Evaluation of entomopathogenic fungus *Beauveria bassiana* on predatory mite and biological control of *Frankliniella occidentalis*

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Frankliniella occidentalis: Pest of concern to China

- West flower thrips (*Frankliniella occidentalis*) are very tiny insects (about 1/50th of an inch), but signs of their feeding are very noticeable.
- *F. occidentalis* causes severe losses in glasshouse crops mainly on ornamentals, but also on vegetables such as sweet pepper, cucumber and tomato; *F. occidentalis* often feeds on flowers, thereby causing growth retardation, destruction of buds and flowers, and malformation of fruits;
- *F. occidentalis* are polyphagous, occur worldwide and are vectors of plant viruses;
- These pests cause direct feeding damage and consequent reduction of photosynthetic capacity.

Frankliniella occidentalis

Reitz et al., Agricultural Sciences in China, 2011

Gao et al., Pest Manag Sci, 2012

Thrips prefer to locate in flowers

Thrips inflict plant damage to leaves

Thrips produces aesthetic damage to fruiting crops

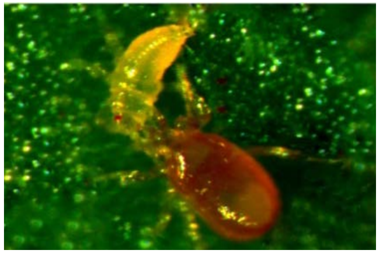
- *F. occidentalis* was first intercepted in quarantine in Kunming, Yunnan province in 2000. Subsequently, its known distribution in China has rapidly expanded.
- This highly invasive pest has developed strong resistance to a great deal of pesticides and make its biological control become the most important measure in IPM.

Biological Control

black hunter thrips(*Aelothrips* spp), green lacewing (*Chrysoperla* spp.)
minute pirate bug (*Orius* spp.),
predatory mites

There are several natural enemies that help in the control of thrips. Unfortunately none of them alone can reduce the thrips populations to a low, non-economical density. Also, the intensive use of pesticides in this crop limits natural enemies activity. There is a need for more study on the role of natural enemies in the crop system.

Orius sauteri



Neoseiulus barkeri

Beauveria bassiana SZ-26

Beauveria bassiana is a biopesticide used for control of :

Frankliniella occidentalis (Pergande)

Thrips tabaci (Lindeman)

Thrips palmi （Karny ）

Thrips flavus （Schrank）

Neoseiulus barkeri prefer to feed on first-instar thrips larvae.

Stratiolaelaps scimitus can be used to control soil-dwelling stages of thrips.

Beauveria bassiana SZ-26

N. barkeri

S. scimitus

Compatibility of *Beauveria bassiana* with predatory mites

Bioassay on predatory mites and thrips and scanning electron microscopic observation

