Control of western flower thrips by entomopathogenic nematodes: possibilities and challenges

by
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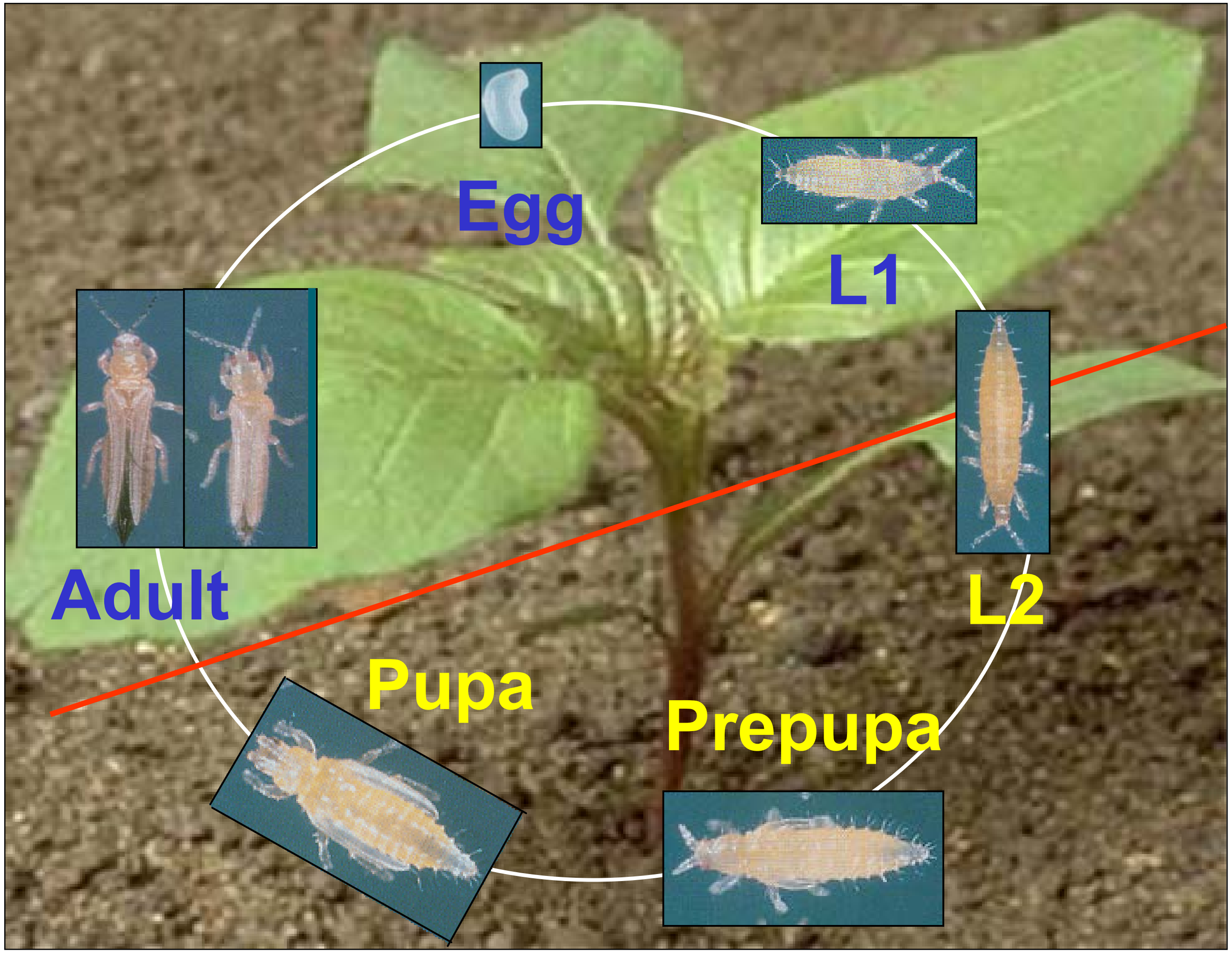
Introduction: Western Flower Thrips (WFT)



Introduction: Western Flower Thrips (WFT)

- Damage high value crops through direct feeding and oviposition

- Vectoring plant viruses, e.g. TSWV

➔WFT is probably number one pest for plant production in greenhouses

Introduction: Western Flower Thrips (WFT)

Control

- WFT control is not easy:
  - Cryptic feeding behaviour
  - High reproductive rate
  - Developed resistance to common insecticides

Introduction: Entomopathogenic nematodes (EPNs)

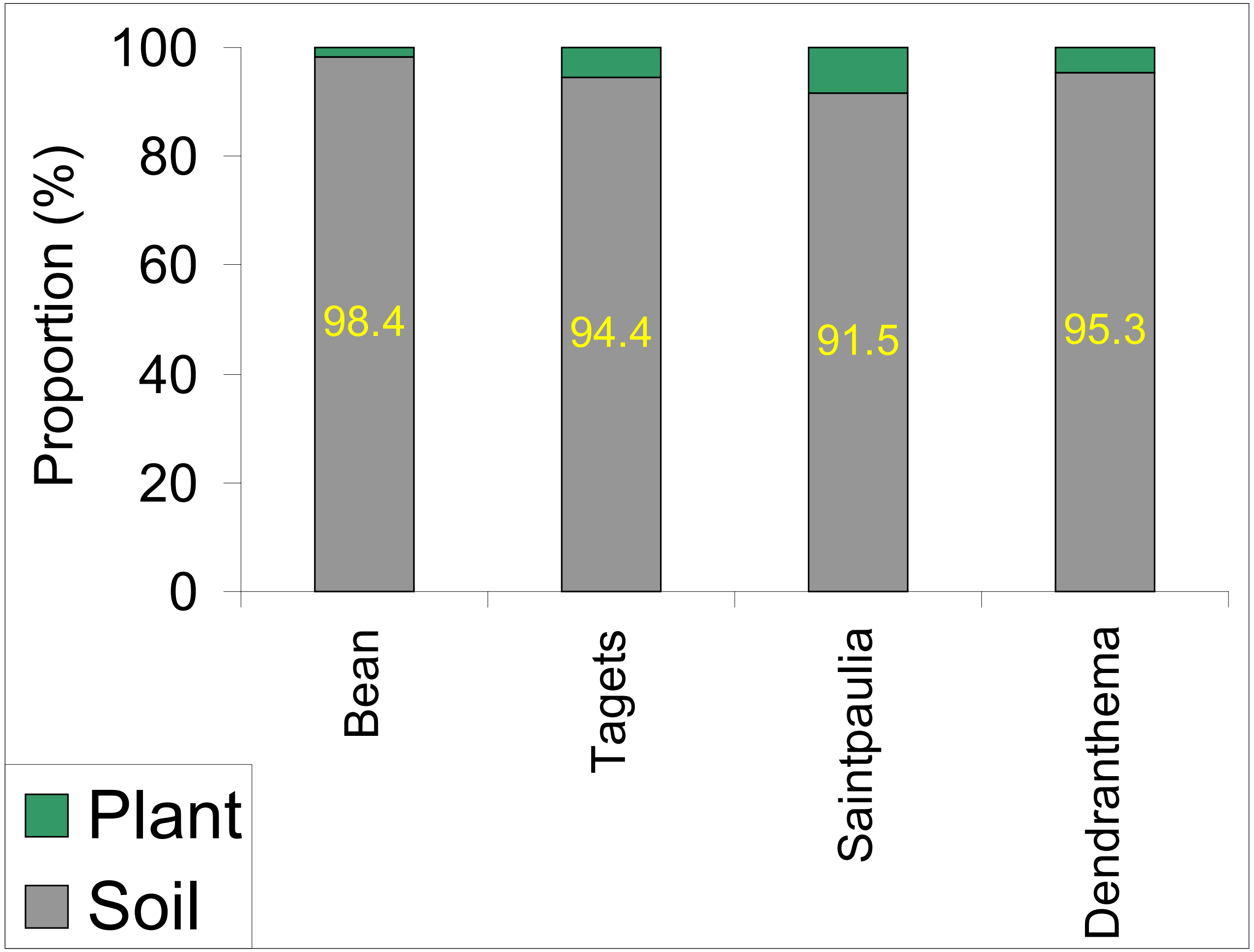
- Heterorhabditidae & Steinernematidae
- Symbiotic bacteria: *Photorhabdus* & *Xenorhabdus* spp.
- 3^{rd} juvenile stage (infective juveniles = IJs) carry bacteria

