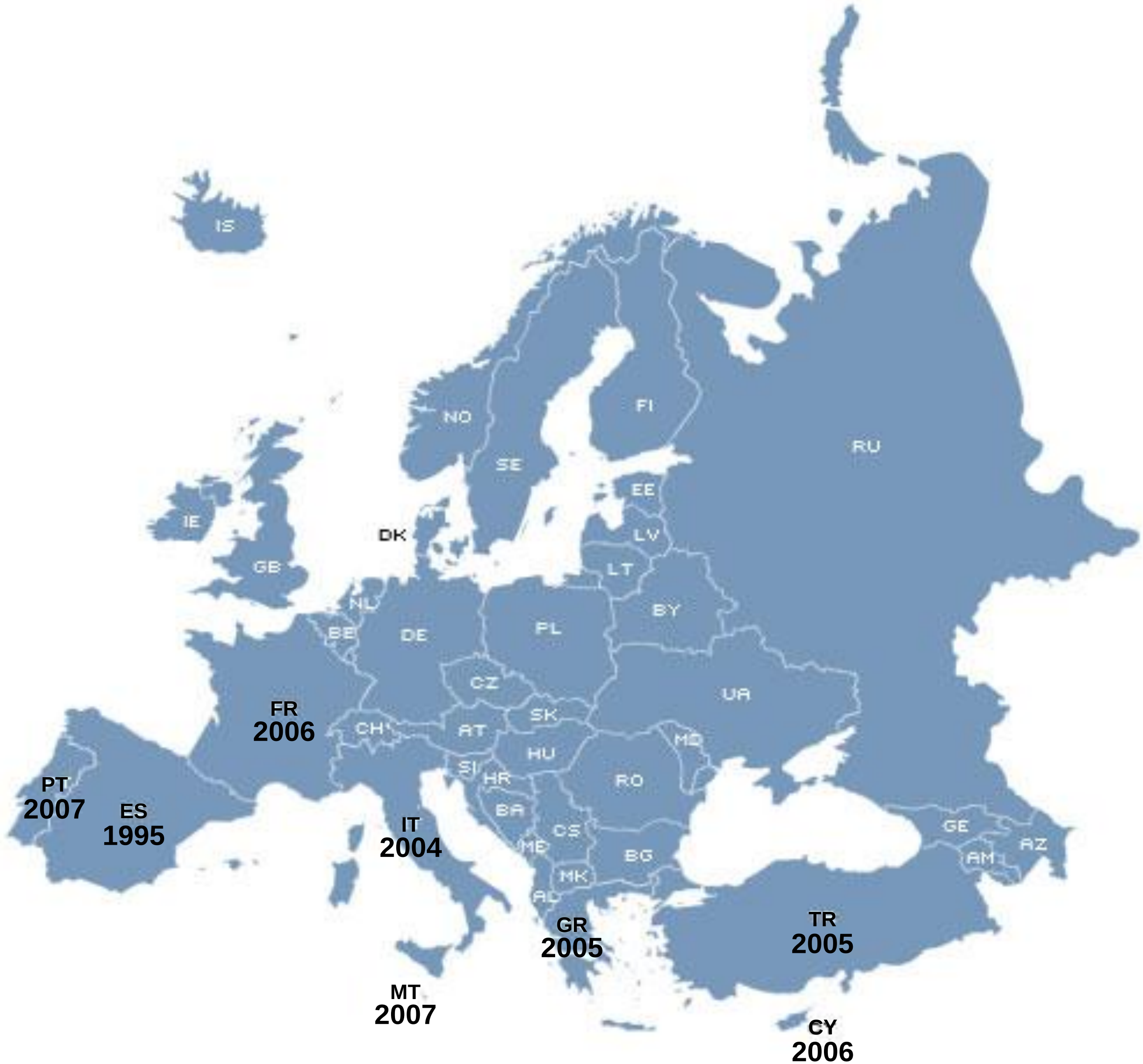
2006



Red palm weevil control by entomopathogenic microorganisms

Fungi

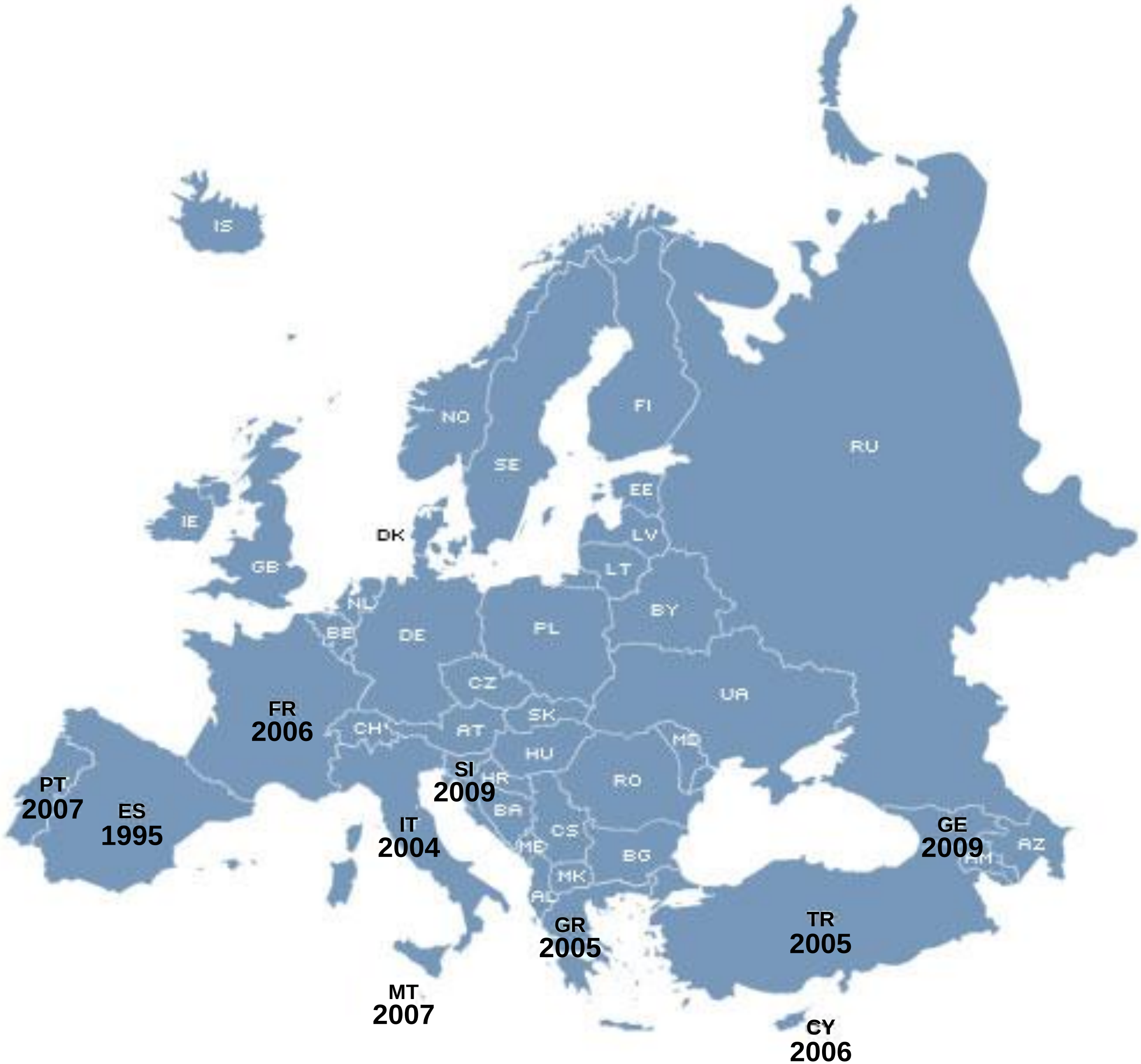
2007



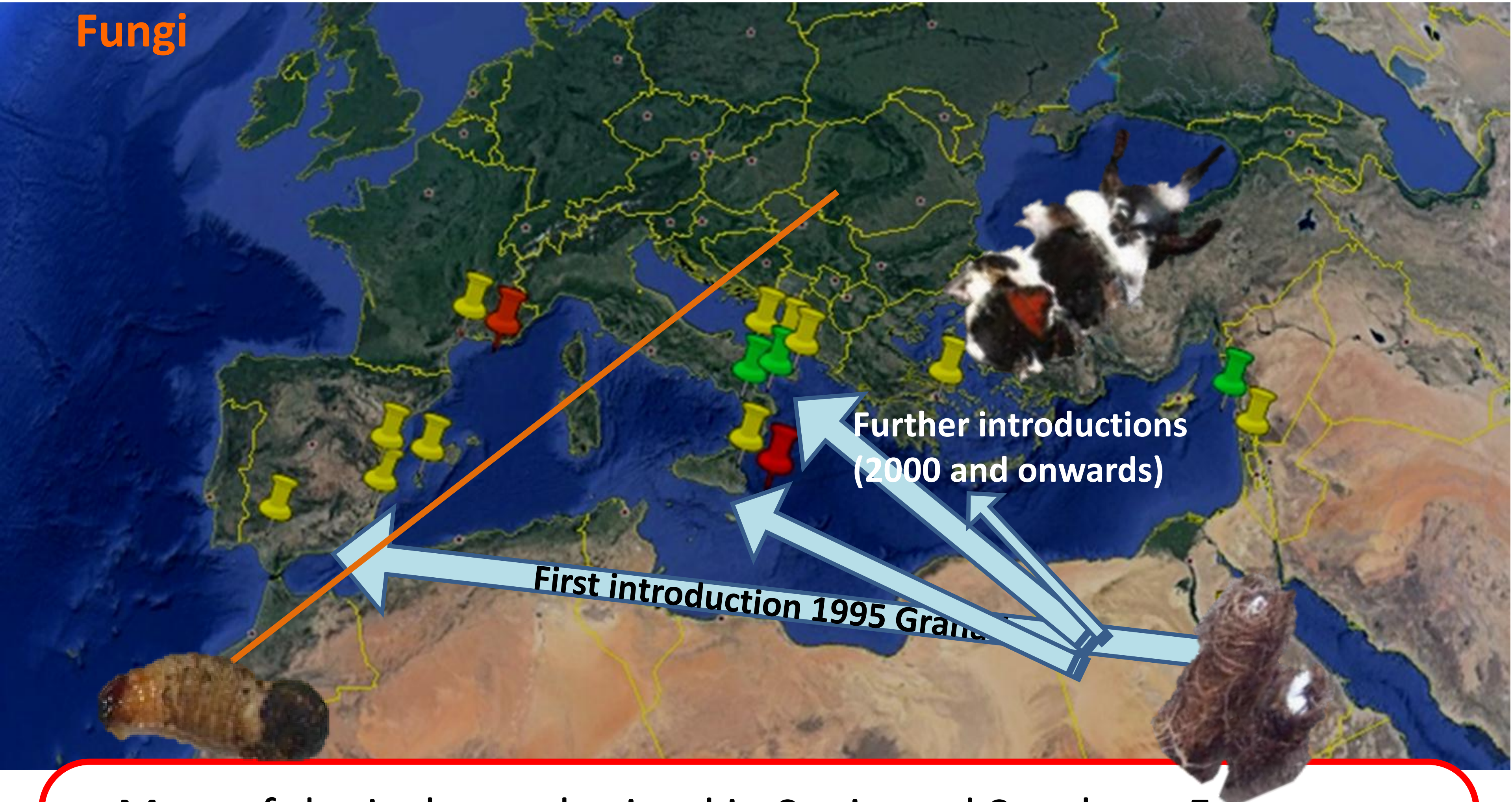
Red palm weevil control by entomopathogenic microorganisms

Fungi

2009



Red palm weevil control by entomopathogenic microorganisms



Most of the isolates obtained in Spain and Southern France are evolutionarily very close, while they are further away from the isolates found in southern Italy, Greece and Israel, which are closer to the posible original Egyptian isolates

Fungi

This could support a host-mediated spread of *B. bassiana* from the *R. ferrugineus* specimens firstly introduced into Europe from Egypt with geographic (introduction point) and time (since introduction) factors determining evolution patterns in the invaded areas. The other palm invasive species, *P. archon*, could also have played an important role in this host-mediated spread.

