

A background image of a tomato plant with several ripe red tomatoes and some unripe green ones. The text is overlaid on a white rectangular box in the upper half of the image.

Prospects for the biological control of *Tuta absoluta* in tomatoes of the Mediterranean basin

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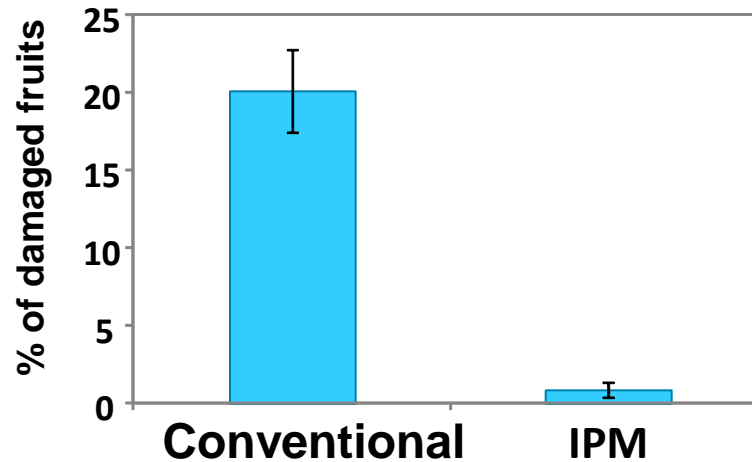
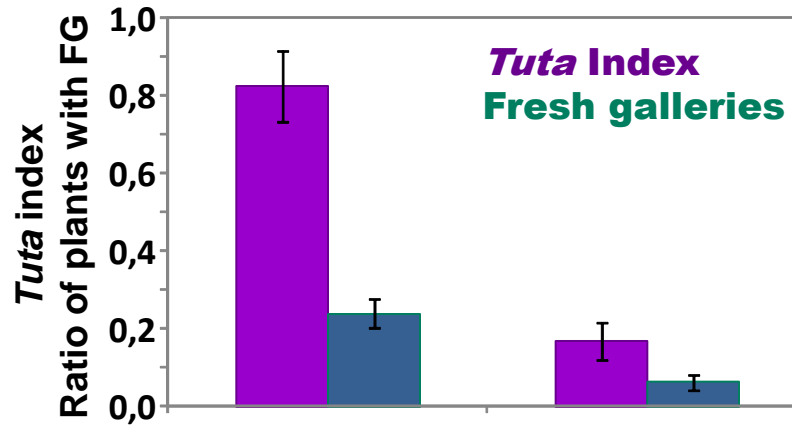
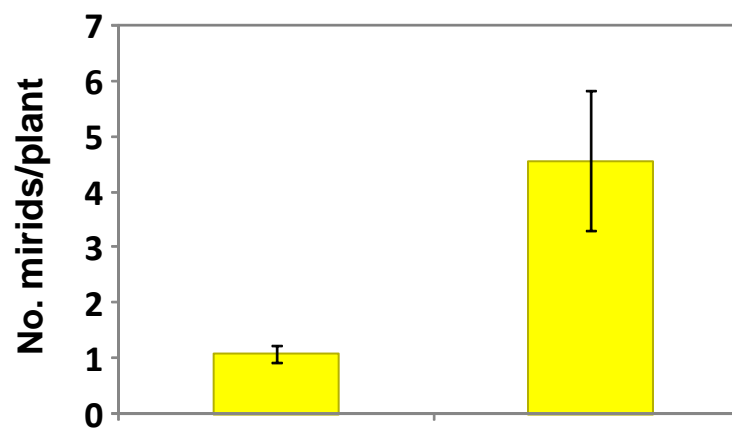
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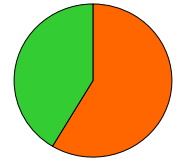
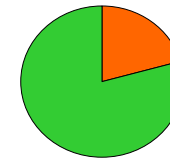
Pest control in tomato early after *Tuta* invasion

- Integrated Pest Management Programs based on the inoculation and / or conservation of biological control agents were widely applied (polyphagous predators)
- First results on effective indigenous predators acting on this exotic pest (fortuitous biological control)
- Effective insecticides not highly toxic for natural enemies
- Biological control as a promising option in its area of origin: parasitoids successfully being used to manage *T. absoluta*
- Survey for native natural enemies of *T. absoluta*