Advantages of EPNs for WFT control

A. High proportions of WFT pupate in the soil
B. All soil-dwelling developmental stages are susceptible
C. The foliar-feeding stages can also be controlled by EPNs

Advantages of EPNs for WFT control

A. Up to 98% of WFT populations pass through the soil to complete their developmental cycle



Berndt, 2003. PhD thesis, Hannover University

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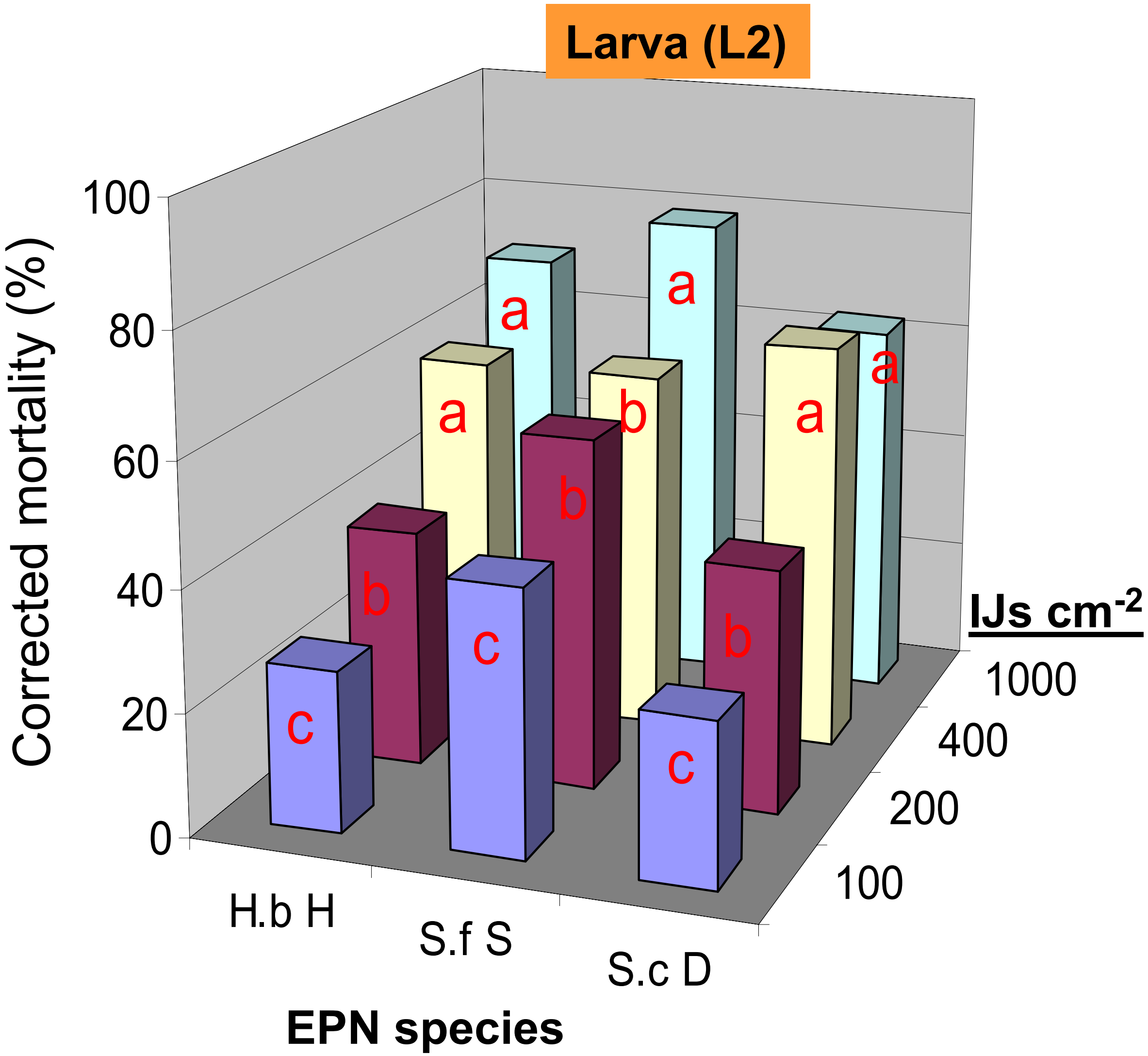
Advantages of EPNs for WFT control

B. All soil-dwelling life stages are susceptible to selected EPNs



Ebssa et al., 2001. *J. Invert. Pathol*. 78, 119–127

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Advantages of EPNs for WFT control

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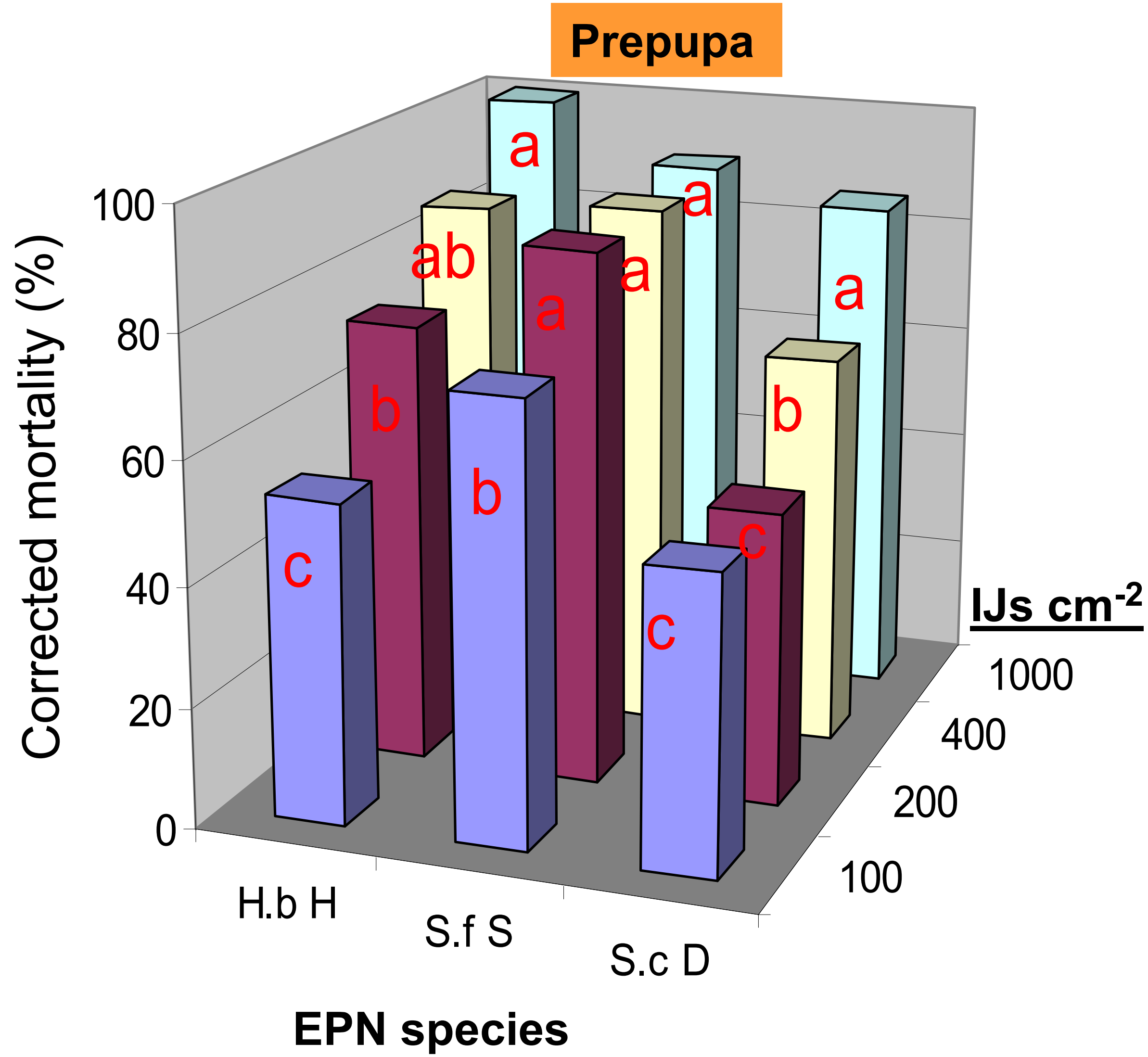