Quesada-Moraga et al. 2014, 2015

Red palm weevil control by entomopathogenic microorganisms

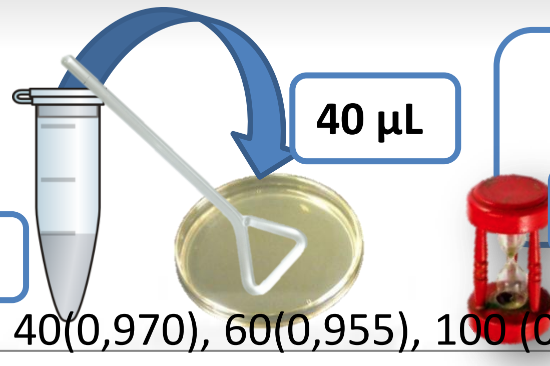
Fungi

- Molecular study of the isolates:
  - Elongation factor (EF1-α)
  - Combined analysis (EF1-α–BLOC)
  - ISSR
- **Environmental competence (RH, Tª, UV-B)**
- Pathogenicity and virulence against *R. ferrugineus* pupae and adults

Quesada-Moraga et al. 2014, 2015

Effect of relative humidity (MPa) on conidial germination

$1x10^5$ conidia/ml

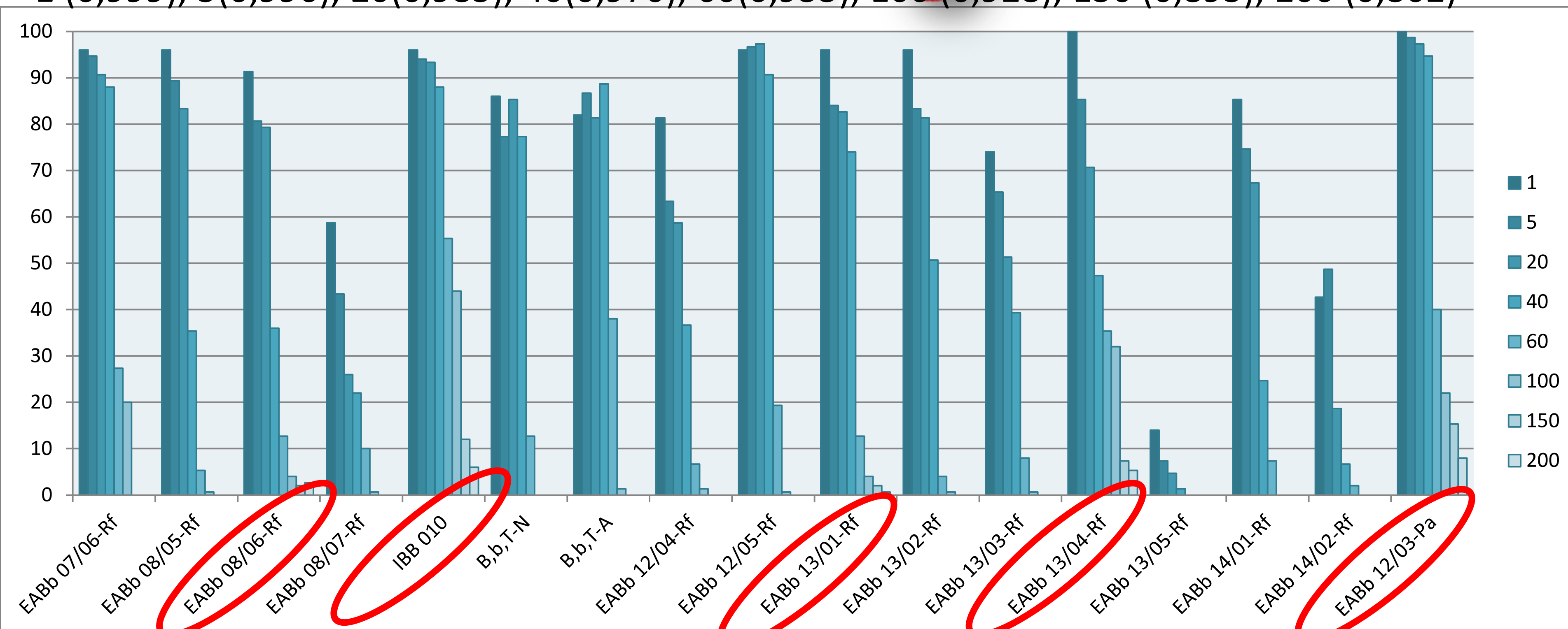


40 µL

18h

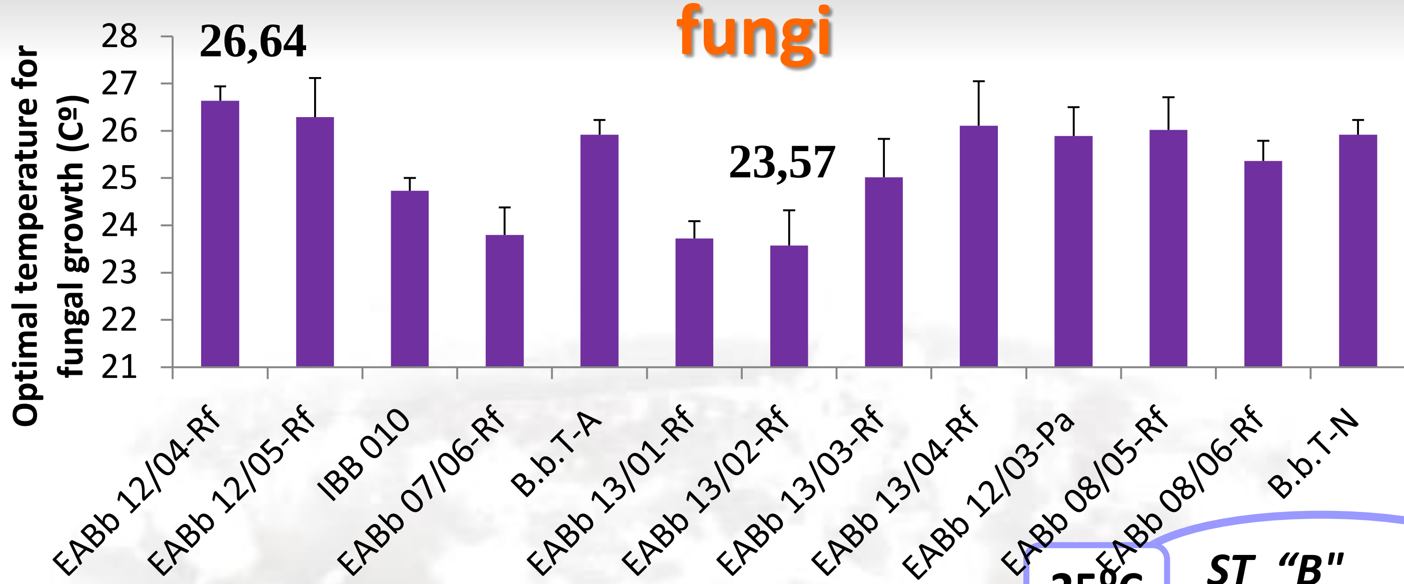
3 replicates /isolate
8 different relative humidity

1 (0,999), 5(0,996), 20(0,985), 40(0,970), 60(0,955), 100 (0,928), 150 (0,895), 200 (0,862)



Only five isolates, four of them from the same type sequence, showed germination even at 0,862 aw (200MPa). This fact should be considered in future strain selection.

Effect of temperature on *in vitro* radial colony growth of fungi



25^{0}C

ST "B"

Conidial germination (%) of *Beauveria bassiana* isolates at different temperatures

Isolate	Temperature (ºC) 15		20		25		30	
EABb 12/04-Rf	25,69 ± 0,75	bcd	69,333 ±	1,764bc	98 ±	2a	86,667 ±	3,712ab
EABb 12/05-Rf	18,07 ± 1,06	de	52,667 ±	6,36cd	82,667 ±	1,333a	67,333 ±	4,055bc
IBB 010	21,83 ± 1,89	cd	54,667 ±	1,764cd	82 ±	4,163a	70,667 ±	4,372abc
EABb 07/06-Rf	32,00 ± 2,31	b	76,667 ±	3,528ab	84,667 ±	4,667a	79,333 ±	1,764ab
B.b.T-A	9,83 ± 0,97	e	22 ±	4,163e	52 ±	3,055b	51,667 ±	2,028c
EABb 13/01-Rf	27,77 ± 1,08	bc	83,333 ±	4,807ab	96 ±	1,155a	81,333 ±	0,667ab
EABb 13/02-Rf	41,09 ± 2,41	a	88,667 ±	1,764a	94 ±	2a	88 ±	1,155a
EABb 13/03-Rf	20,86 ± 1,43	cd	68 ±	4,619bc	90,667 ±	4,372a	76 ±	6,11ab
EABb 13/04-Rf	47,15 ± 0,60	a	88,667 ±	3,333a	94 ±	2,309a	78 ±	3,055ab
EABb 12/03-Pa	41,45 ± 1,06	a	87,333 ±	2,906a	90 ±	4,619a	86,667 ±	4,807ab
EABb 08/05-Rf	28,19 ± 0,69	bc	56 ±	2c	87,333 ±	2,404a	75,333 ±	6,667ab
EABb 08/06-Rf	24,79 ± 3,61	bcd	78 ±	1,155ab	91,333 ±	2,404a	85,333 ±	0,667ab
B.b.T-N	27,74 ± 1,44	bc	36,667 ±	2,404de	89,333 ±	4,807a	82 ±	2ab