IPM experience in 2008



N= 109



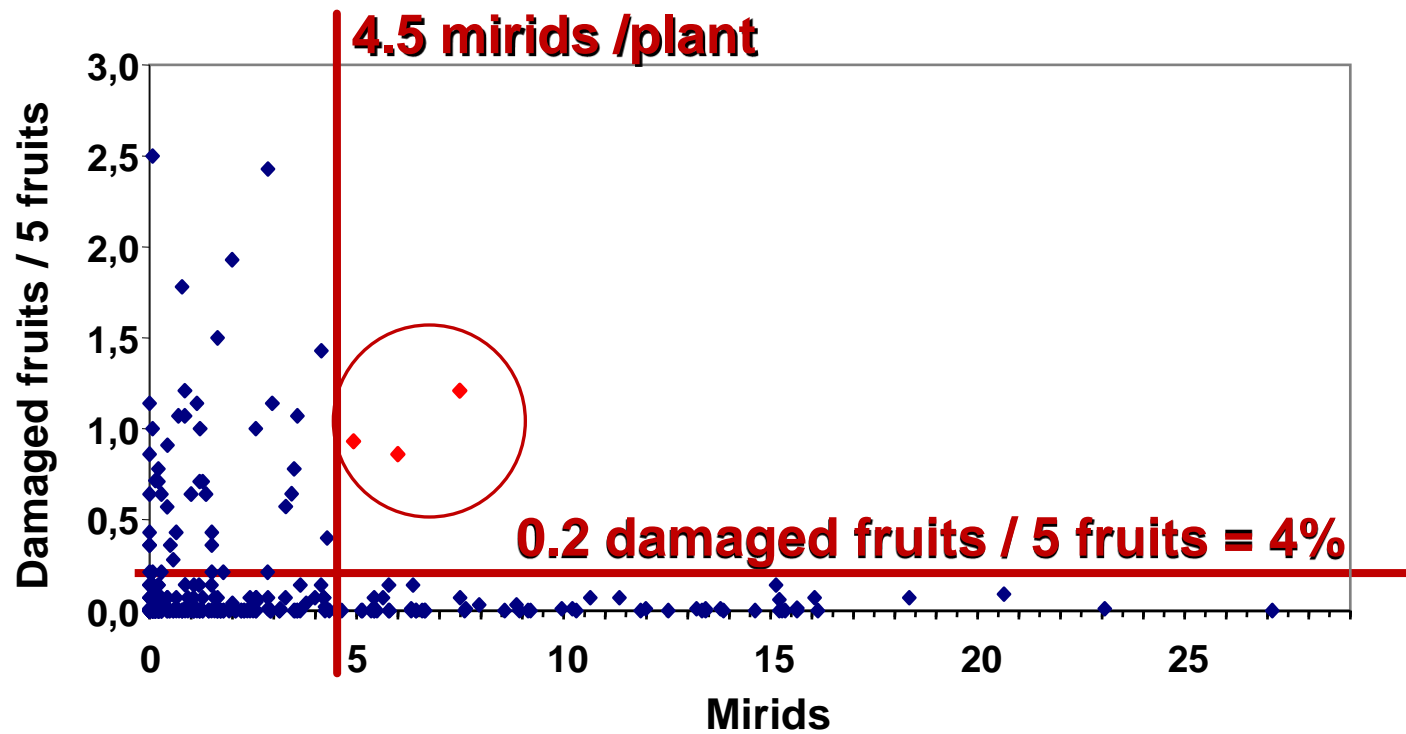
Conventional IPM

Macrolophus
Nesidiocoris

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IPM experience in 2008



Parasitoids of *Tuta absoluta* reported in the Mediterranean basin

Family	Species	Preference
Eulophidae	<i>Necremnus artynes</i>	L ₂ -L ₃
	<i>Necremnus metalarus</i>	L ₂ -L ₃
	<i>Necremnus tidius</i>	L ₂ -L ₃
	<i>Stenomesus</i> cf. <i>japonicus</i>	L ₂ -L ₃
	<i>Neochrysocharis formosa</i>	L ₁
Braconidae	<i>Habrobracon</i> cf. <i>nigricans</i>	-
	<i>Agathis fuscipennis</i>	-(on <i>Solanum nigrum</i>)
	Braconidae sp.	-
Ichneumonidae	<i>Diadegma ledicola</i>	-
Trichogrammatidae	<i>Trichogramma achaeae</i>	Eggs
	<i>Trichogramma</i> sp.	Eggs

New parasitoid species of *T. absoluta* larvae Northeast Spain (2011)

Family	Species
Eulophidae	<i>Pnigalio soemius</i>
	<i>Miotropis</i> sp.
Braconidae	<i>Cotesia</i> sp.
	<i>Dolichogenidea litae</i>
Ichneumonidae	<i>Temelucha anatolica</i>
	<i>Zoophthorus macrops</i>
Chalcididae	<i>Hockeria unicolor</i>

Predators of *Tuta absoluta* reported on the Mediterranean basin

Order	Family	Species	Preference
Hemiptera	Miridae	<i>Nesidiocoris tenuis</i>	Eggs and L ₁
		<i>Macrolophus pygmaeus</i>	Eggs and L ₁
		<i>Dicyphus marrocannus</i>	Eggs and L ₁
	Anthocoridae	<i>Orius majusculus</i>	Eggs (on potato)
		<i>Orius laevigatus</i>	Eggs (on potato)
	Nabidae	<i>Nabis pseudoferus ibericus</i>	Eggs and larvae
Hymenoptera	Sphecidae	Undetermined species	Larvae
Acari	Phytoseiidae	<i>Amblyseius swirskii</i>	Eggs (on eggplant)
		<i>Amblyseius cucumeris</i>	Eggs (on eggplant)

Entomopathogens

- **Bacteria:**
 - different formulations using *Bacillus thuringiensis* Berliner
- **Fungus:**
 - *Beauveria bassiana*,
 - *Metarhizium anisopliae* var. *anisopliae*
- **Entomopathogenic nematodes:**
 - Steinernematidae
 - *Steinernema carpocapsae*
 - *S. feltiae*
 - Heterorhabditidae
 - *Heterorhabditis bacteriophora*