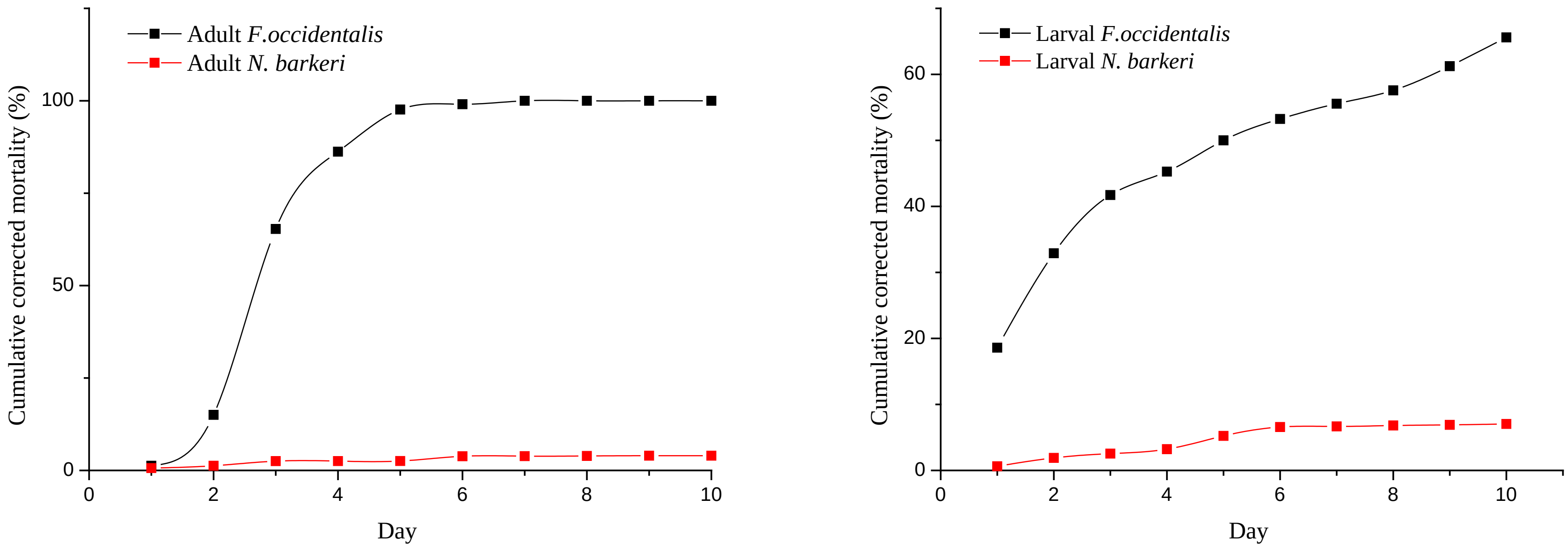
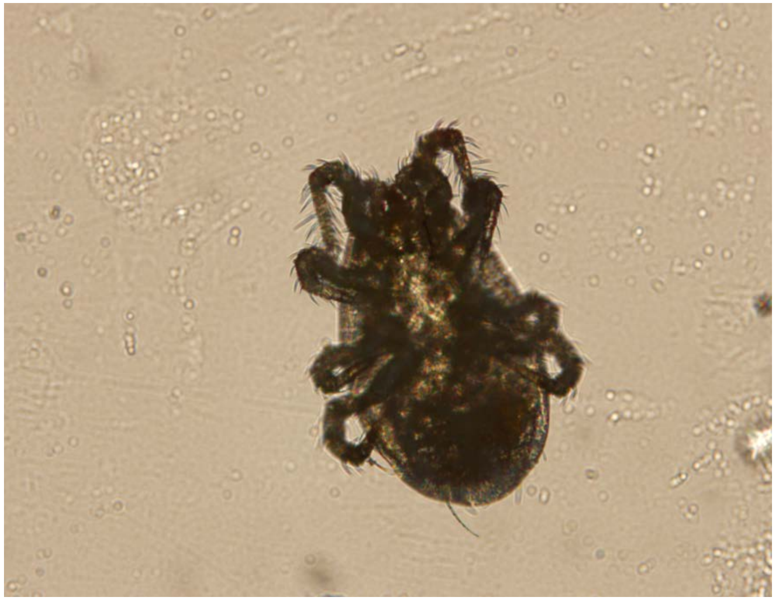


fig. Corrected mortality of *B. bassiana* SZ-26 to *F. occidentalis* and *N. barkeri* fungal hyphae



the dead *F. occidentalis*

(fungal hyphae growing from the body)

the dead *N. barkeri*

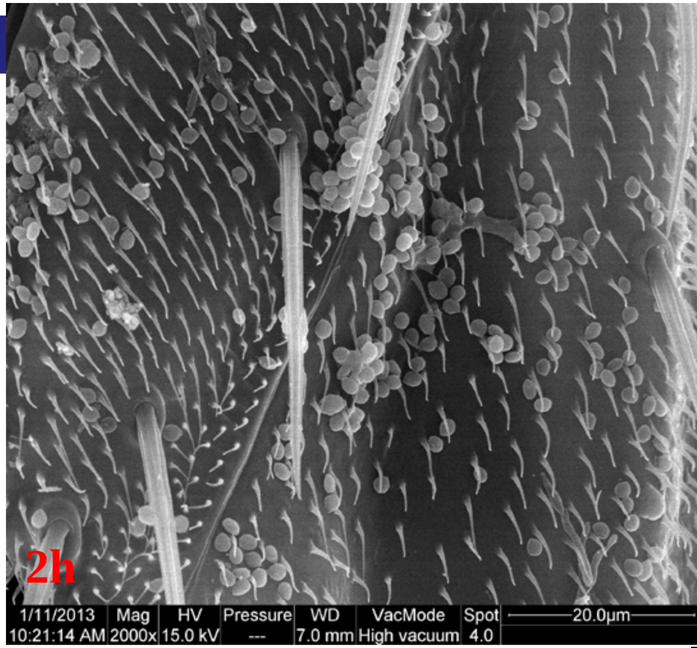
(normal death)