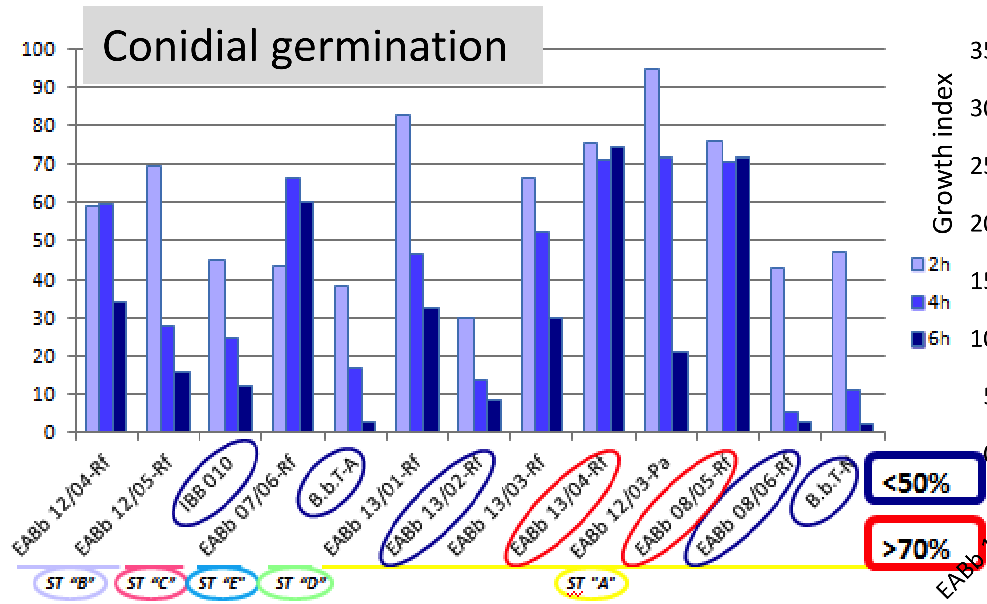
ST "D"

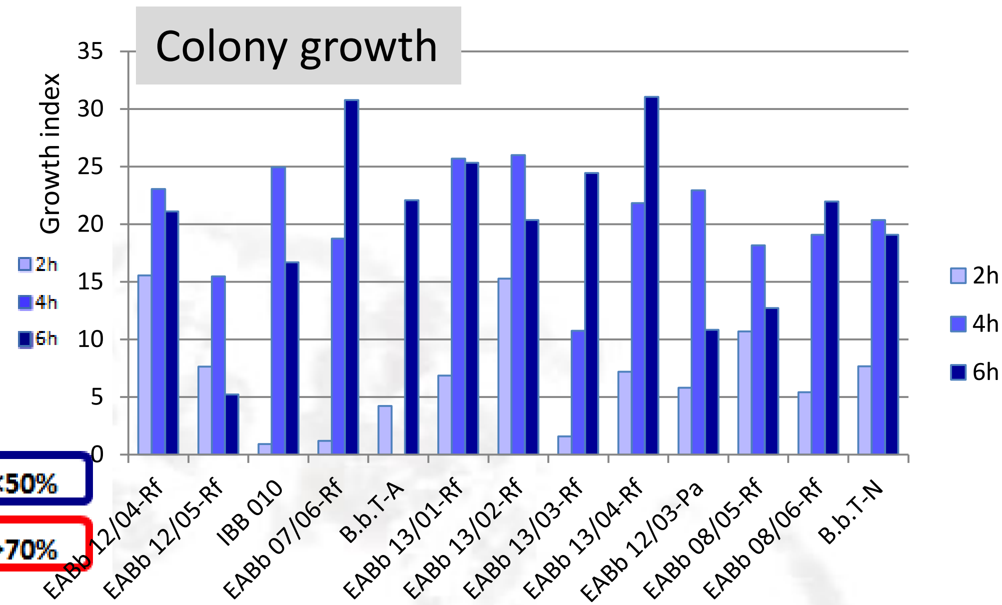
25-30^{0}C

ST "A"

20-30^{0}C

Effect of ultraviolet radiation (UV-B) on conidial germination culturability and colony growth





Culturability (%)

Isolate	1200 mW m^{-2} 2h		4h		6h	
EABb 12/04-Rf	86,19 ± 6,53	b	85,5 ± 2,95	abc	61,24 ± 0,76	efg
EABb 12/05-Rf	100,00 ± 0,00	e	73,9 ± 1,61	abc	43,91 ± 8,22	ef
IBB 010	99,59 ± 0,41	e	83,7 ± 8,25	abc	16,63 ± 1,91	ab
EABb 07/06-Rf	91,67 ± 8,33	de	90,5 ± 4,76	ab	100,00 ± 0,00	a
B.b.T-A	92,81 ± 6,11	e	71,8 ± 9,12	bc	54,63 ± 3,34	fg
EABb 13/01-Rf	98,67 ± 1,09	bc	91,2 ± 1,88	ab	95,3 ± 4,70	ab
EABb 13/02-Rf	86,19 ± 4,52	a	100,0 ± 0,00	a	92,87 ± 6,24	ab
EABb 13/03-Rf	90,85 ± 4,64	de	91,9 ± 3,16	ab	85,43 ± 0,45	abc
EABb 13/04-Rf	92,41 ± 4,34	de	81,5 ± 2,98	abc	85,43 ± 0,45	bcd
EABb 12/03-Pa	100,00 ± 0,00	de	95,4 ± 2,47	ab	73,23 ± 6,65	cde
EABb 08/05-Rf	84,80 ± 7,87	cd	59,1 ± 9,68	c	38,60 ± 6,03	ab
EABb 08/06-Rf	100,00 ± 0,00	bc	60,6 ± 6,14	c	90,58 ± 5,87	g
B.b.T-N	100,00 ± 0,00	bc	71,2 ± 2,68	bc	89,19 ± 6,24	def

ST "B"

ST "A"

Red palm weevil control by entomopathogenic microorganisms

Fungi

***B. bassiana* strains obtained from RPW in the Mediterranean basin are highly adapted to Mediterranean conditions (environmental competence) explaining high prevalence among RPW (and PBM)**

Red palm weevil control by entomopathogenic microorganisms

Fungi

- Molecular study of the isolates:
  - Elongation factor (EF1-α)
  - Combined analysis (EF1-α–BLOC)
  - ISSR
- Effect of humidity, temperature, and UV
- **Pathogenicity and virulence against *R. ferrugineus* pupae and adults**

Red palm weevil control by entomopathogenic microorganisms

Fungi

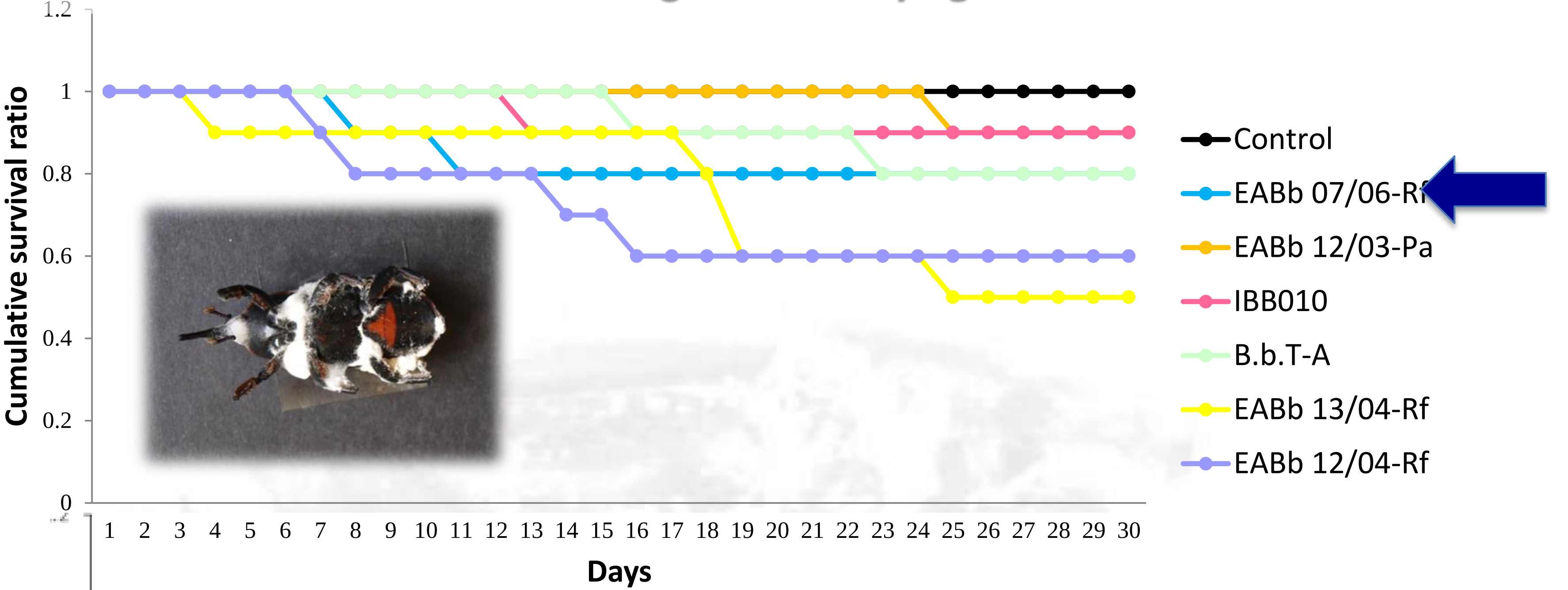
Project KBBE-2011-5-289566. Strategies for the eradication and containment of the invasive pests *Rhynchophorus ferrugineus* Olivier and *Paysandisia archon* Burmeister (2011-2015) PALM PROTECT