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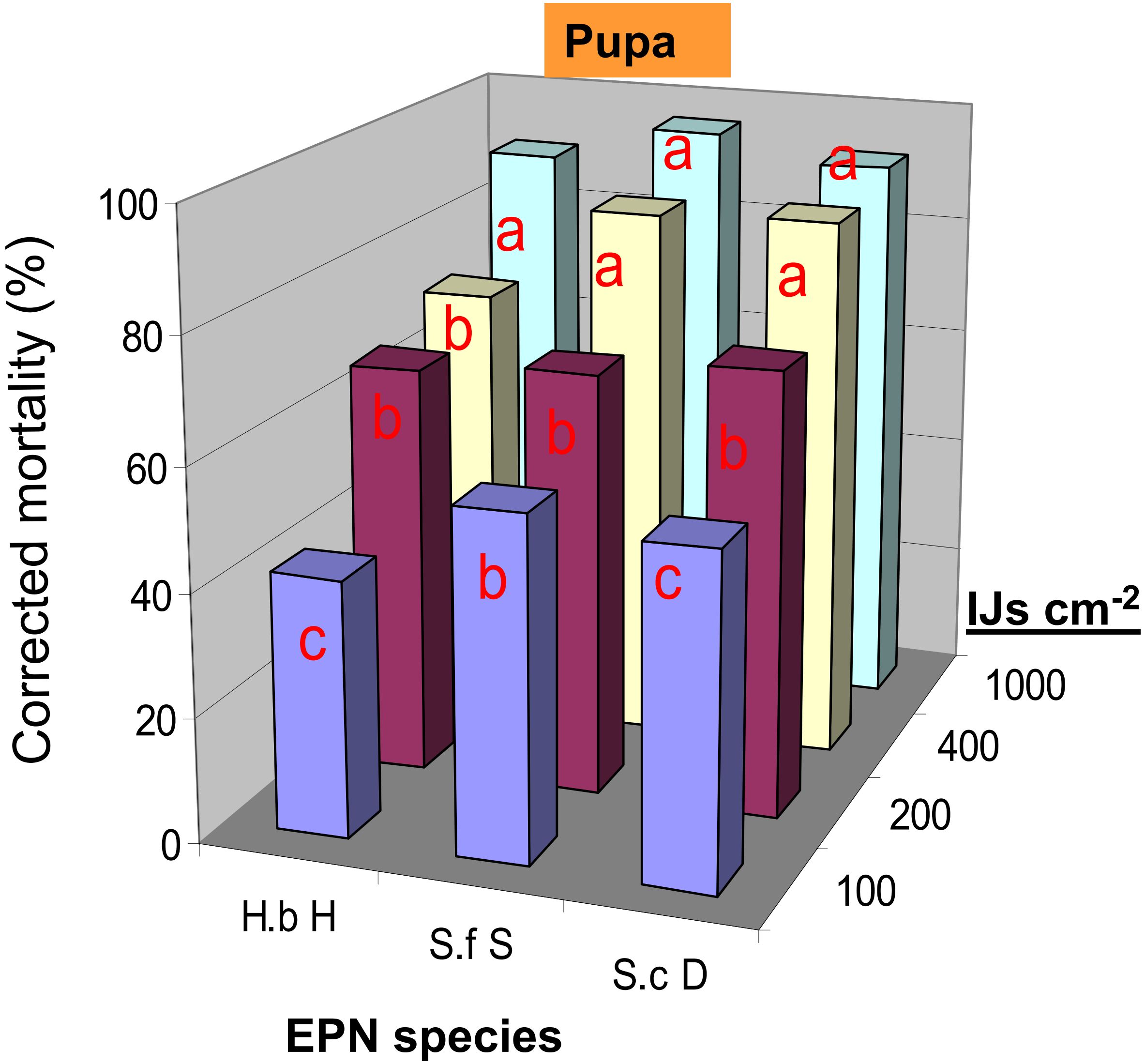
Advantages of EPNs for WFT control

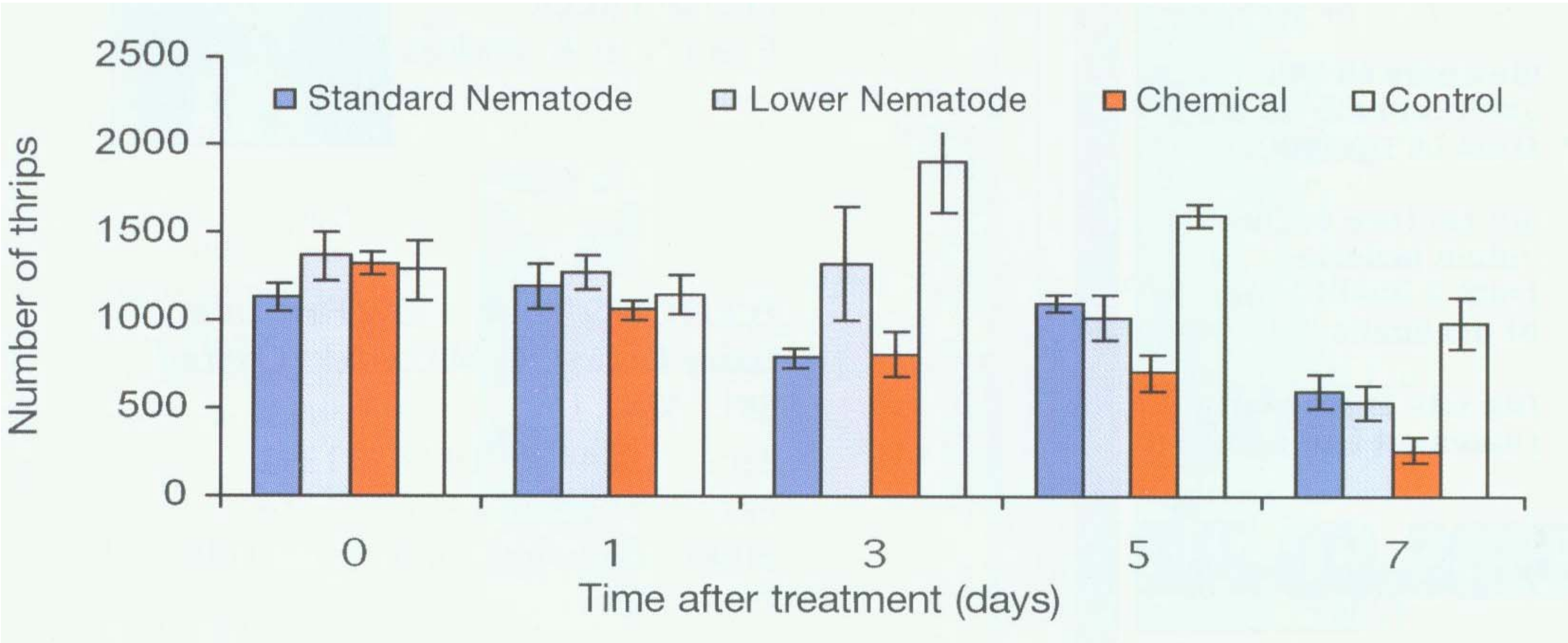
B. All soil-dwelling life stages are susceptible to selected EPNs



Ebssa et al., 2001. *J. Invert. Pathol*. 78, 119–127

Advantages of EPNs for WFT control

C. The foliar feeding stages can also be targeted
(e.g. by use of Nemasys F)



Chemical = abamectin, Standard = 2.5 x 10^9 IJs/ha, Low = 2.5 x 10^8 IJs/ha

Piggot & Wardlow, 2002. The Growers, Feb. 20-23.