Fig. Pictures of dead *F. occidentalis* and *N. barkeri* treated by *B. bassiana*

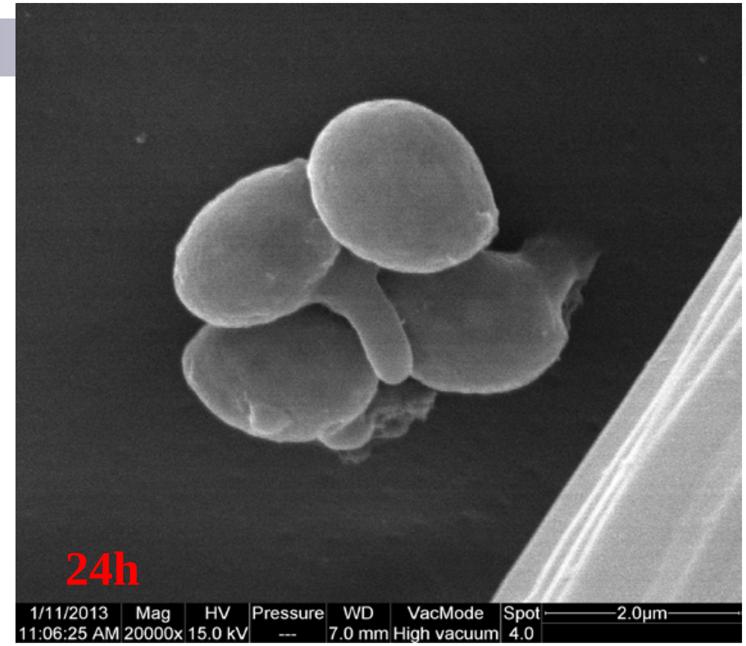
Table Length of reproductive durations, longevity (days ± SE) and fecundity (eggs ± SE) of *N. barkeri* when treated with *B. bassiana* strain SZ-26

	Length of reproductive durations, longevity and fecundity				
	Preoviposition	Oviposition	Postoviposition	Female Longevity	Daily fecundity
Untreated	2.48±0.12a	26.58±3.28a	7.12±0.47a	36.19±0.90a	1.90±0.05a
Treated	3.35±0.17b	25.00±3.03a	6.00±0.38a	34.32±0.56a	1.79±0.03a
df	45	49	49	41	49
t	-4.036	1.783	1.843	1.763	1.911
p	<0.001	0.081	0.071	0.085	0.062

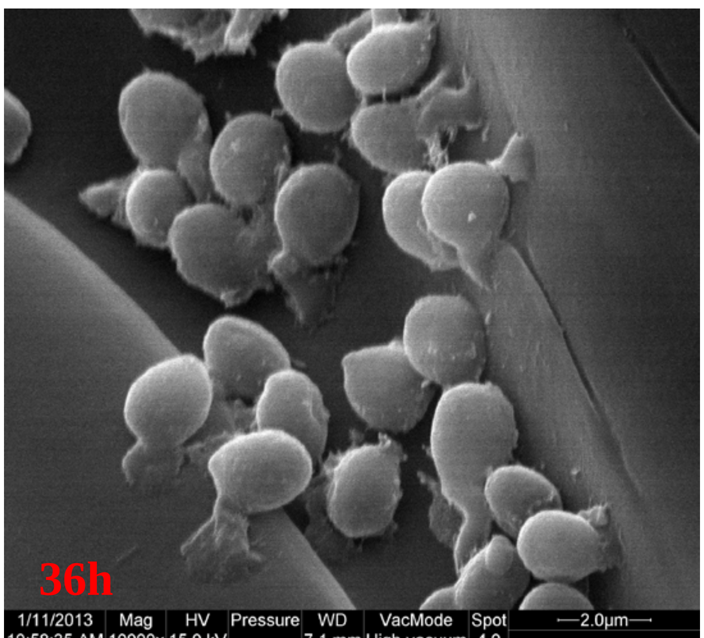
Note: The same small letters in the same column represented no significant difference at 0.05 levels by T-test.