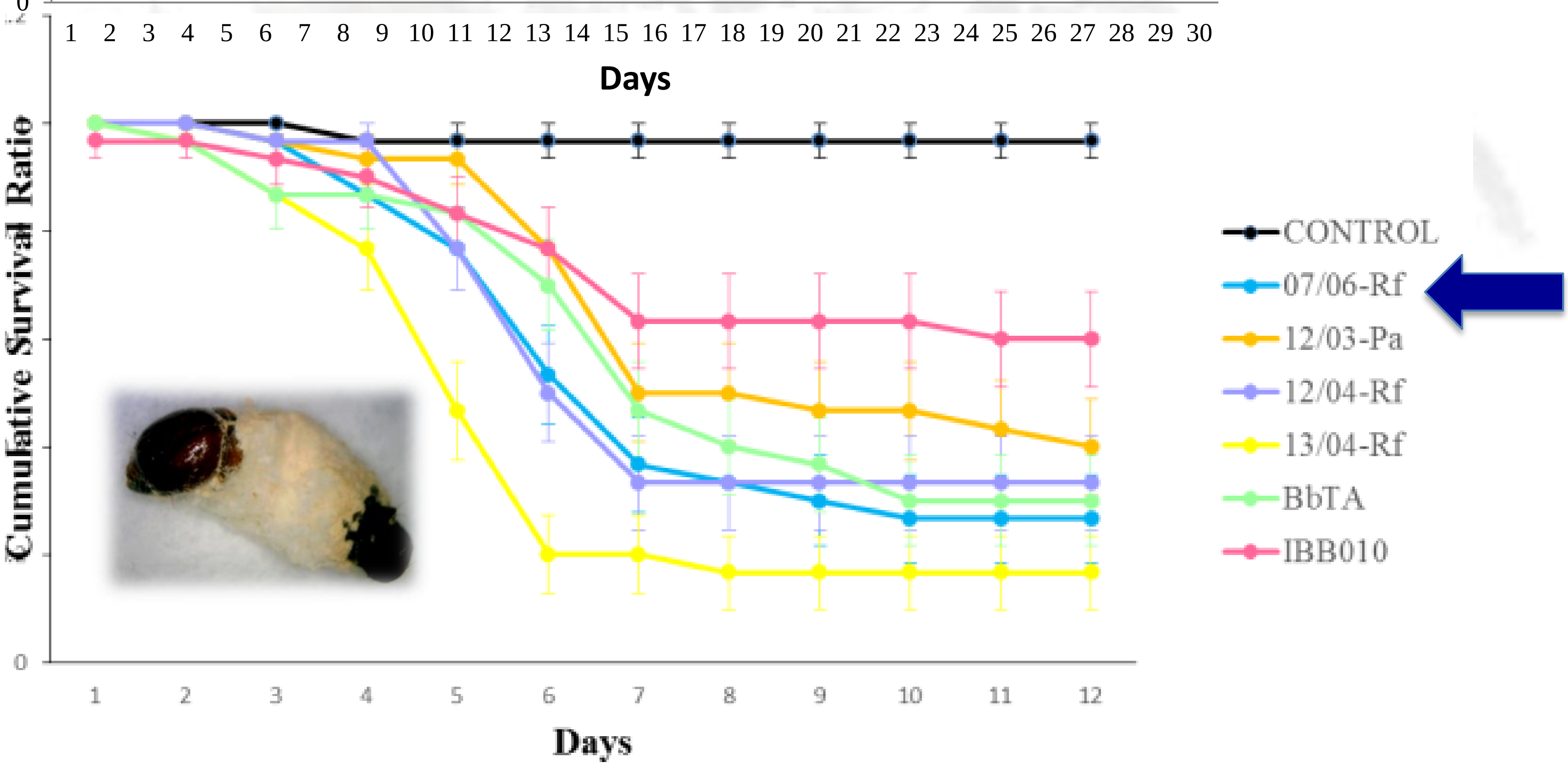
Entomopathogenic fungi for RPW control

Natural incidence and environmental competence

Laboratory and semifield trials

B. bassiana isolates have revealed high effectivity against larvae and adult RPW





Red palm weevil control by entomopathogenic microorganisms

Fungi

Beauveria bassiana EABb 07/06-Su strain virulence towards different RPW stages and instars

Probit lines adjusted to mortality data of *R. ferrugineus* different stages when exposed to *B. bassiana* in the laboratory.

Stage	Time (days)	*n*	Slope ± SE	χ^2	*P*-value[a]	LC_{50} (conidia/ml)	95% *FL*
Eggs	4	144	0.706 ± 0.194	0.1823	0.9129	1.5×10^8	1.1×10^7–5.6×10^8
Neonate	4	144	1.384 ± 0.260	0.5184	0.7717	3.7×10^8	1.8×10^8–6.5×10^8
Fourth instar	4	120	1.561 ± 0.246	0.1575	0.9243	6.3×10^7	3.7×10^7–1.0×10^8
Lab adults[b]	21	144	1.471 ± 0.278	0.8021	0.6696	7.2×10^8	3.7×10^8–1.2×10^9
Field adult[b]	21	144	0.861 ± 0.236	0.1217	0.9410	3.0×10^9	1.1×10^9–1.1×10^{10}

Red palm weevil control by entomopathogenic microorganisms

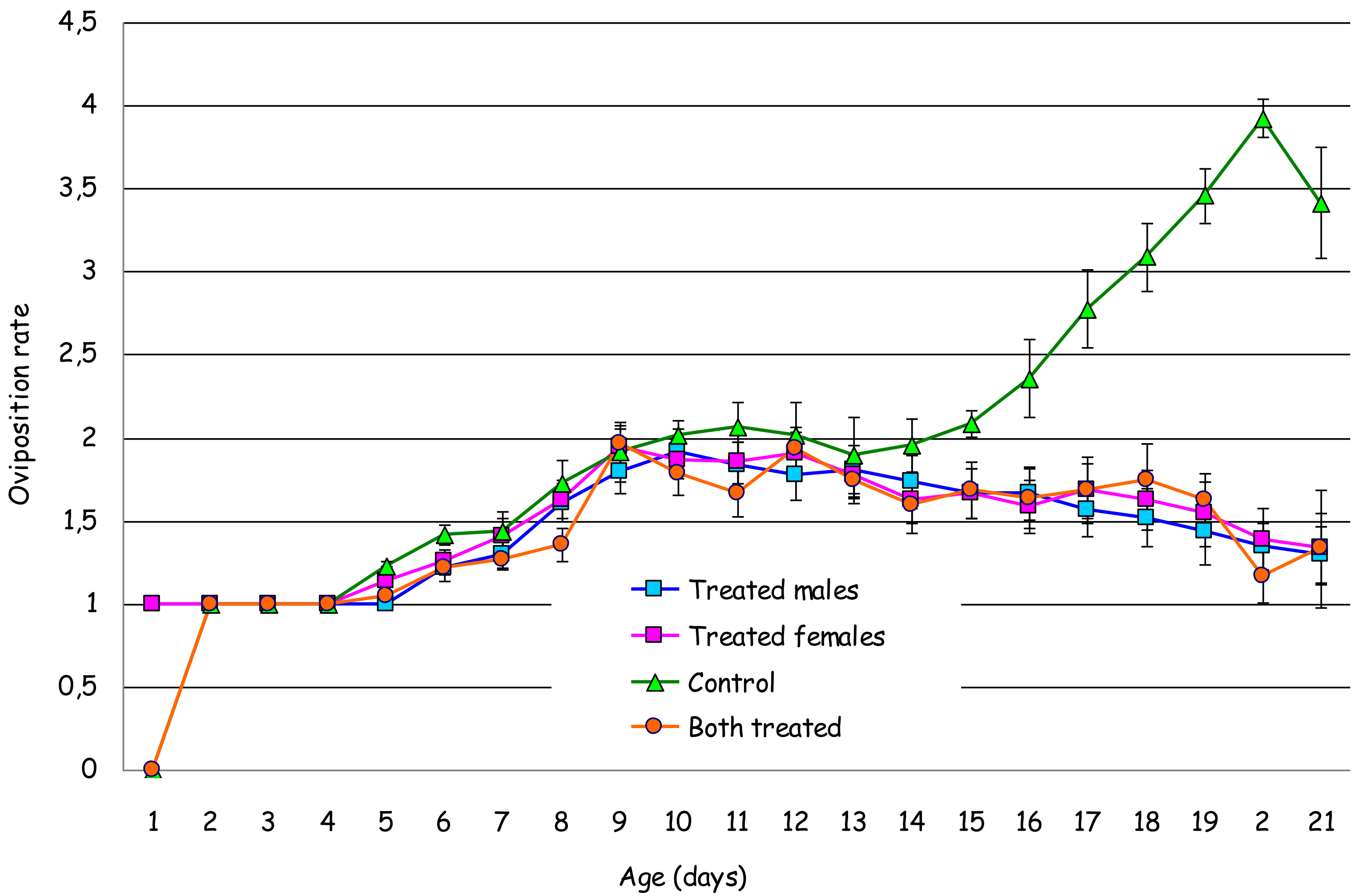
Fungi

But in estimating the full biocontrol potential of *Beauveria bassiana* it is important not only the direct mortality caused by the treatment but also the sublethal reproductive effects and autodissemination potential highly impacting mid and long term population dynamics

Red palm weevil control by entomopathogenic microorganisms

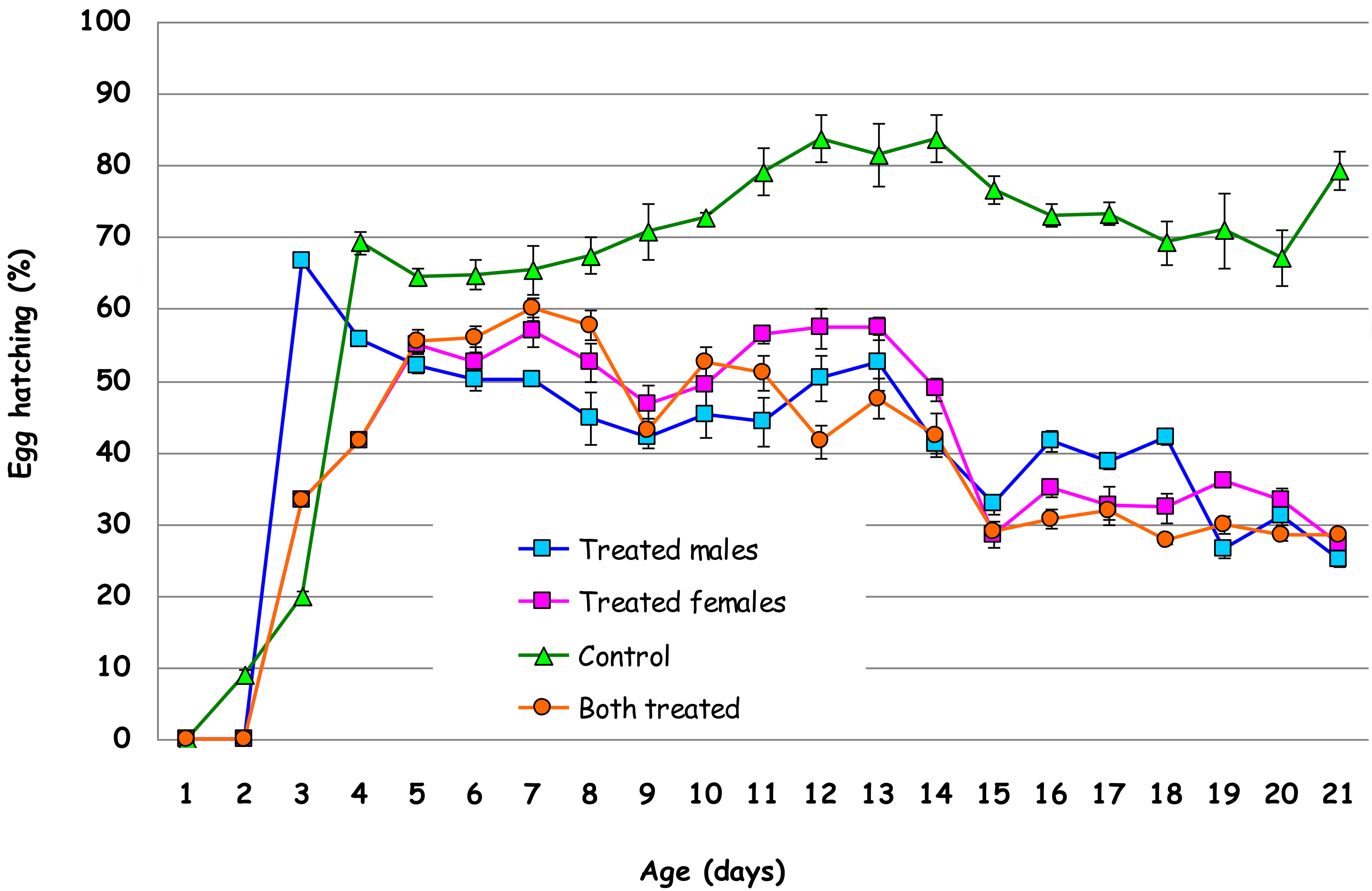
Fungi

Lower fecundity of surviving females



Red palm weevil control by entomopathogenic microorganisms
Fungi

Lower egg viability



Red palm weevil control by entomopathogenic microorganisms

Fungi

Project KBBE-2011-5-289566. Strategies for the eradication and containment of the invasive pests *Rhynchophorus ferrugineus* Olivier and *Paysandisia archon* Burmeister (2011-2015) PALM PROTECT