Challenges for use of EPNs in WFT control

A. High temperatures – pest population, soil moisture

B. WFT body size

C. Behaviour of the soil-dwelling stages of WFT

D. Foliar applications of EPN could also be challenging

E. Pest of high value crops and vector of Tospoviruses (= very low economic threshold levels is required)

➔ These are some of the factors that may affect the efficacy of EPNs against WFT and call for application of nematodes at high concentrations.

Challenges for use of EPNs in WFT control

WFT becomes more important under warmer temperatures; and such high temperatures:

1. favour fast WFT population build-up, increasing WFT density per area

Life history and life tables of western flower thrips

Table 2. Summary of life table data for *Frankliniella occidentalis* at different temperatures.

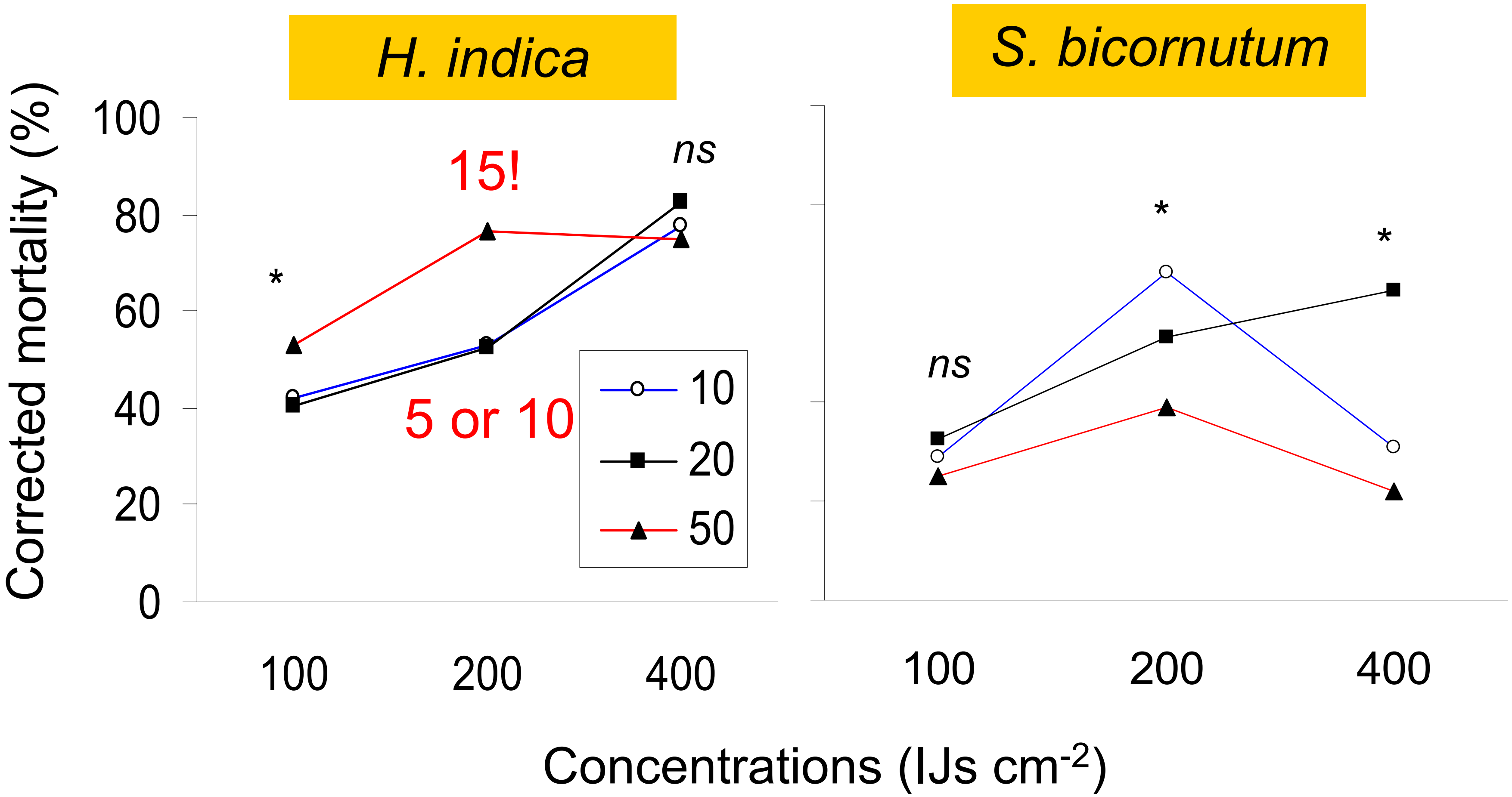
Temperature °C	Σm_x	R_0	r_m	T days	Proportion females	°D for development; egg to adult
15	2.24	1.02	0.002	12.685	0.55	274
18	2.64	2.54	0.11	8.789	0.58	253
20	5.24	5.00	0.21	8.057	0.61	242
23	6.68	5.77	0.30	6.150	0.69	228
25	5.20	6.04	0.30	4.577	0.64	245
30	9.48	8.48	0.51	4.321	0.86	257

R_0=net replacement rate; r_m=intrinsic rate of natural increase; T=mean generation time; Σm_x=sum of average number of female offspring.

Gaum et al., 1994. *Bulletin of Entomological Research* 89, 219-224

Challenges for use of EPNs in WFT control

EPN-induced mortality at different WFT densities



Ebssa et al, 2004. *Biological Control* 29, 145–154

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Challenges for use of EPNs in WFT control

WFT becomes more important under warmer temperatures;

and such high temperatures:

1. favour fast WFT population build up, increasing WFT density per area

2. shorten the life period of the soil-dwelling stages, thus shorten the contact time of EPN and WFT in the soil

Challenges for use of EPNs in WFT control

Table 1. Average duration (days) of each developmental stage and the number of eggs laid by *Frankliniella occidentalis* on English cucumbers cv. Pepinex at different temperatures. The percentage of time spent in each life stage is given in brackets.