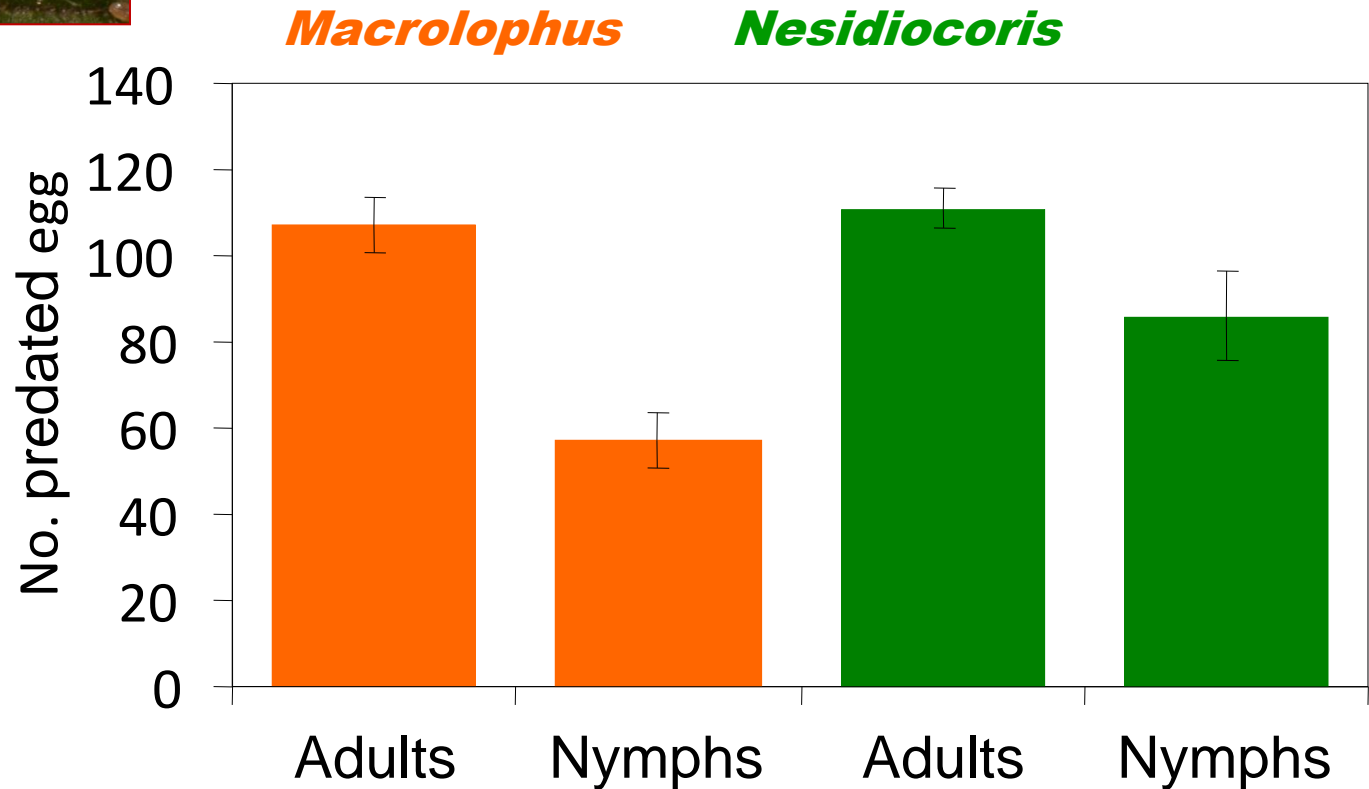
Natural enemies efficacy



Predators

- Species
 - *Nesidiocoris tenuis*
 - *Macrolophus pygmaeus* (*M. melanotoma* or commercially *M. caliginosus*)
- Both species are:
 - polyphagous (whiteflies, thrips, leafminers, aphids, spidermites, and Lepidoptera species)
 - zoophytophagous
 - mass-reared and released