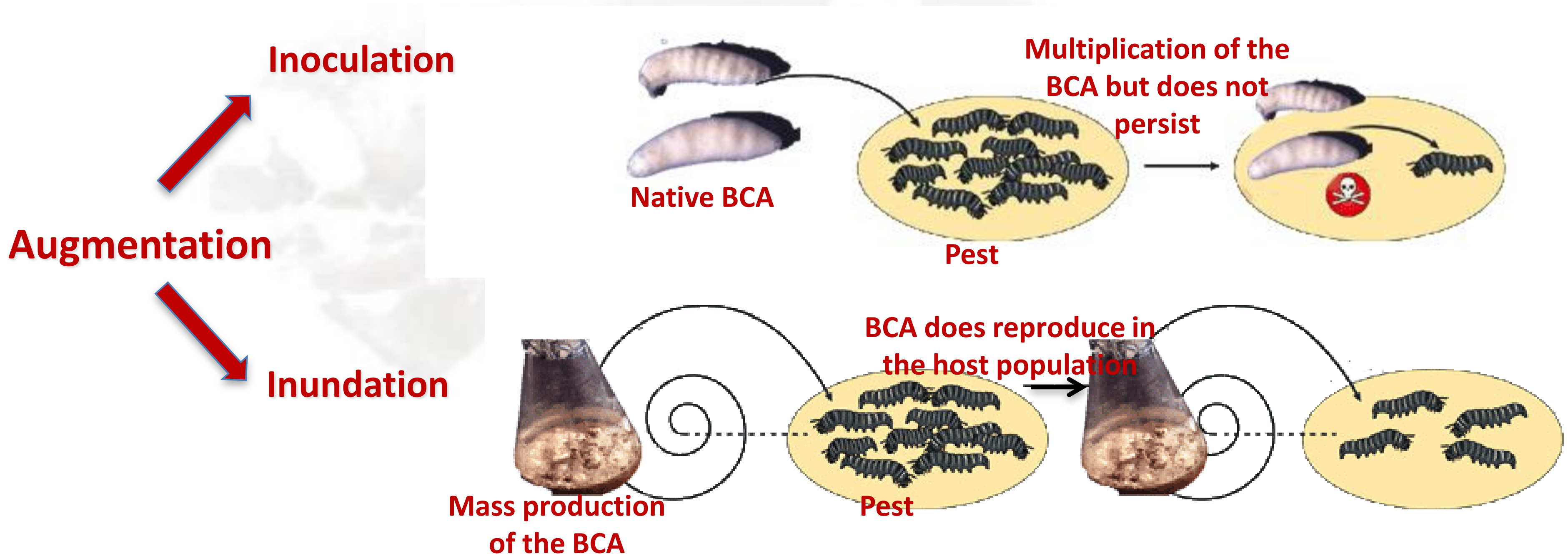
Entomopathogenic fungi for RPW control

Field evaluation

Leaf (crown) sprays

Strategies for the use of microbial control agents for pest control

¡¡Mycoinsecticides¡¡¡¡



BCA: Biological Control Agent

Modifies from: Roderick y Navajas. 2003. Genes in new environments: genetics and evolution in biological control. Nature Reviews Genetics 4, 889-899.

Red palm weevil control by entomopathogenic microorganisms

Fungi

Efficacy of EABb 07/06-Su strain at field conditions by leaf spray

EABb 07/06-Rf

6 plots:

- Campus UJI (**Castelló**)
- **Vila-real** (est. exp.)
- **La Vall d'Uixó** (vivero)
- IVIA (**Montcada**)
- Campus UCO (**Córdoba**) ×2

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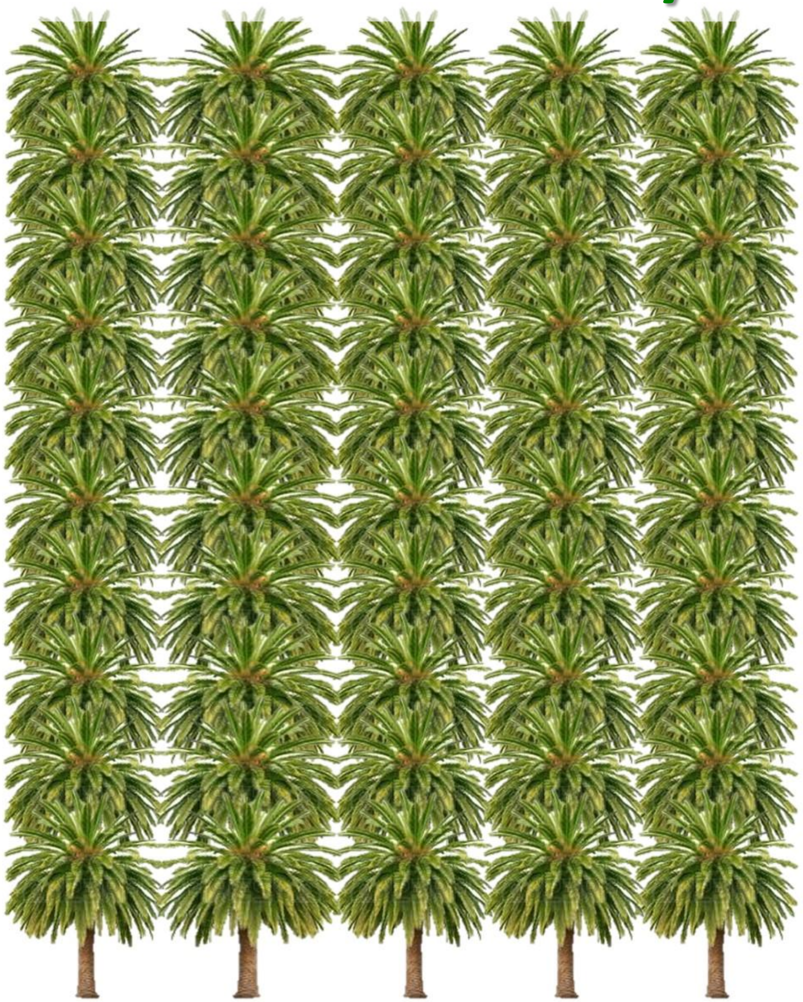
Red palm weevil control by entomopathogenic microorganisms

Fungi

Efficacy of EABb 07/06-Su strain at field conditions by leaf spray



Red palm weevil control by entomopathogenic microorganisms

Fungi

Efficacy of EABb 07/06-Su strain at field conditions

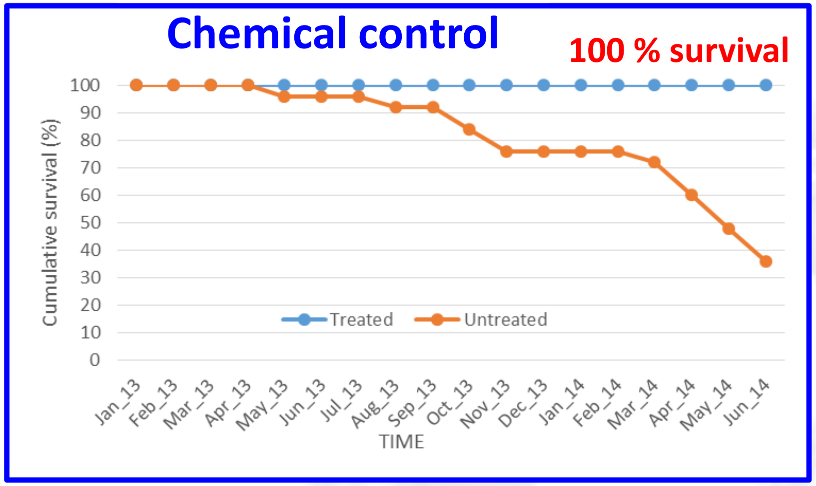
- Chemical control (monthly)
- *Beauveria bassiana* (EABb 07/06-Rf)
    - Monthly
    - Bimonthly
    - Three-monthly

Jan 2013-Jun 2014

Red palm weevil control by entomopathogenic microorganisms

Fungi

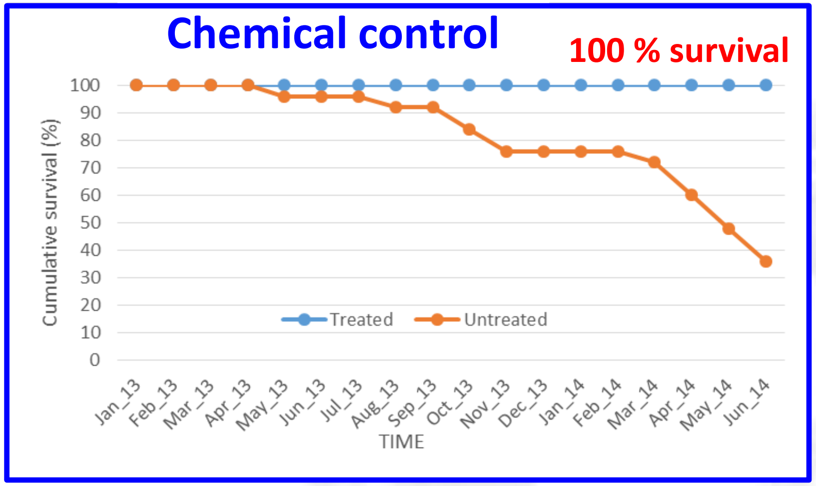
Efficacy of EABb 07/06-Su strain at field conditions