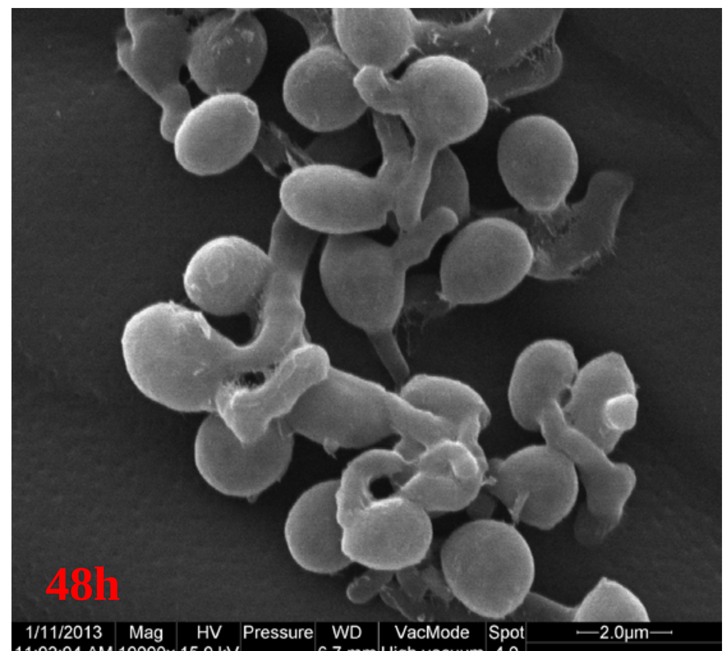
conidia adhering to the cuticle of *F. occidentalis*



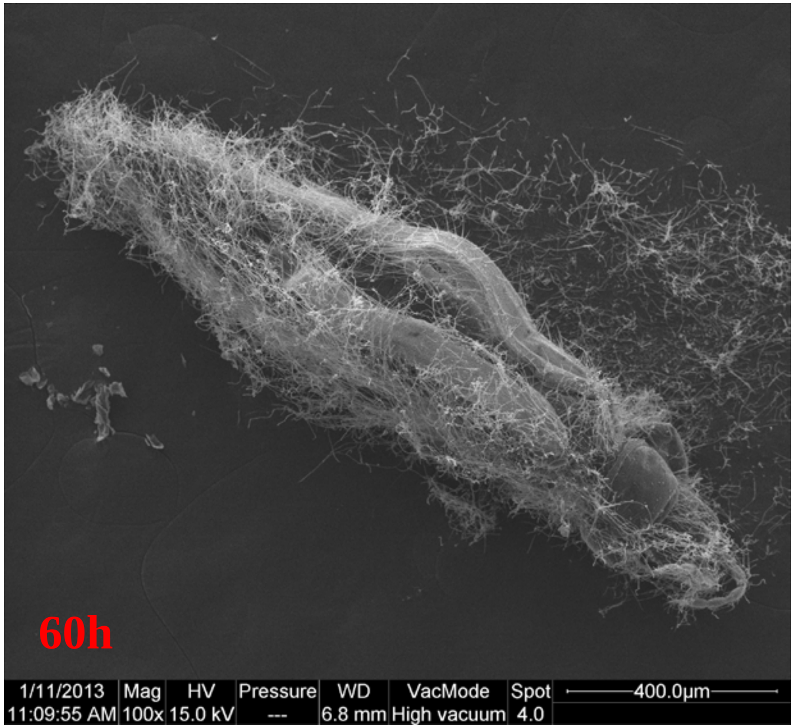
Thrips germ tube of conidia oriented toward cuticle