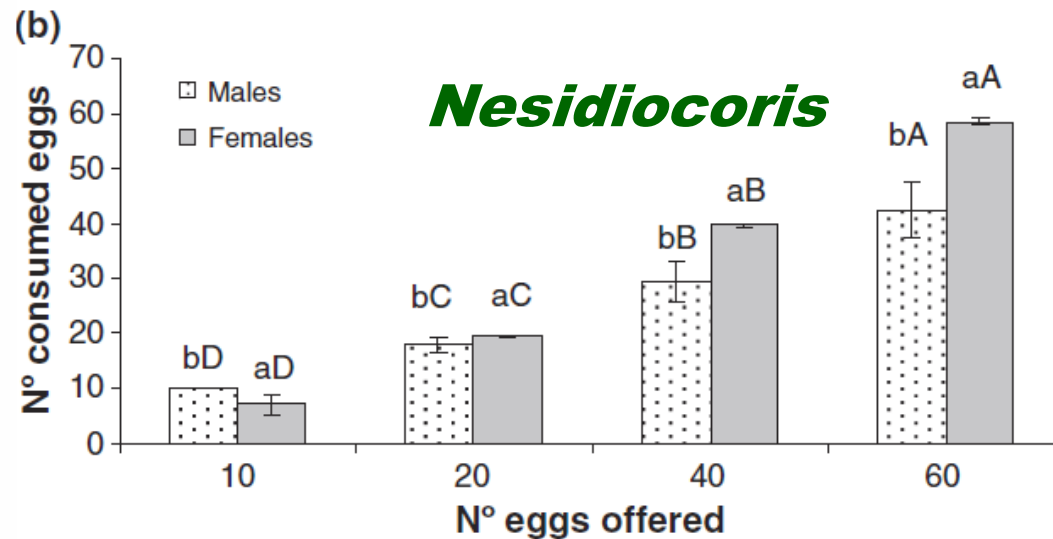
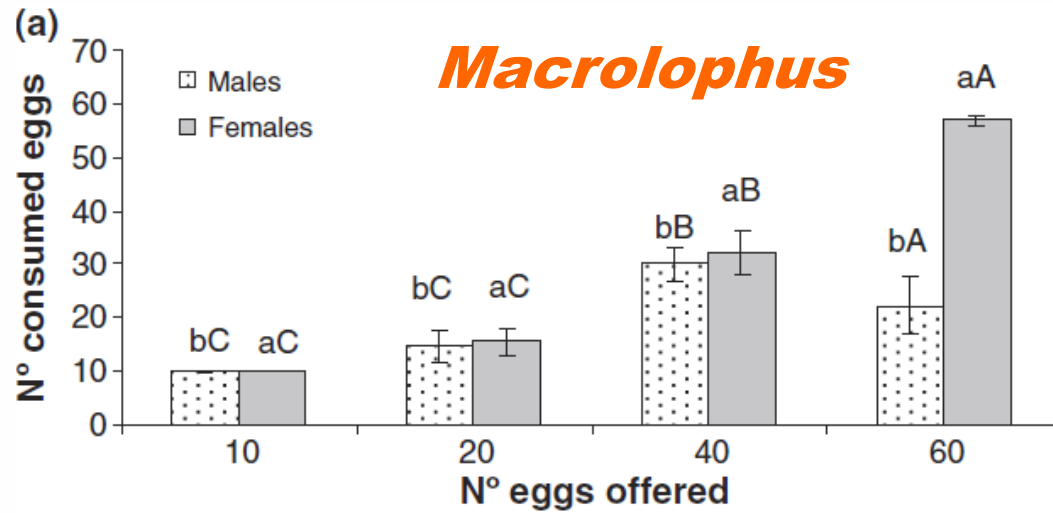
Mirids as *Tuta* predators



Arnó et al. 2009

Trial conditions: 145±5 eggs; 24 h; 25°C; 16:8 (L:D)

Mirids as *Tuta* predators



Urbaneja et al. 2009

Trial conditions: 24 h; 25°C; 16:8 (L:D)