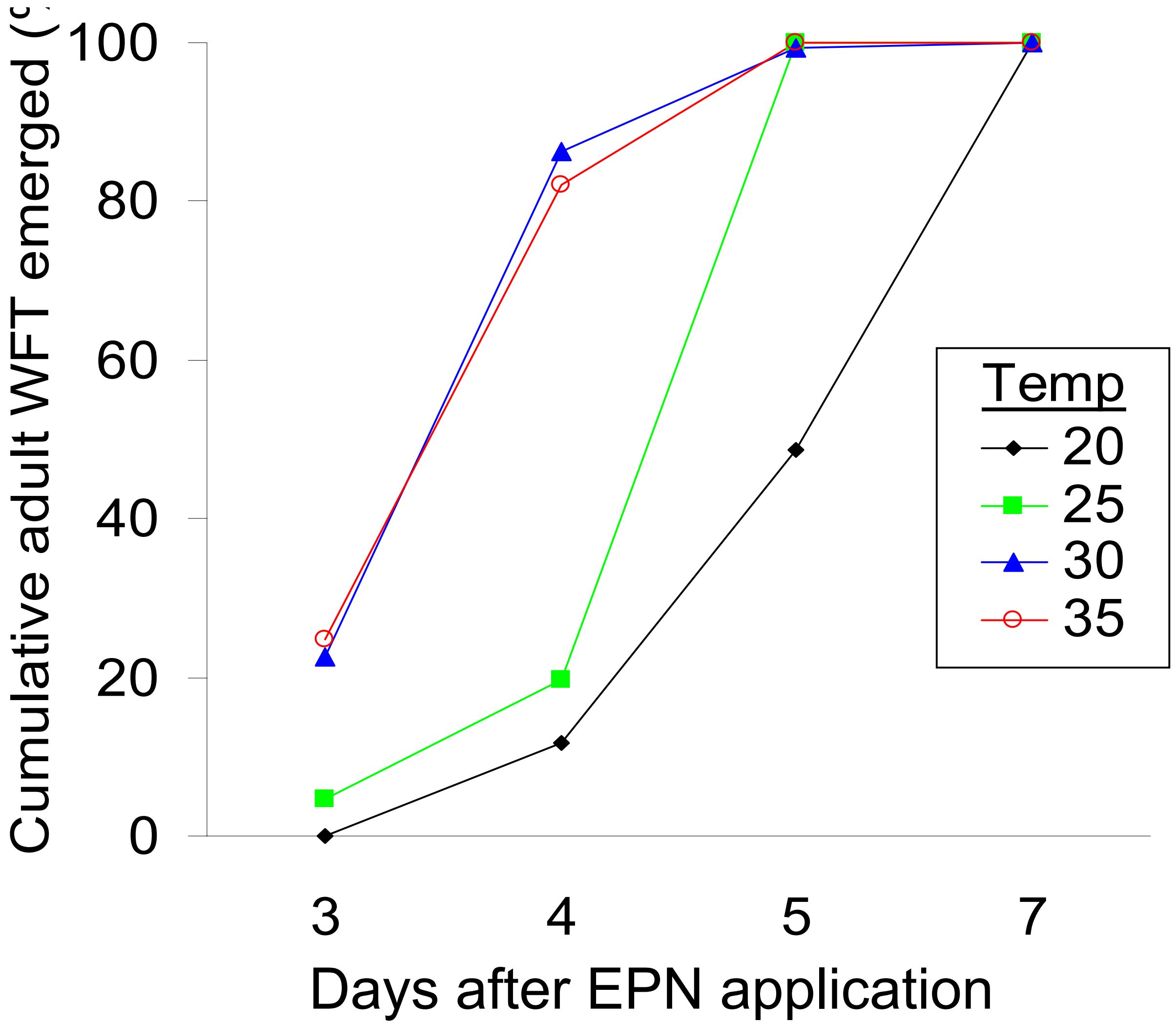
Stage	15°C	18°C	20°C	23°C	25°C	30°C
Egg	15.53 ± 0.205 (32.4)	9.75 ± 0.167 (34.3)	6.76 ± 0.132 (30.9)	5.11 ± 0.153 (32.4)	4.25 ± 0.960 (28.9)	3.09 ± 0.079 (26.9)
Larva ($L_1 + L_2$)	22.55 ± 0.434 (47.0)	13.31 ± 0.243 (46.8)	9.80 ± 0.174 (44.9)	6.60 ± 0.152 (41.8)	6.46 ± 0.086 (43.9)	5.40 ± 0.079 (47.0)
Prepupa	3.00 ± 0.028 (6.3)	1.63 ± 0.069 (5.7)	1.56 ± 0.071 (7.1)	1.04 ± 0.028 (6.6)	1.04 ± 0.028 (7.1)	1.01 ± 0.020 (8.8)
Pupa	6.88 ± 0.073 (14.3)	3.75 ± 0.083 (13.2)	3.73 ± 0.064 (17.1)	3.02 ± 0.020 (19.2)	2.96 ± 0.028 (20.1)	1.99 ± 0.020 (17.3)
Tot. immature stage	47.96 ± 0.540	28.44 ± 0.293	21.85 ± 0.230	15.77 ± 0.123	14.71 ± 0.136	11.49 ± 0.099
Female	39.70 ± 0.435	30.67 ± 0.218	25.19 ± 0.302	18.92 ± 0.210	12.80 ± 0.270	10.08 ± 0.302
Av. number of eggs/female hatched	2.76	4.62	8.59	9.68	9.65	10.65

[a] ± SEM = Standard error of the mean; percentage of developmental time required for each life stage given in parentheses.

Gaum et al., 1994. *Bulletin of Entomological Research* 89, 219-224

Thus, shorter contact time of EPN and WFT in the soil

Challenges for use of EPNs in WFT control



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Challenges for use of EPNs in WFT control

➔ results in lower efficacy of EPN against WFT

➔ this could be a combined influence of the direct effects of temperature on EPN survival and efficacy and influence on the WFT population (rate of development)

Challenges for use of EPNs in WFT control

Ebssa et al, 2004. *Biological Control* 29, 145–154

CM(%) of WFT as caused by EPNs at different temperatures

	100 IJs cm^{-2}		400 IJs cm^{-2}	
°C	*H. indica*	*S. bicornutum*	*H. indica*	*S. bicornutum*
20	23.6 B a	29.8 A a	54.2 B a	34.1 B b
25	48.9 A a	39.3 A b	84.0 A a	47.0 A b
30	36.4 AB a	3.2 B b	77.7 A a	14.1 C b
35	26.4 AB a	0.0 B b	27.2 C a	0.0 D b

For a given concentration: means within a column (row) followed by the same upper case (lower case) letter do not differ significantly

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Challenges for use of EPNs in WFT control

WFT becomes more important under warmer temperatures;
and such high temperatures:

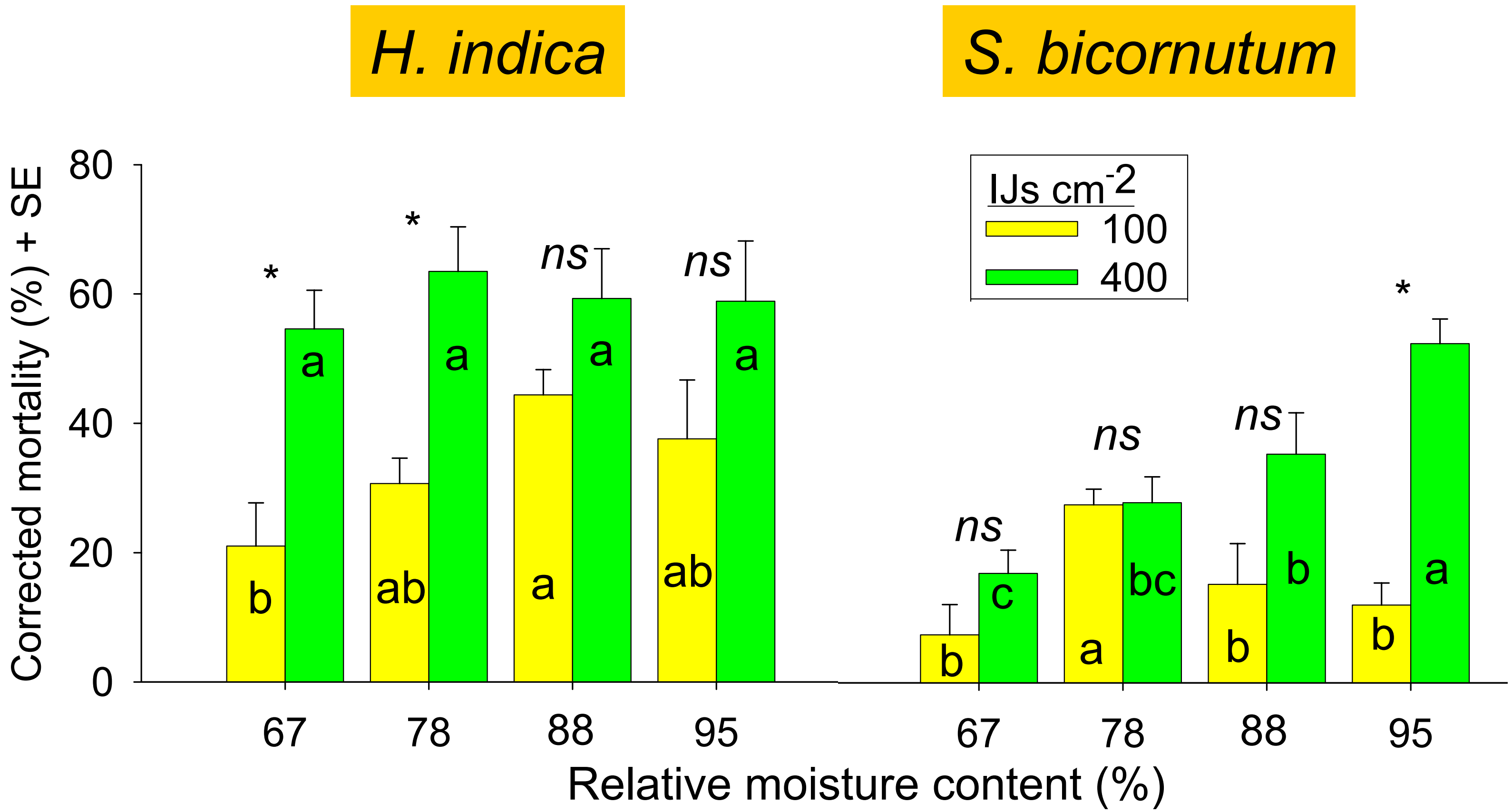
1. favour fast WFT population build up, increasing WFT density per area