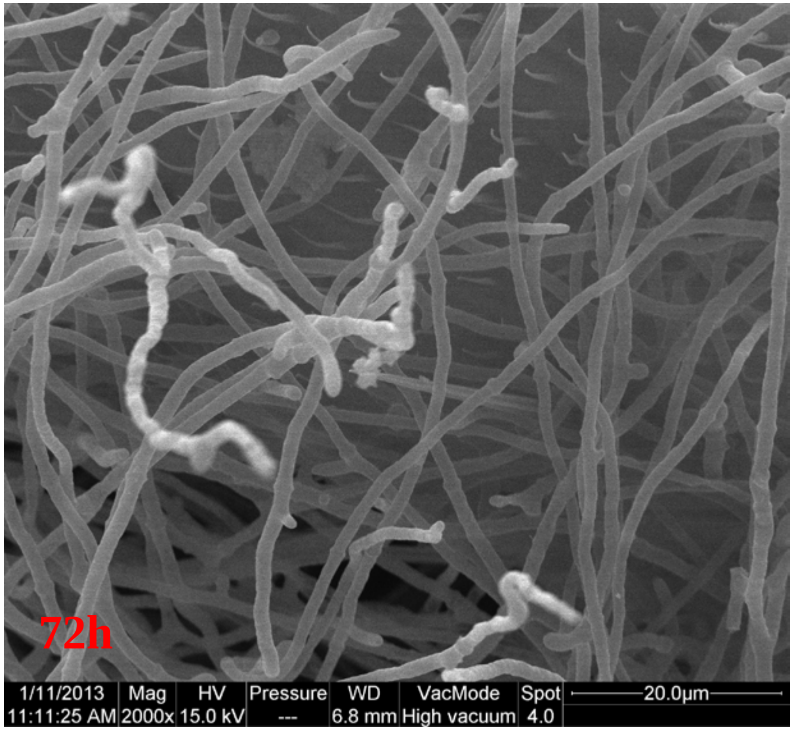
germ tube penetrate toward the cuticle



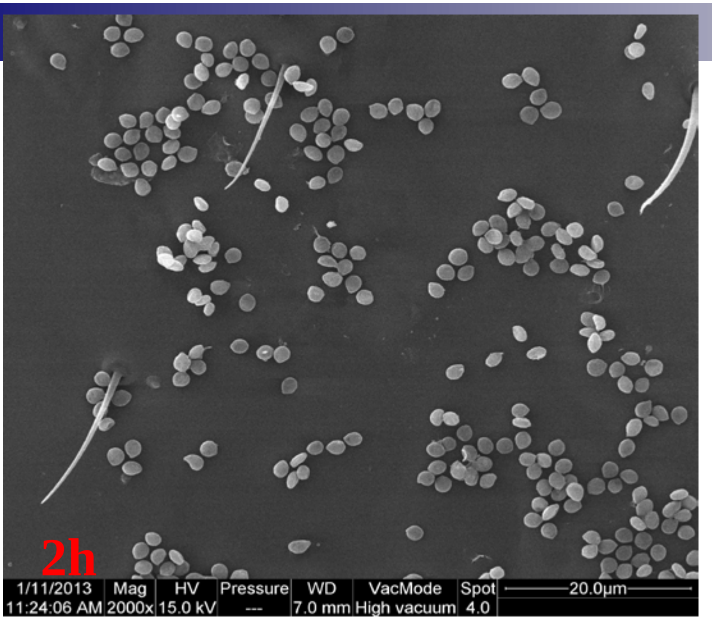
fungal hyphae growing on the cuticle

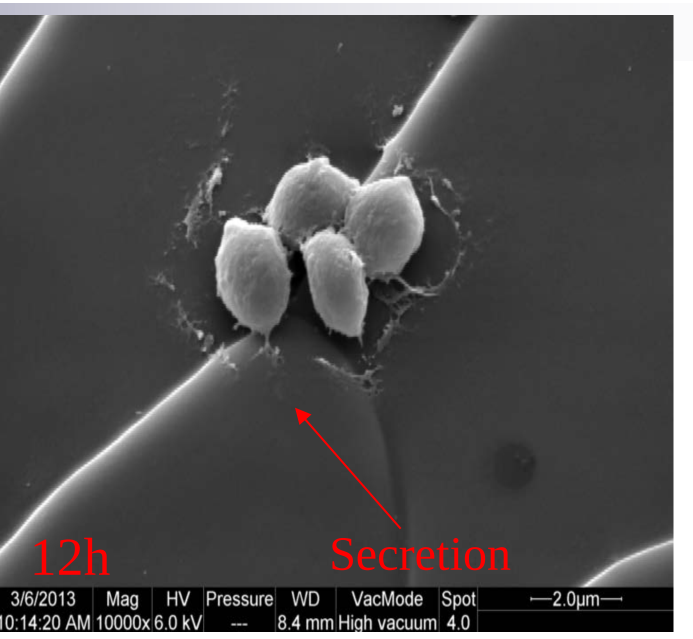


mycelium colonized the whole body



conidia emerged from the dead adult

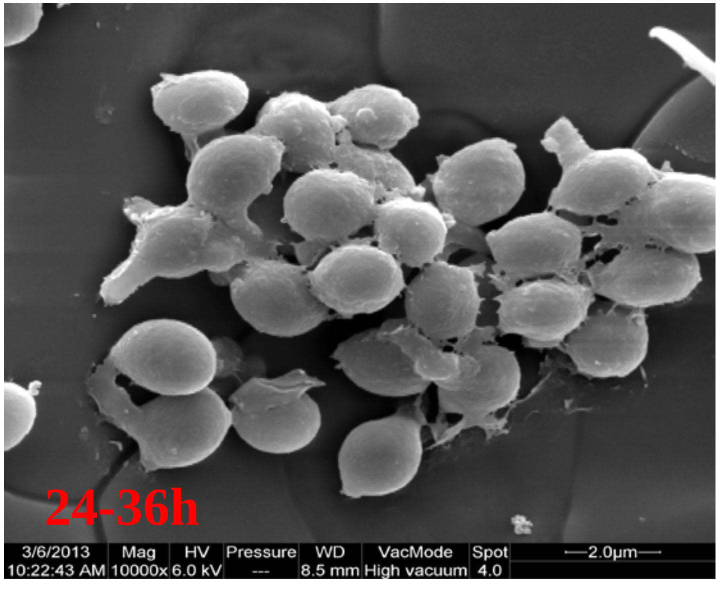




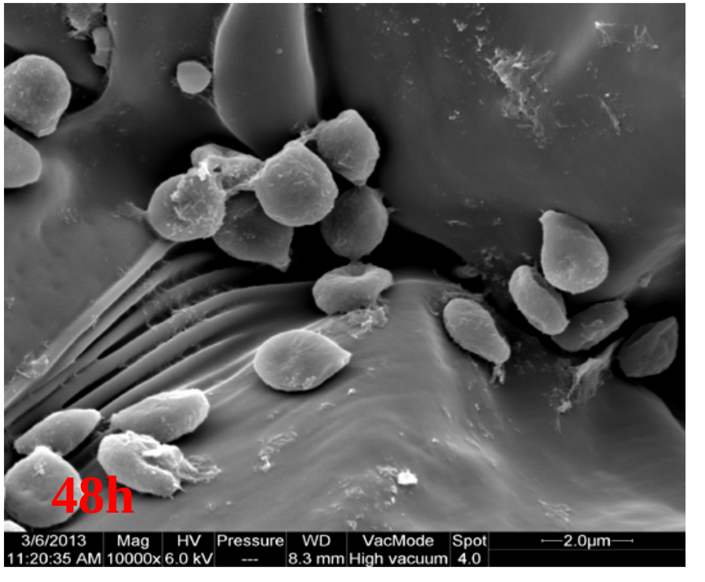
conidia adhering to the cuticle of *N. barkeri*

Predatory mite

secretion on the interface of conidia and cuticle



germ tube of conidia oriented toward cuticle



shriveled conidia

Side-effects of *B. bassiana* on predatory mites

Table Developmental time, longevity and mean fecundity of *N. barkeri* in control and treatment

Stage	Control n	Control Developmental time (d) (mean±SE)	Treatment n	Treatment Developmental time (d) (mean±SE)
Egg	60	1.99±0.06a	60	2.12±0.05a
Larva	57	1.08±0.05a	57	1.15±0.04a
Protonymph	56	2.11±0.05b	49	2.46±0.08a
Deutonymph	48	1.84±0.06b	45	2.34±0.06a
Preadult	48	7.25±0.10b	45	8.39±0.10a
Adult longevity				
Female	27	29.46±0.55a	23	22.86±0.38b
Male	23	22.34±0.32a	24	17.39±0.30b
Apop	27	2.54±0.12a	23	2.50±0.10a
Tpop	27	10.13±0.19b	23	11.25±0.13a
Mean fecundity				
Female	27	52±2a	23	38±1b

Treatment: *N. barkeri* which fed on *B. bassiana*-infected *F. occidentalis* larvae (12 h);
Control: *N. barkeri* which fed on untreated *F. occidentalis* larvae
Small letters within a row followed by the different letter are significantly different.