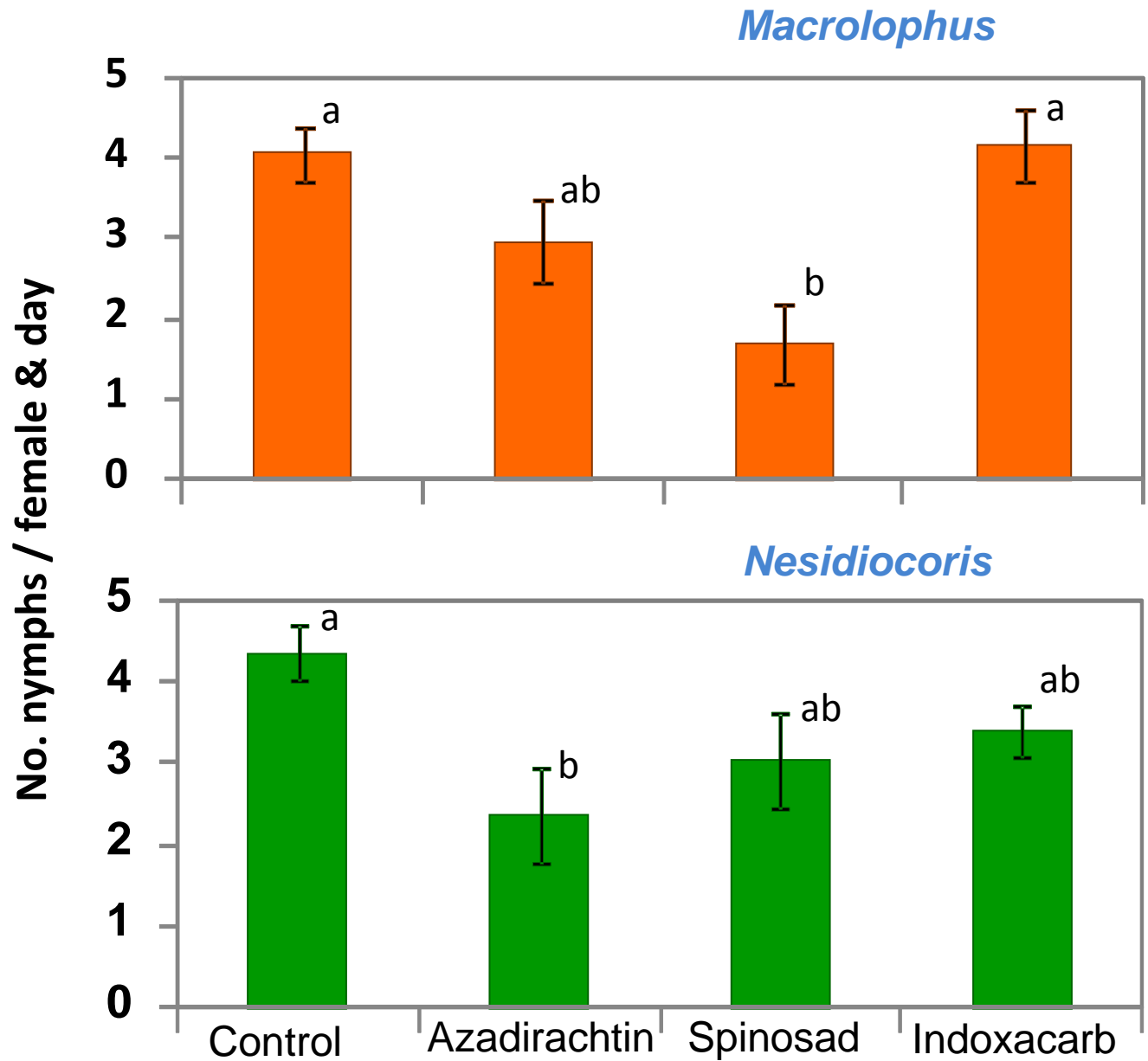
Side effects on mortality

Percentage of predator mortality 7 days after treatment

AI	Females				3 rd -4 th instar nymphs			
	<i>M. pygmaeus</i>		<i>N. tenuis</i>		<i>M. pygmaeus</i>		<i>N. tenuis</i>	
Control	8.0 ± 3.74	b	4.2 ± 2.59	b	0.0 ± 0.00	b	6.9 ± 4.52	b
Azadiracthin	5.0 ± 2.89	b	2.5 ± 2.50	b	3.8 ± 2.34	b	12.4 ± 4.60	b
Spinosad	7.3 ± 4.75	b	8.7 ± 4.13	b	7.4 ± 1.89	b	4.7 ± 2.90	b
Indoxacarb	51.1 ± 12.98	a	76.7 ± 16.32	a	28.3 ± 7.19	a	46.9 ± 7.47	a

(Arnó et al 2011)

Side effects on fertility



(Arnó et al 2011)

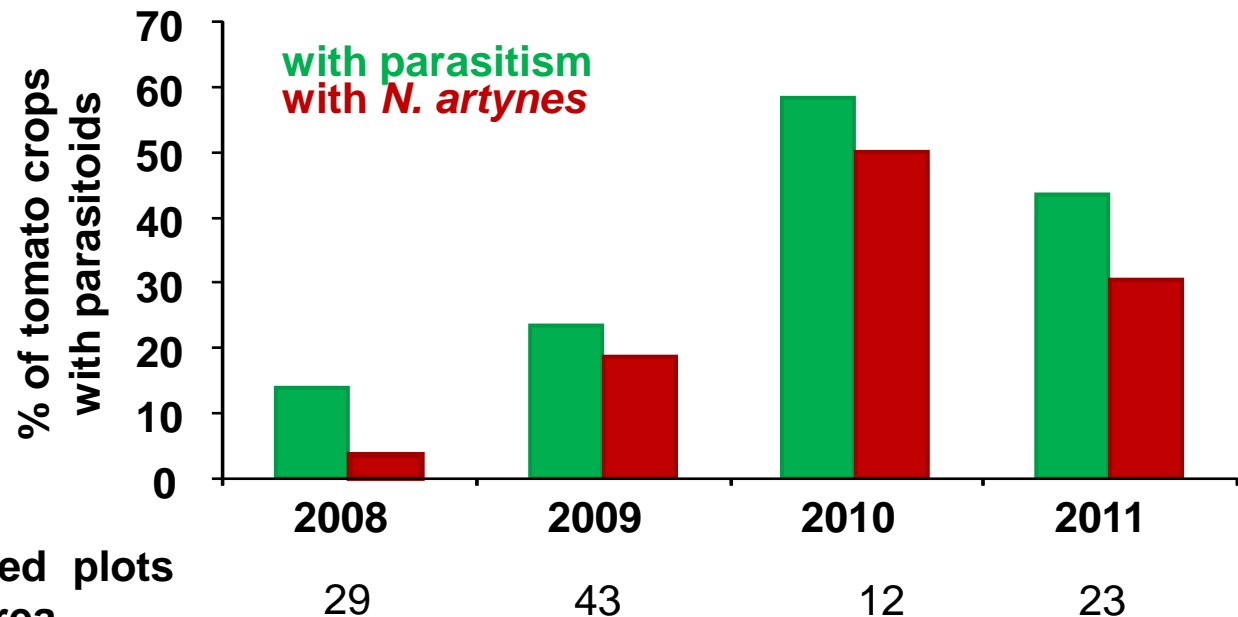
Parasitoids

- *Trichogramma achaeae* mass-reared and released
- *Necremnus artynes* (not commercially available until now)
- Others?