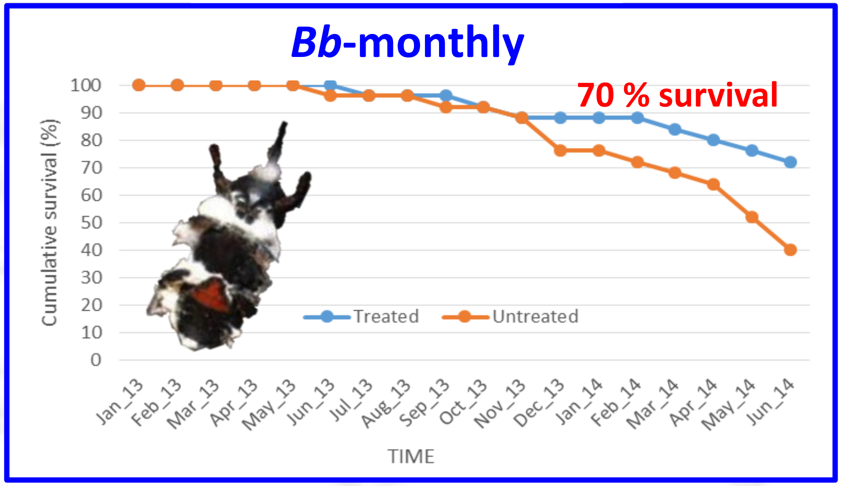


Red palm weevil control by entomopathogenic microorganisms

Fungi

Efficacy of EABb 07/06-Su strain at field conditions

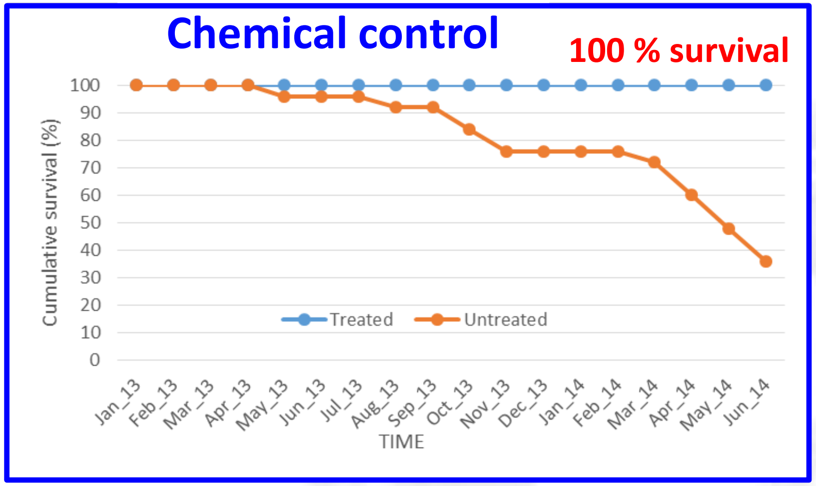


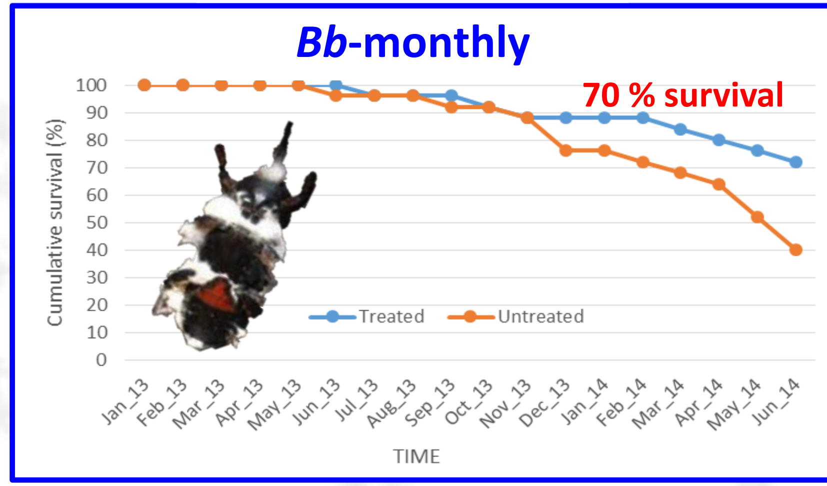


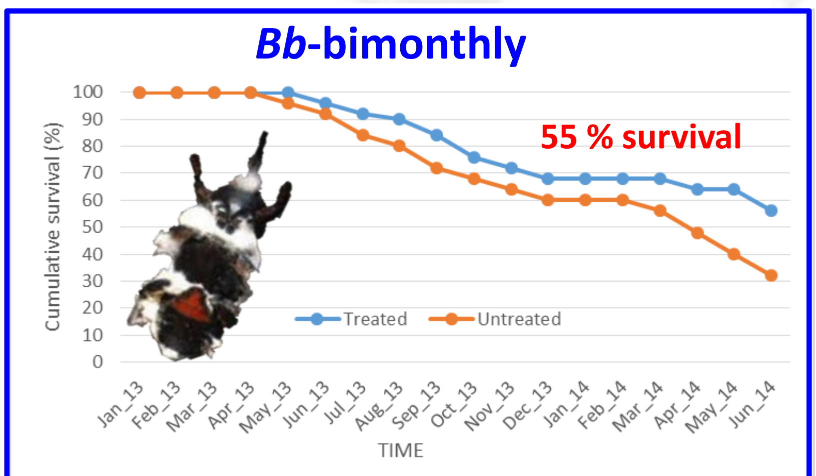
Red palm weevil control by entomopathogenic microorganisms

Fungi

Efficacy of EABb 07/06-Su strain at field conditions



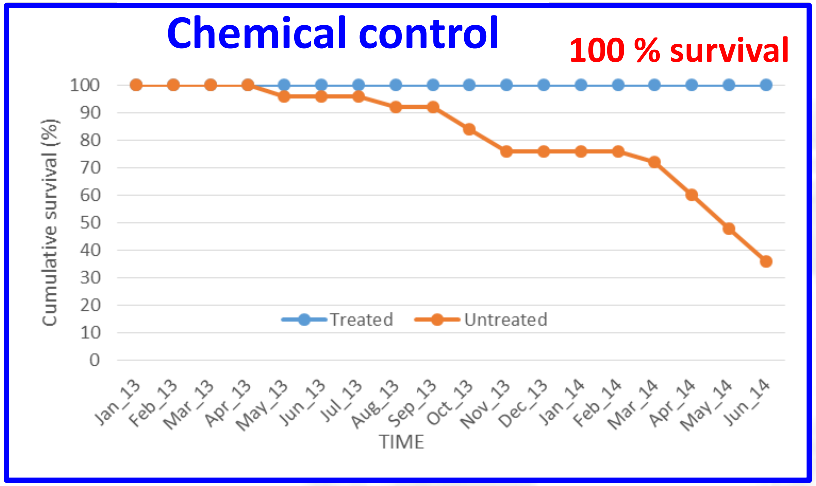


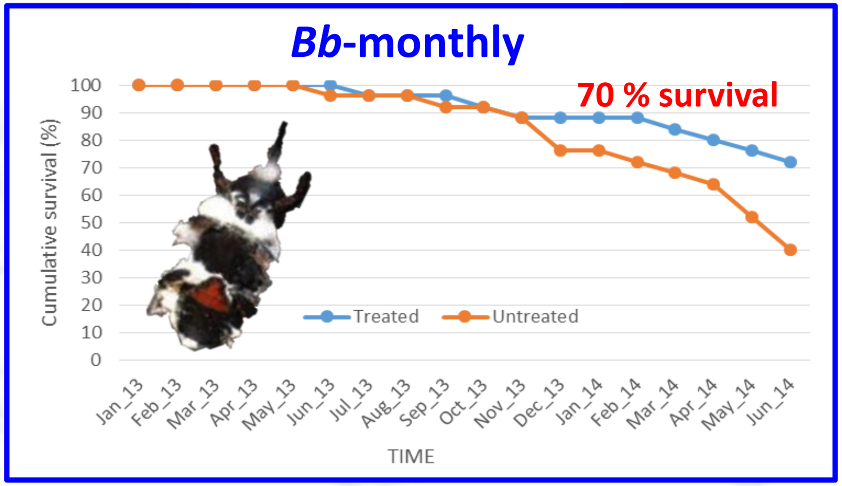


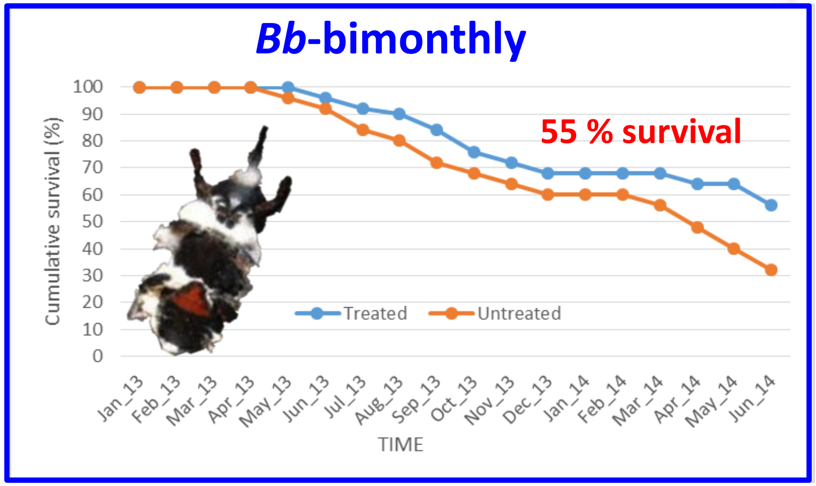
Red palm weevil control by entomopathogenic microorganisms