2. shorten life period of the soil-dwelling stages thus, shorten contact time of EPN and WFT in the soil

3. increase soil desiccation rate, which has a negative impact on EPN efficacy

Challenges for use of EPNs in WFT control

WFT mortality by EPNs at different pre-application moisture levels



Ebssa et al. 2004, *Ent. Exp.Appl.* 112, 65–72

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Challenges for use of EPNs in WFT control

A. Temperatures

B. Body size

- Soil-dwelling stages of WFT are less than 1mm in length and IJs of most EPN species are about 0.5mm in length

➔ could be difficult for IJs to locate their host (otherwise, high concentrations are required)

C. Behaviour of the soil-dwelling life stages of WFT

Prepupa and pupa **do not feed and hence induce no cue** sources from plants to attract the IJs

Upon disturbance (possibly including attempts of IJs to colonise the host), both prepupa and pupa **move and may search for a new "IJ-free" space** in the soil;
remain there motionless until IJs again reach and disturb them

➔ the speed of the host in changing its position is by far greater than the speed by which IJs follow the position-changing host

➔ before the IJs reach the host at its new position, WFT may finish its soil-dwelling developmental stages and leave the soil, thereby escaping a nematode attack

➔ These call for application of EPNs at higher concentrations.
But production cost maybe reduced significantly in the future.

Challenges for use of EPNs in WFT control

A. Temperatures

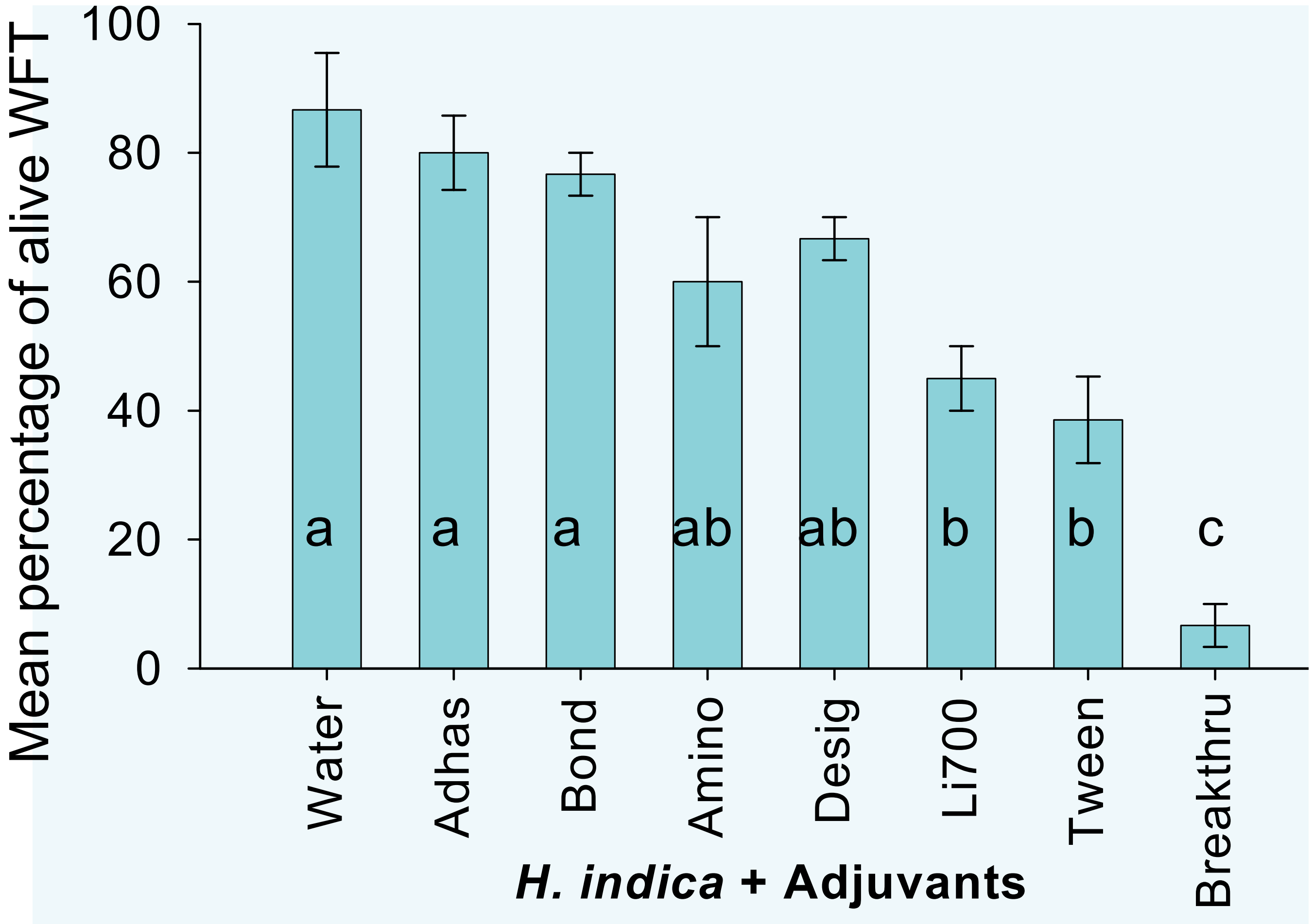
B. Body size

C. Behaviour

D. All challenges of using EPNs for foliar applications, such as desiccation and application problems, need to be resolved