Parasitoids abundance (Spain)

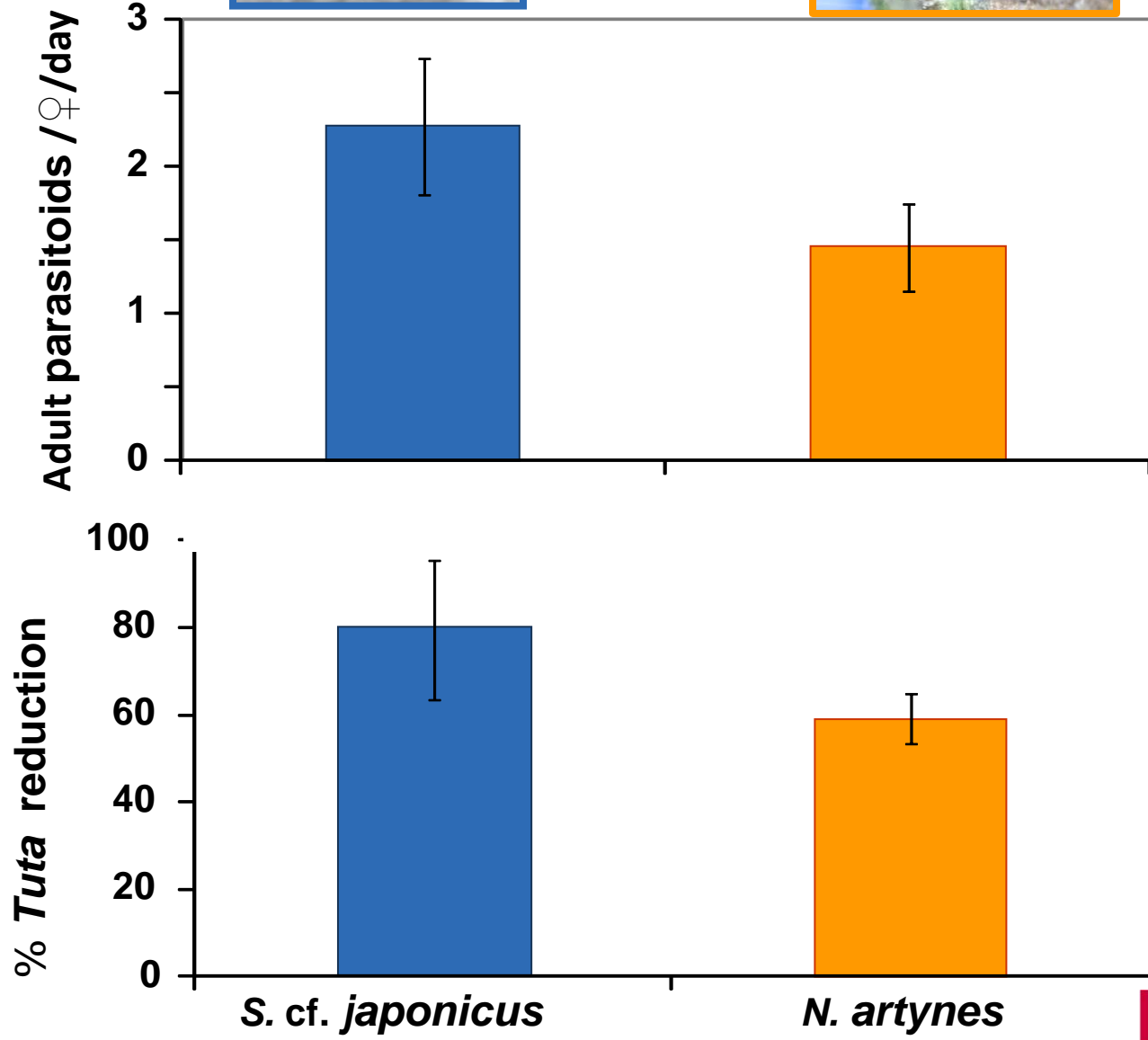


Parasitoid	Distribution	Abundance
<i>N. artynes</i>	More than one area	High in some crops & years
<i>S. cf. japonicus</i>	More than one area	Several years