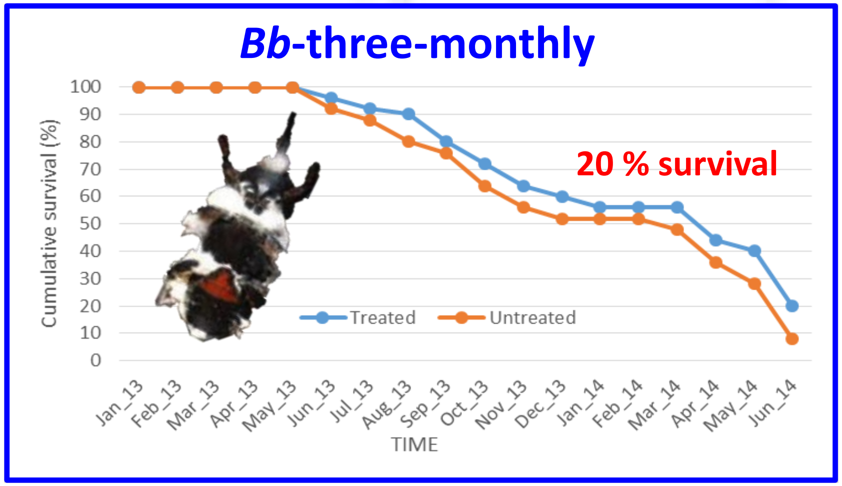
Fungi

Efficacy of EABb 07/06-Su strain at field conditions





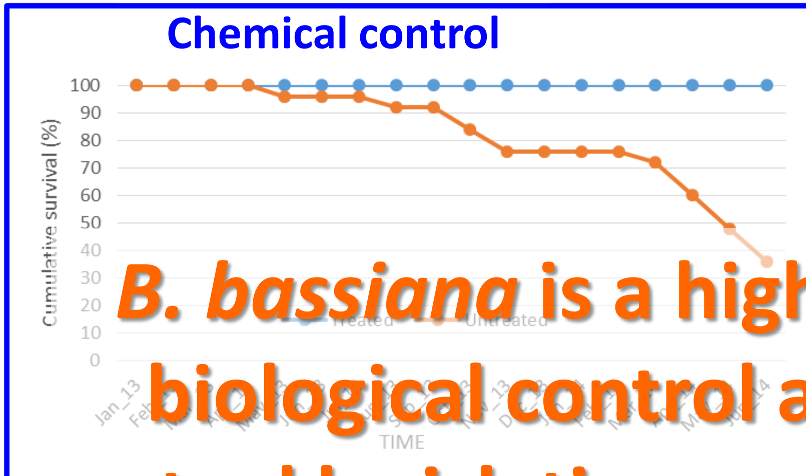


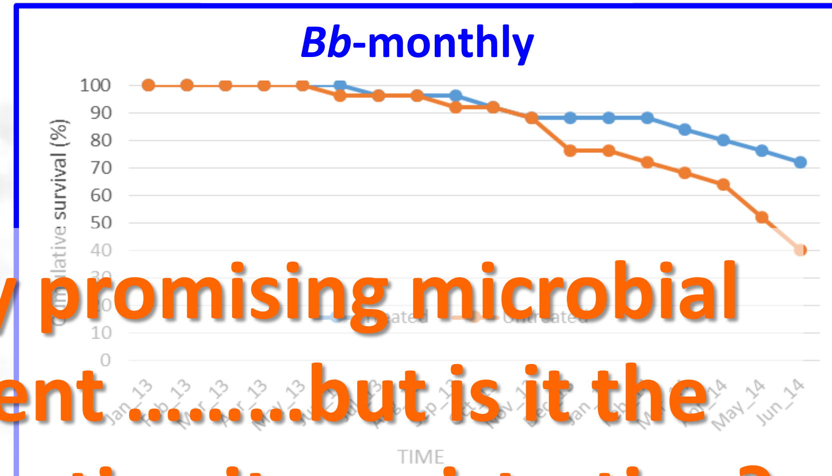


Red palm weevil control by entomopathogenic microorganisms

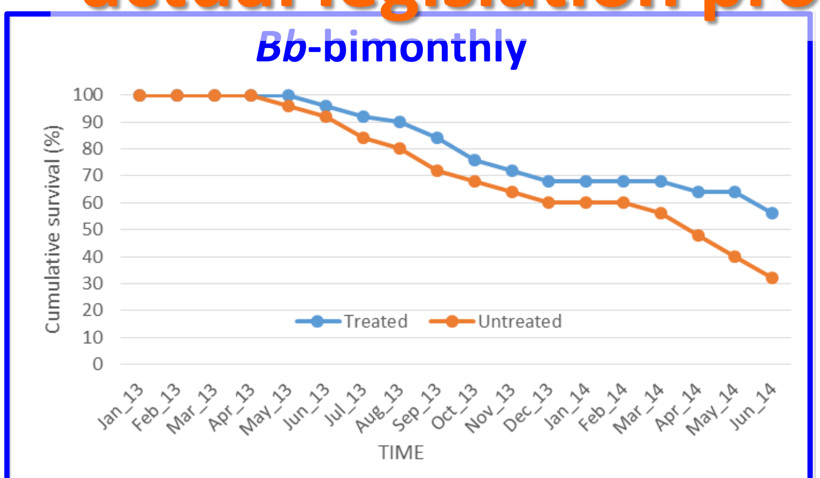
Fungi

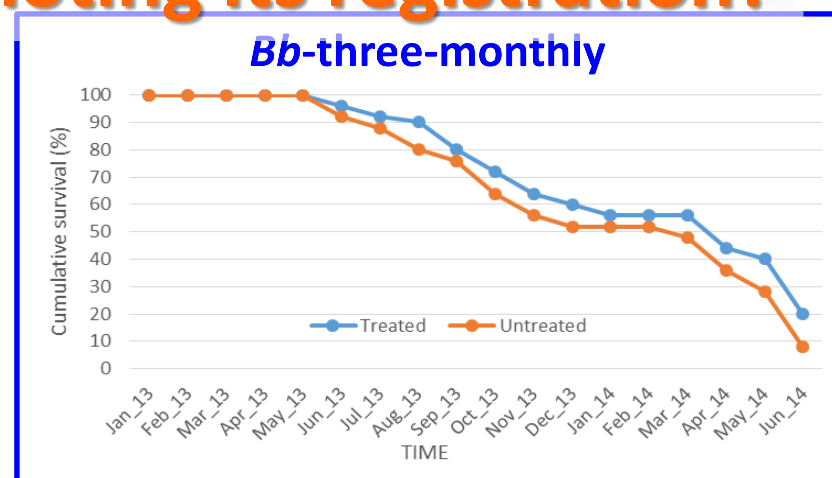
Efficacy of EABb 07/06-Su strain at field conditions





B. bassiana **is a highly promising microbial biological control agent ……..but is it the actual legislation promoting its registration?**





Fungi

Project KBBE-2011-5-289566. Strategies for the eradication and containment of the invasive pests *Rhynchophorus ferrugineus* Olivier and *Paysandisia archon* Burmeister (2011-2015) PALM PROTECT

Entomopathogenic fungi for RPW control

Field evaluation

Lure and kill

Red palm weevil control by entomopathogenic microorganisms

Fungi

Efficacy of EABb 07/06-Su strain at field conditions by the lure & kill (attract-and-infect) strategy

EABb 07/06-Rf

Since R. ferrugineus adults are mobile they can vector the fungus to less reachable areas and spread it to cryptic individuals and/or life stages, which are otherwise hard to eradicate.

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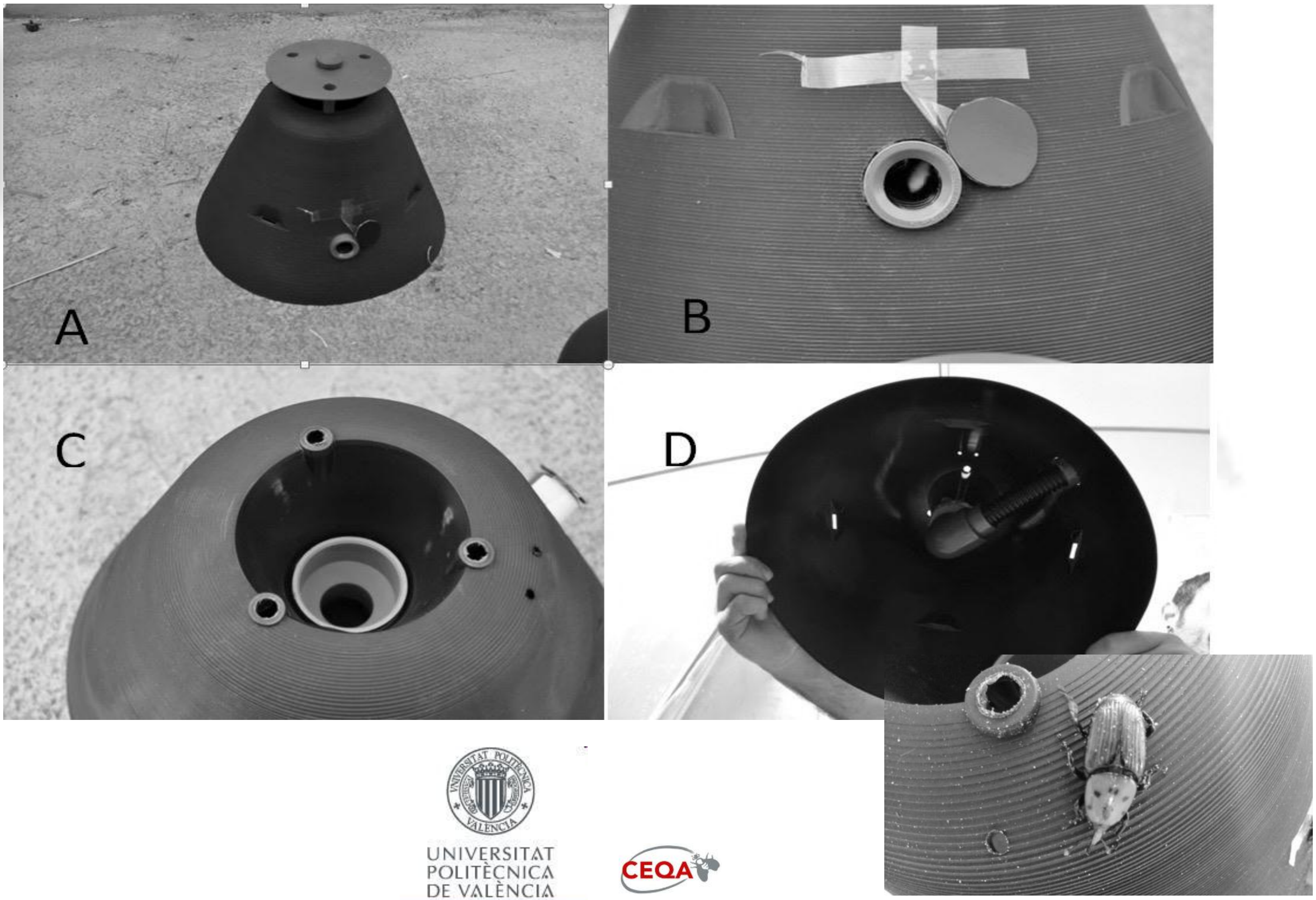
Design of a better trap based on existing "Picusan" trap to be developed as a attract and infect device (lure & kill device)