Challenges for use of EPNs in WFT control

Screening adjuvants



Halaweh 2004, M.Sc. thesis, Hannover University

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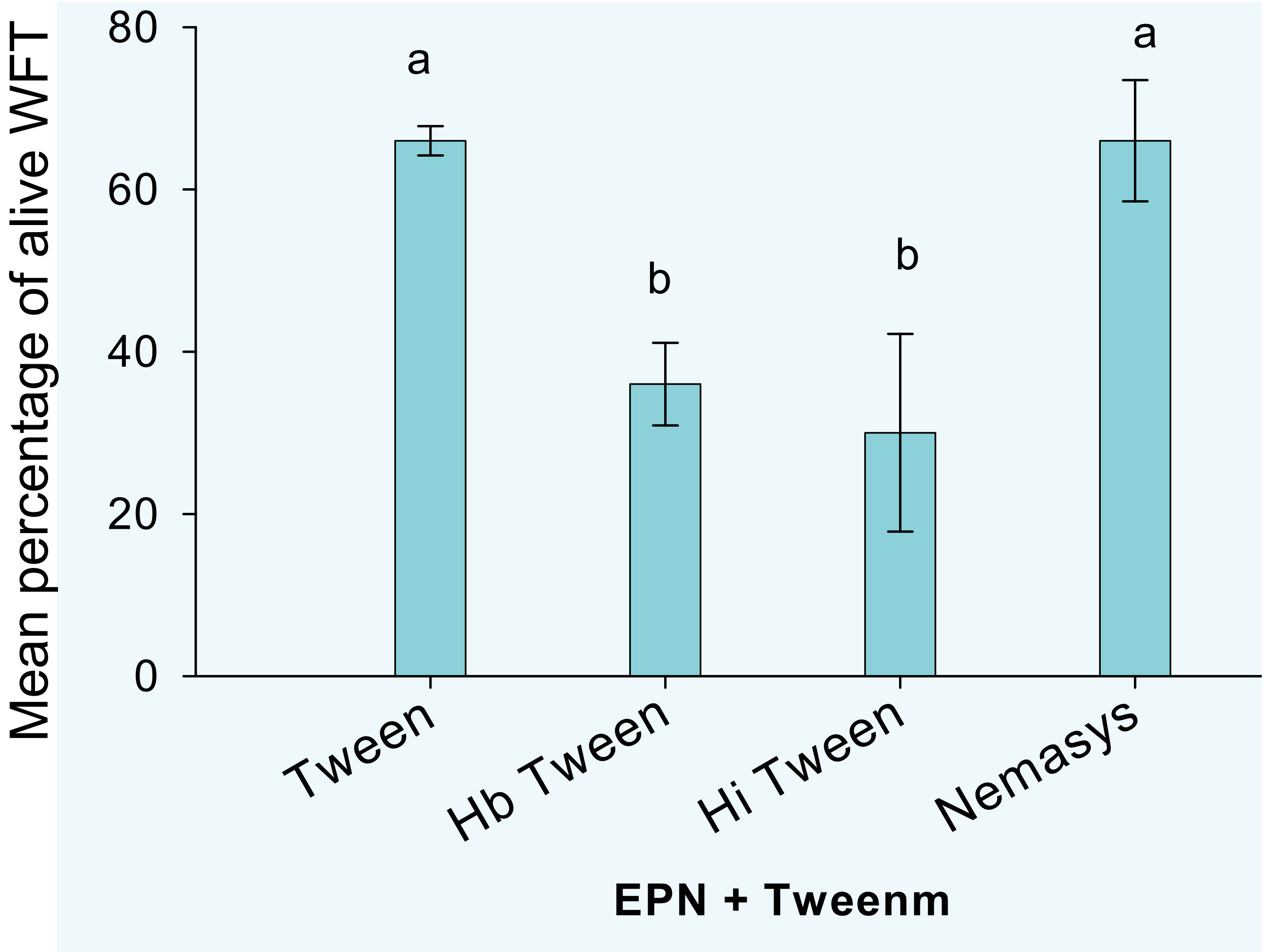
Challenges for use of EPNs in WFT control

Screening EPNs, against L2 WFT



Halaweh 2004, M.Sc. thesis, Hannover University

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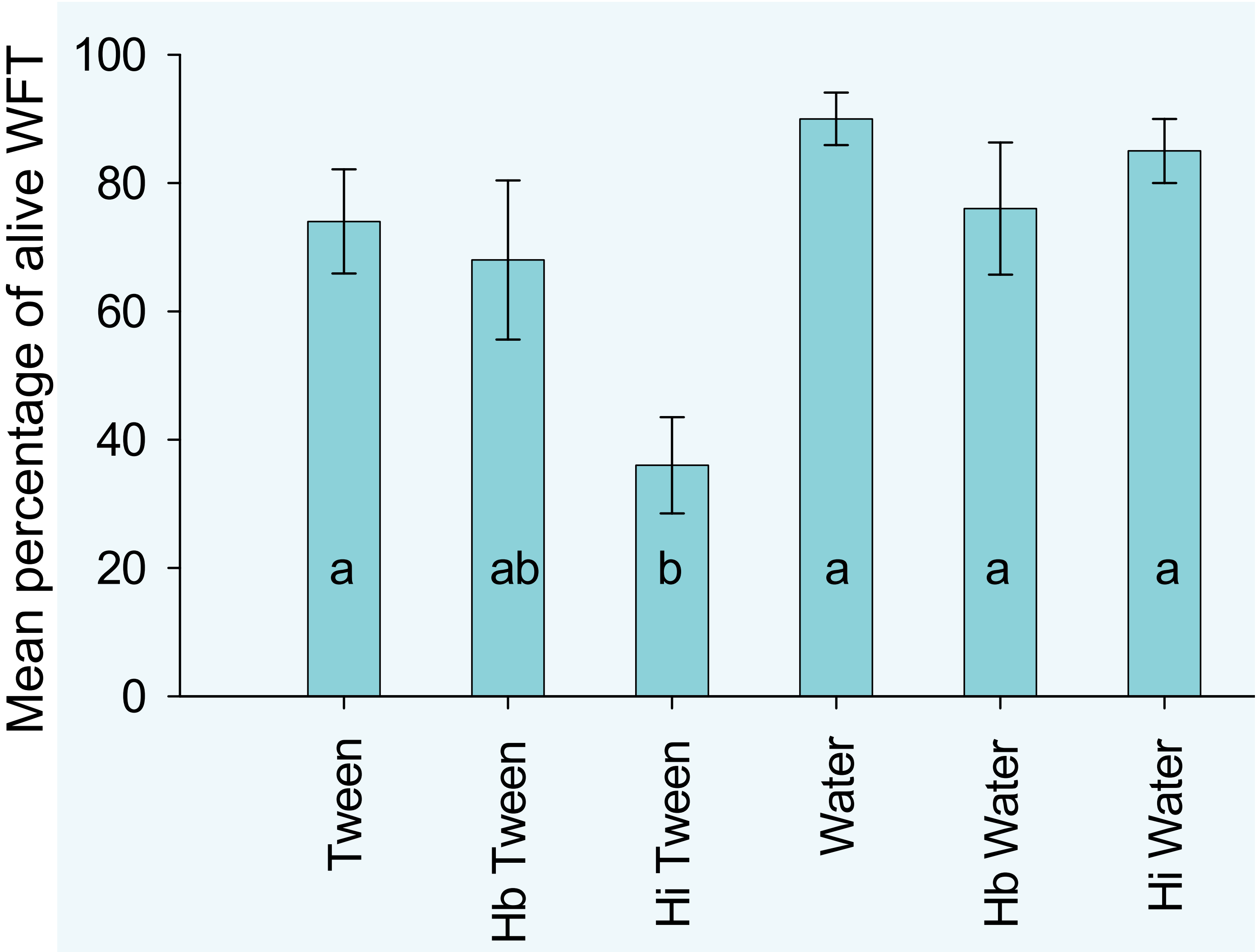
Challenges for use of EPNs in WFT control