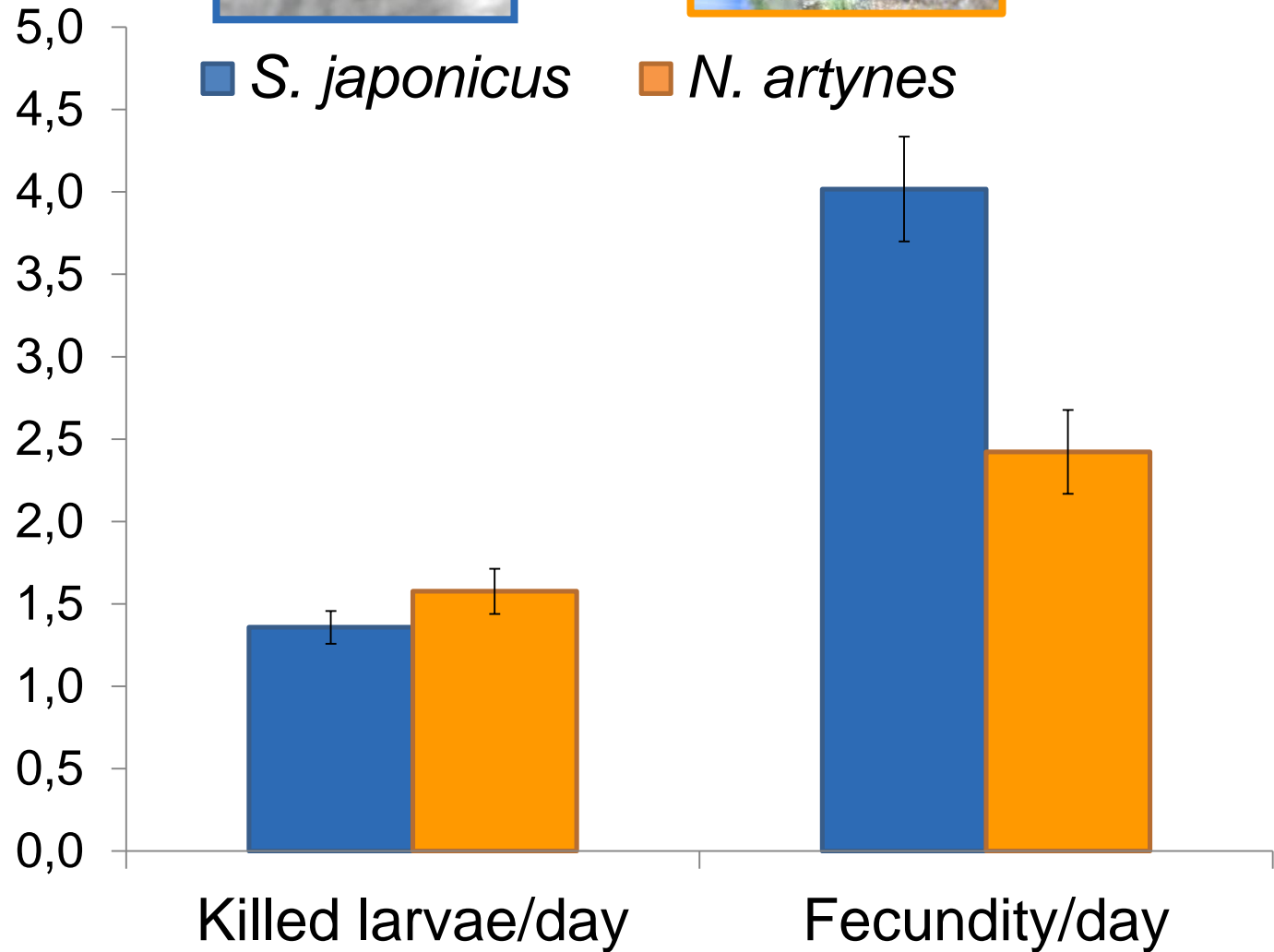


N° of surveyed plots
Barcelona area

Efficacy of *N. artynes* and *S. japonicus*

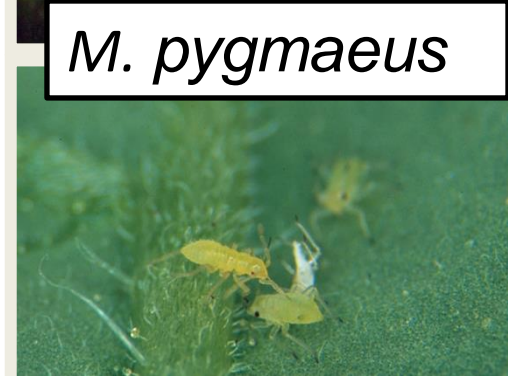
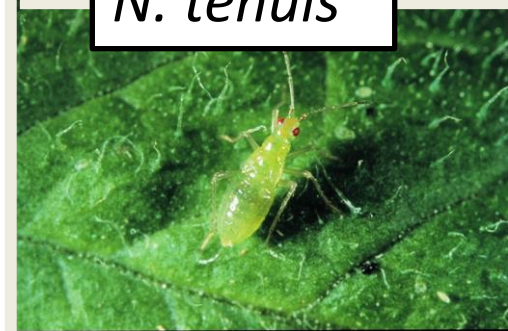


N. artynes and *S. japonicus* biology

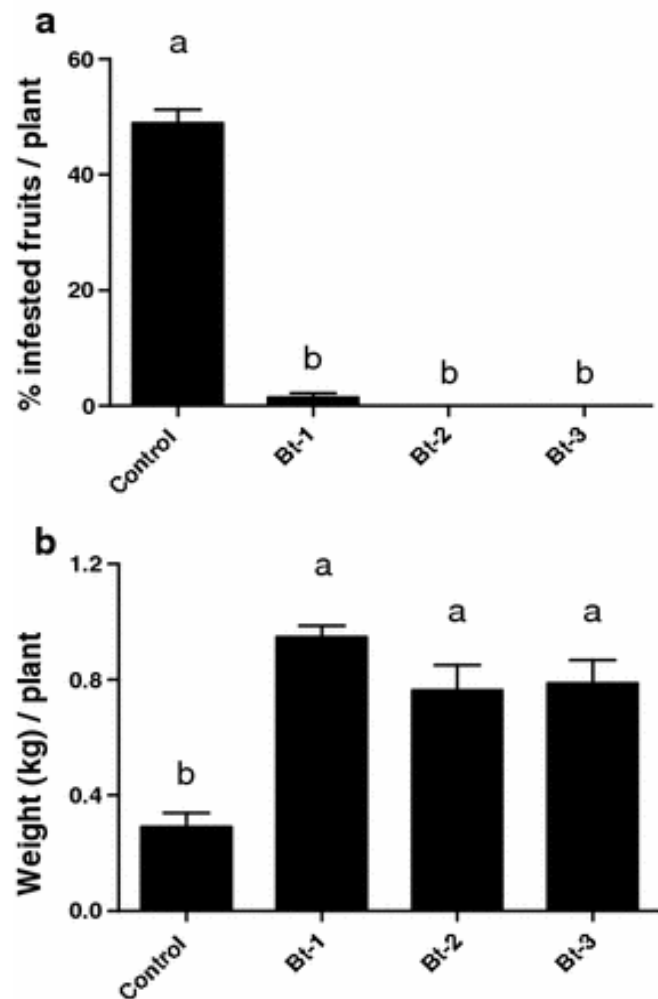


Current strategies for biological control of *T. absoluta*

- *N. tenuis* and *M. pygmaeus*
 - Inoculative releases
 - Conservation
 - Banker -plants
 - Releases in plant nurseries
- Treatments with *B. thuringiensis*
- Treatments with selective insecticides
- Releases of *T. achaeae*