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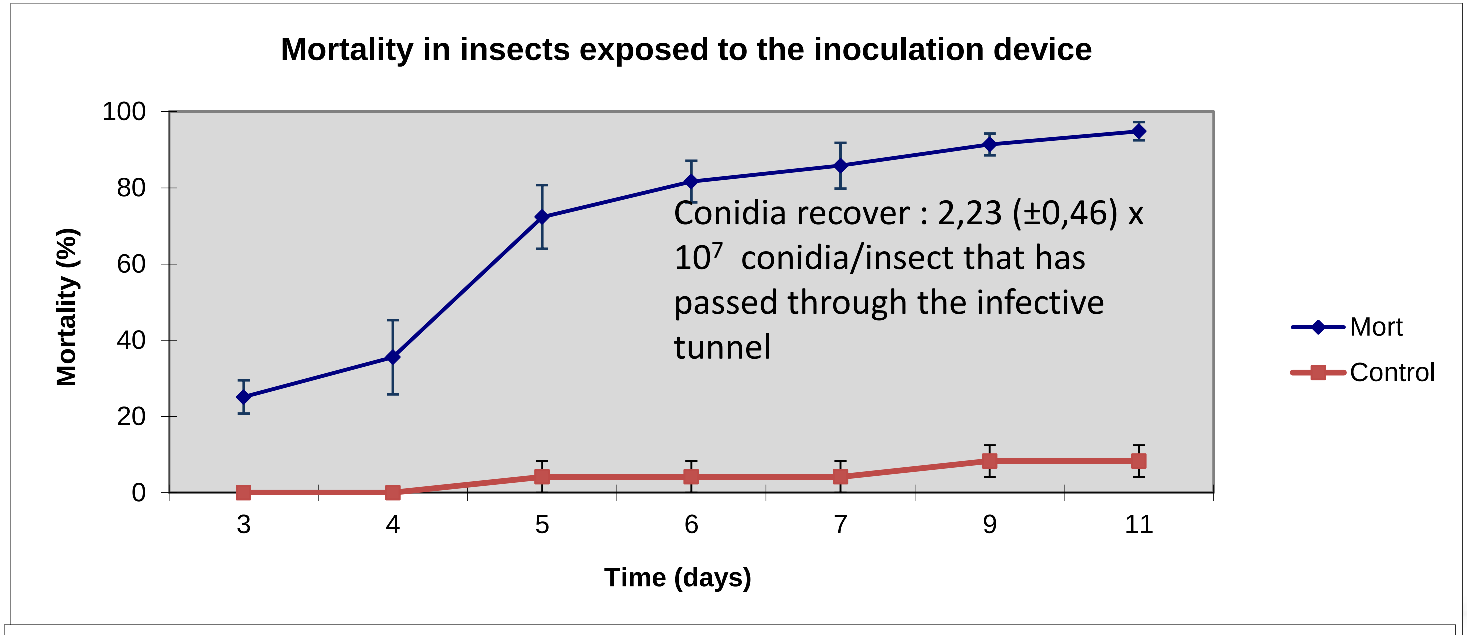
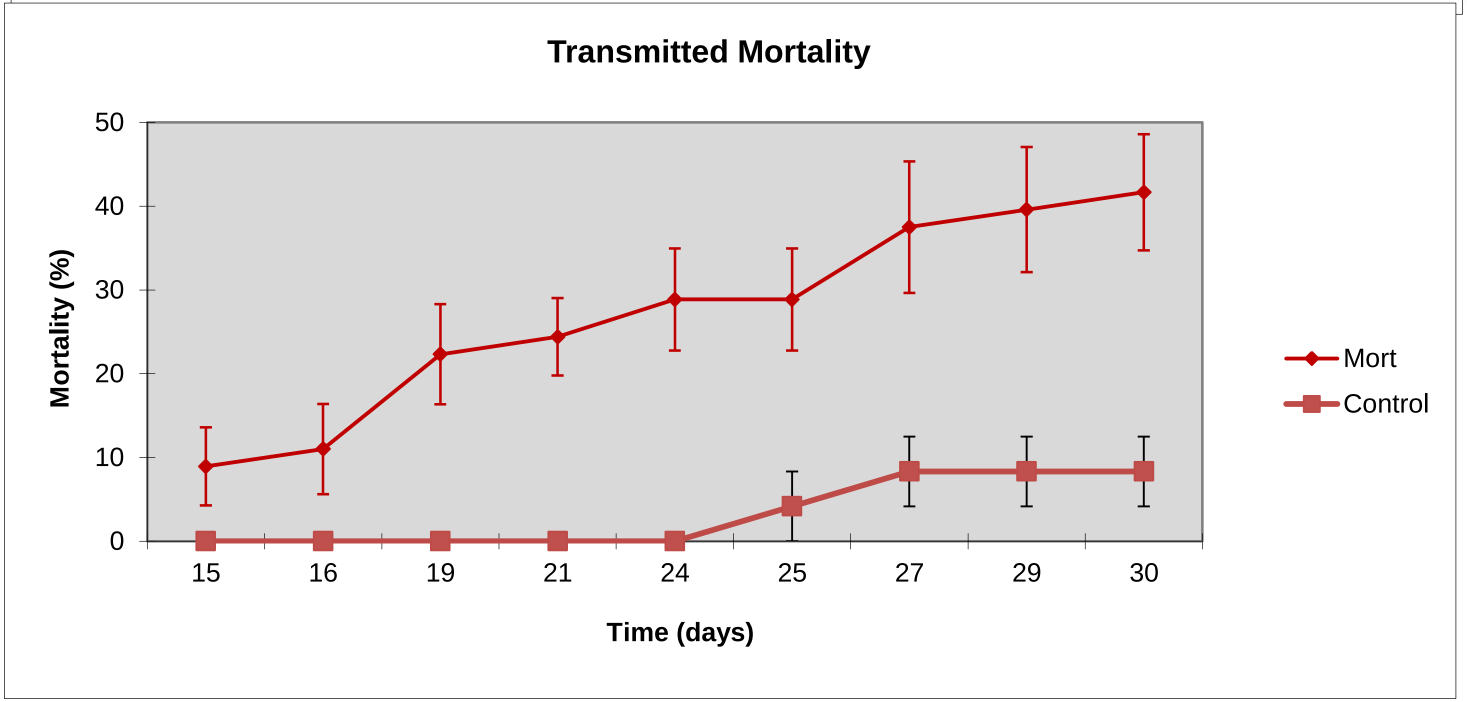
Ongoing work.....promissing...........



Infectivity



Horizontal transmission

Handmade lure & kill device

Arundo donax Cane inoculated with EABb 07/06 Rf

Arundo donax L. (poales:poaceae)

Red palm weevil control by entomopathogenic microorganisms

Fungi

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Entomopathogenic fungi for RPW control

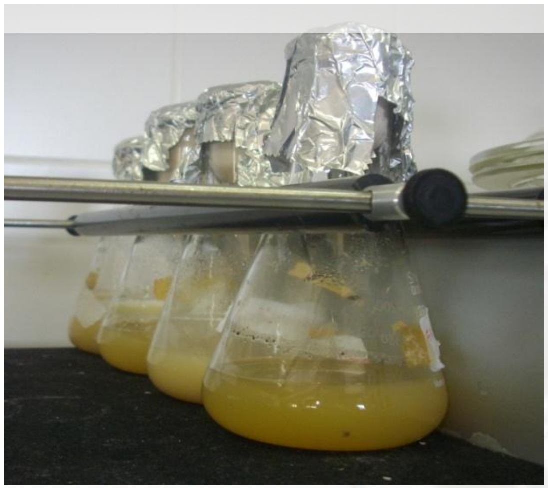
PALM PROTECT

Insecticidal compounds from EPF

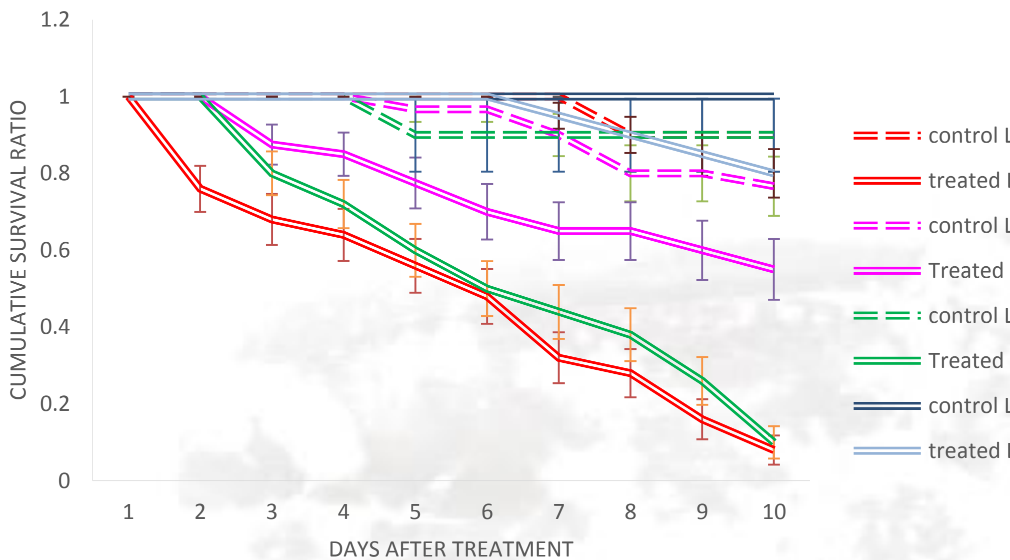
Red palm weevil control by entomopathogenic microorganisms

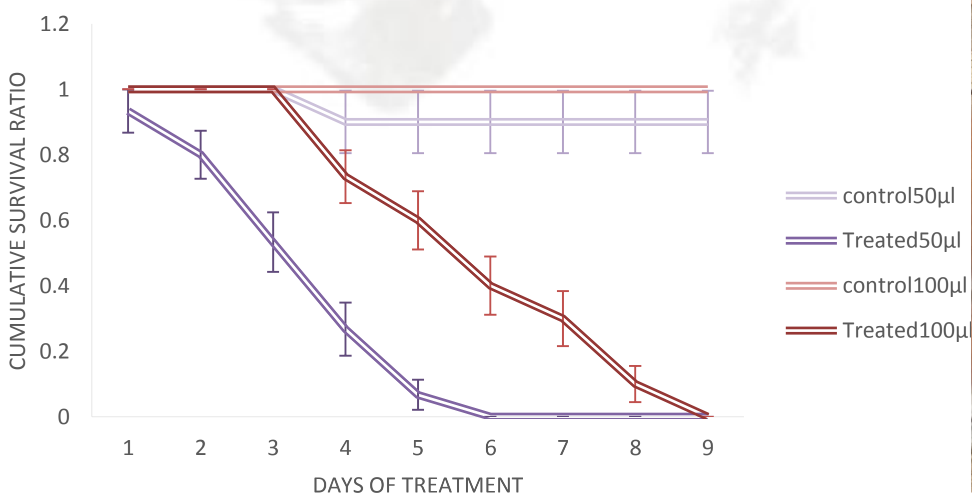
Fungi

EMA are able to produce high-molecular-weight proteins or low molecular weight secondary metabolites that can also applied against *R. ferrugineus* adults and larvae



Evaluation of EAMb 09/01-Su strain extract against *R. ferrugineus* larvae and adults





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✓To Prof. Jaime Primo and Dr. Vicente Navarro

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✓To FAO for this opportunity

Many thanks for your attention……..