Applications of EPNs against female WFT on leaf-discs



Halaweh 2004, M.Sc. thesis, Hannover University

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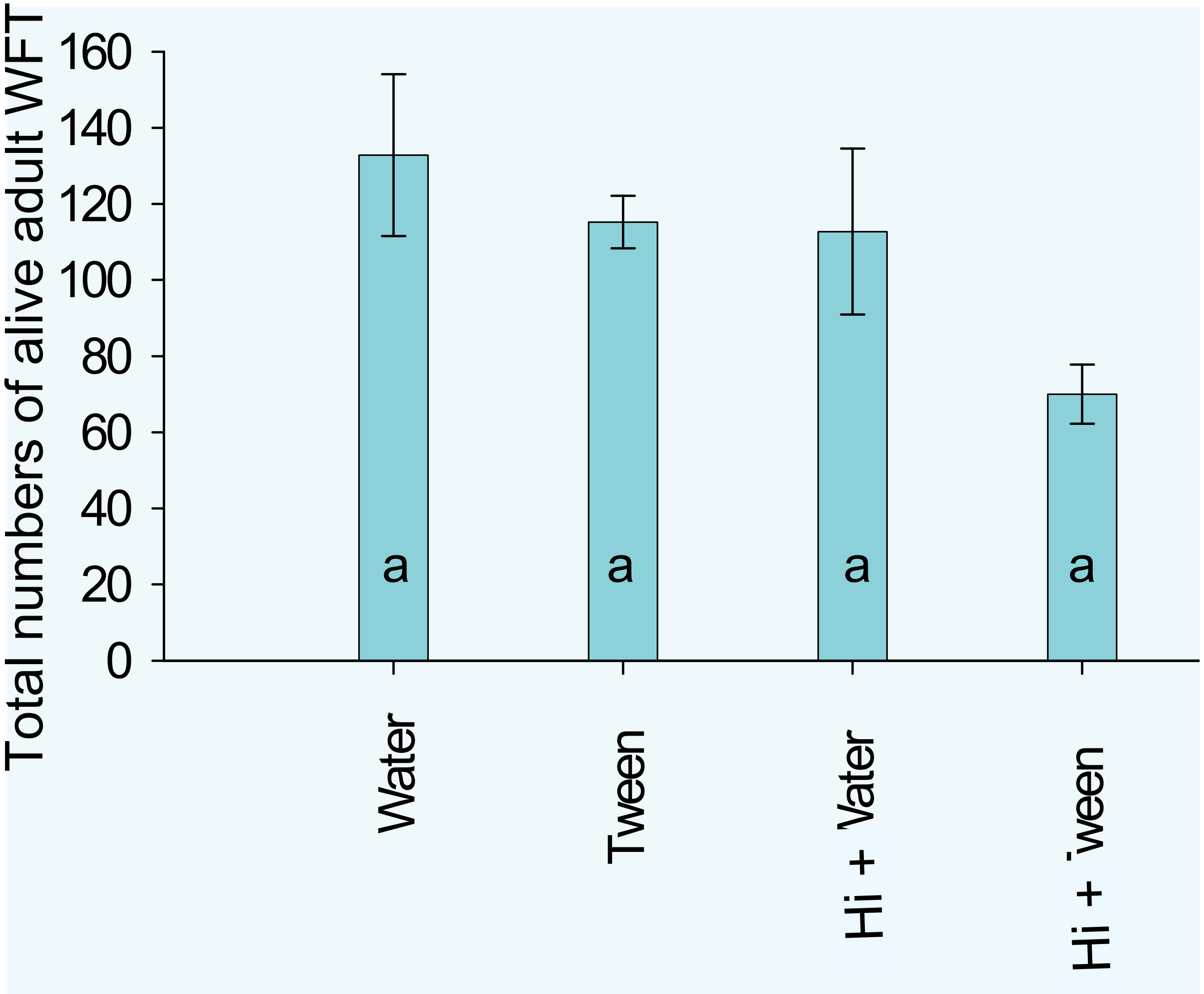
Challenges for use of EPNs in WFT control

Weekly applications of EPNs on flowering Chrysanthemums



Halaweh 2004, M.Sc. thesis, Hannover University

Challenges for use of EPNs in WFT control

A. Temperatures

B. Body size

C. Behaviour

D. Foliar applications could be also challenging

E. WFT is a high value crop pest and vector of Tospoviruses

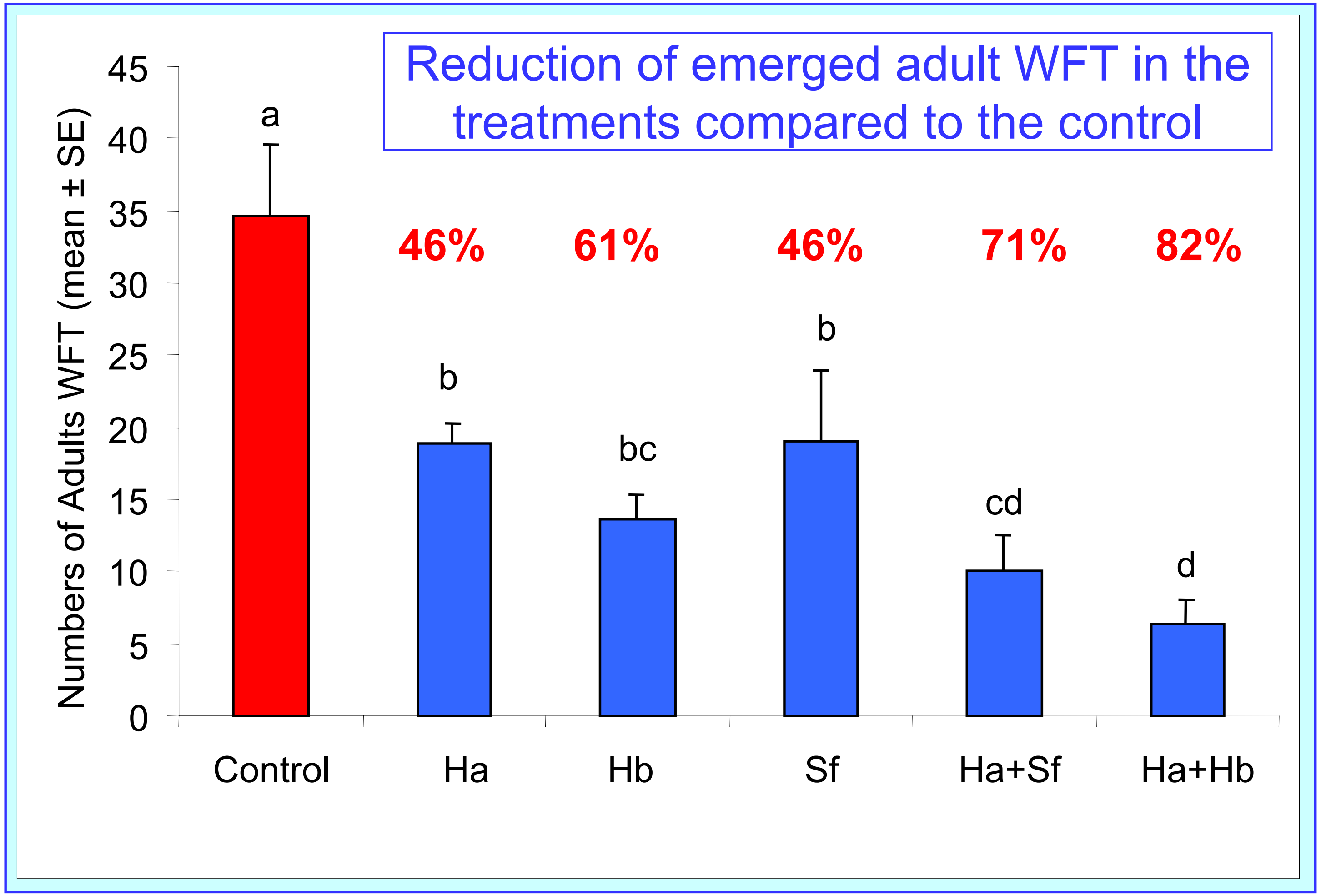
➔ extremely low economic threshold level is needed

The good thing is that:

EPN can successfully be combined with other biocontrol agents of WFT

Combining EPNs & other biocontrol agents

EPNs and *Hypoaspis aculeifer*



Premachandra et al. 2003. *BioControl* 48, 529-541.

Combining EPNs & other biocontrol agents

EPNs and *Amblyseius cucumeris* (AC)

WFT Corrected mortality using emerged adult thrips

EPN	IJs cm^{-2}	AC density 0	3	5	10
Control	0	*	15.5 d	24.6 d	47.1 c
H. b	100	55.8 bc	47.2 c	62.3 bc	68.0 ab
	200	64.6 bc	60.2 bc	68.2 ab	82.9 a
H. indica	100	60.1 bc	67.9 bc	57.4 bc	73.2 ab
	200	64.7 bc	64.1 abc	67.9 ab	83.1 a

L. Ebssa 2005, unpublished data

Conclusion:

Great potential, but significant challenges remain to improve the efficacy of EPNs for control of Western Flower Thrips!!