Combined action of *B. thuringiensis* and *N. tenuis* (Molla et al 2011)



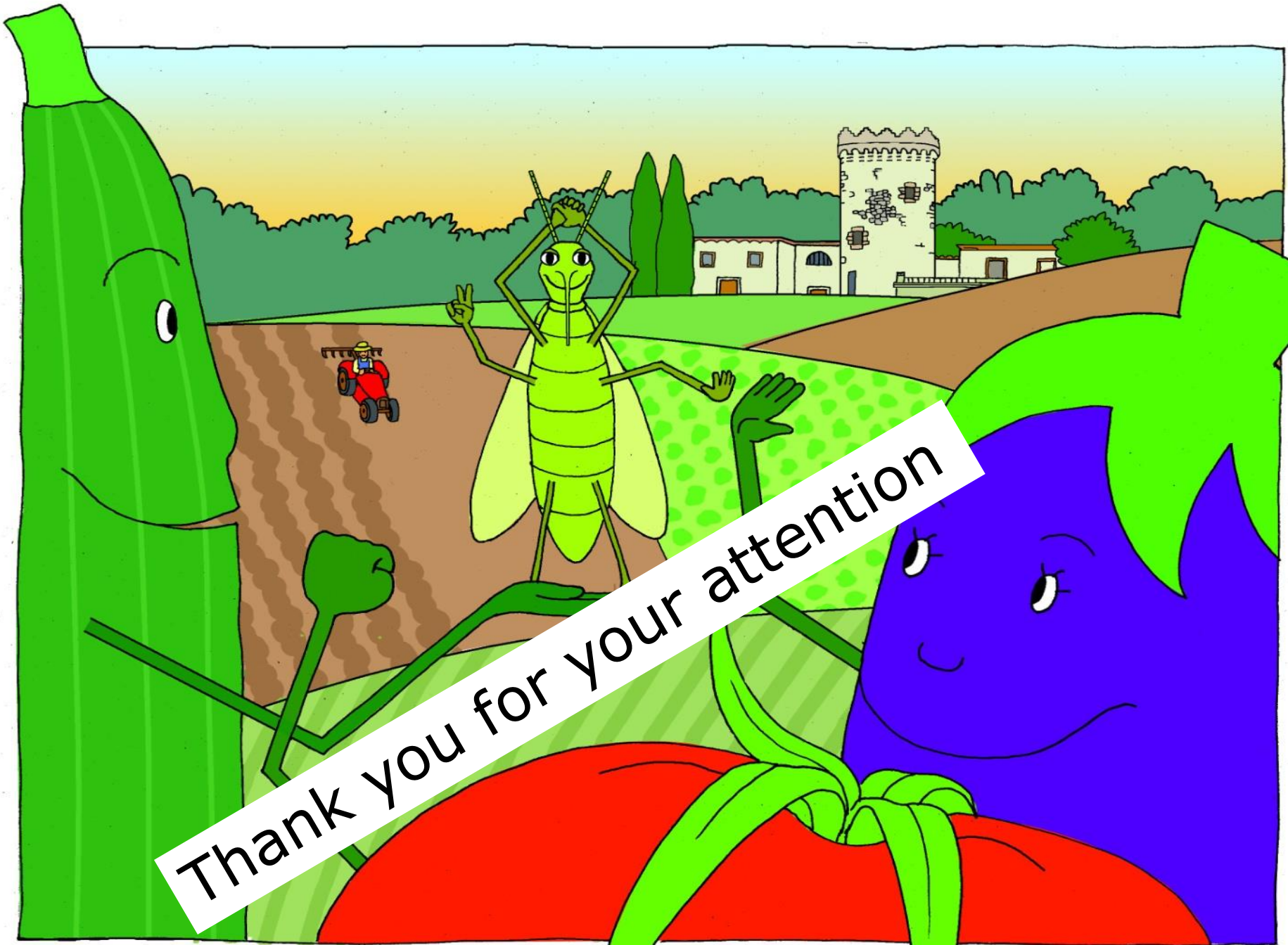
- **Fig. 4** Percentage of infested fruits (a) and weight (b) (mean + SE) for plants infested with *T. absoluta* and sprayed weekly with *B. thuringiensis*. One *N. tenuis* was released per plant three weeks after infestation.

Biological Control on tomatoes

- in greenhouse tomatoes of Murcia (2011) approximately 3000 ha are managed under IPM based in the inoculation and/or conservation of mirids (P. C., A. Monserrat. CARM, Murcia, Spain)
- in Almería, during 2010-2011, inoculation of *N. tenuis* showed to be a good strategy for controlling *T. absoluta*. More than 3500 ha are planned for 2011-2012 (P. C., J.E. Belda, Koppert BS, Almería, Spain)

Future strategies on Biological Control

- combining parasitoids and predators (parasitoids to prevent the pest increase until predators establishment)
- combining different parasitoid species for different life stages of the pest
- combining natural enemies with *B. thuringiensis* or other entomopathogens
- new effective natural enemies?



Thank you for your attention