Table Population parameters (mean±SE) of *N. barkeri* in control and treatment

Parameter	Control	Treatment	t	p
Intrinsic rate of increase, *r* (d^{-1})	**0.1896±0.0108a**	**0.1461±0.0109b**	**21.99**	**<0.0001**
Finite rate of increase, *λ* (d^{-1})	**1.2088±0.0130a**	**1.1572±0.0170b**	**18.65**	**<0.0001**
Net reproductive rate, R^0 (offspring)	**22.4833±3.3773a**	**13.4634±2.3000b**	**17.10**	**<0.0001**
Mean generation time, *T* (d)	**16.3684±0.2580b**	**17.7014±0.2660a**	**27.86**	**<0.0001**

Treatment: *N. barkeri* which fed on *B. bassiana*-infected *F. occidentalis* larvae;
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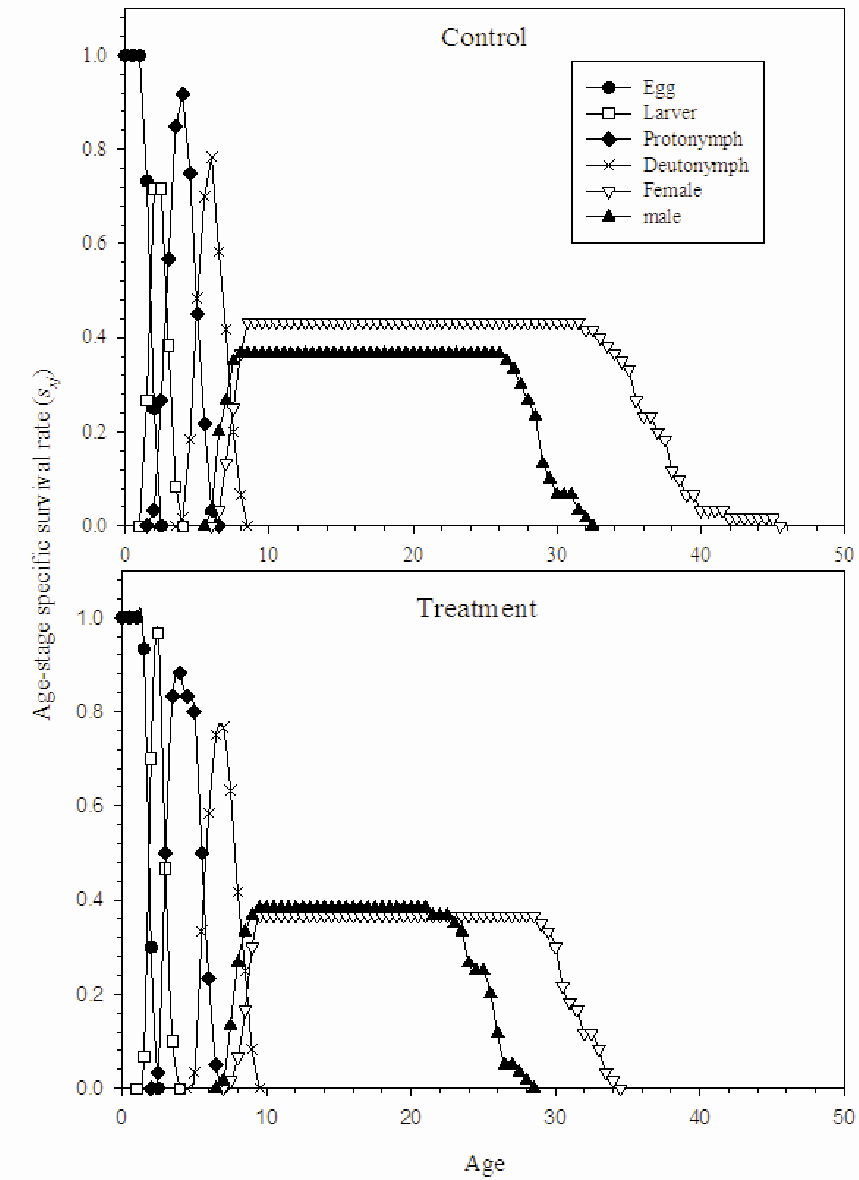


Fig. Age-stage survival rate (s_{xj}) of *N. barkeri* on untreated and *B. bassiana*-infected first instars of thrips

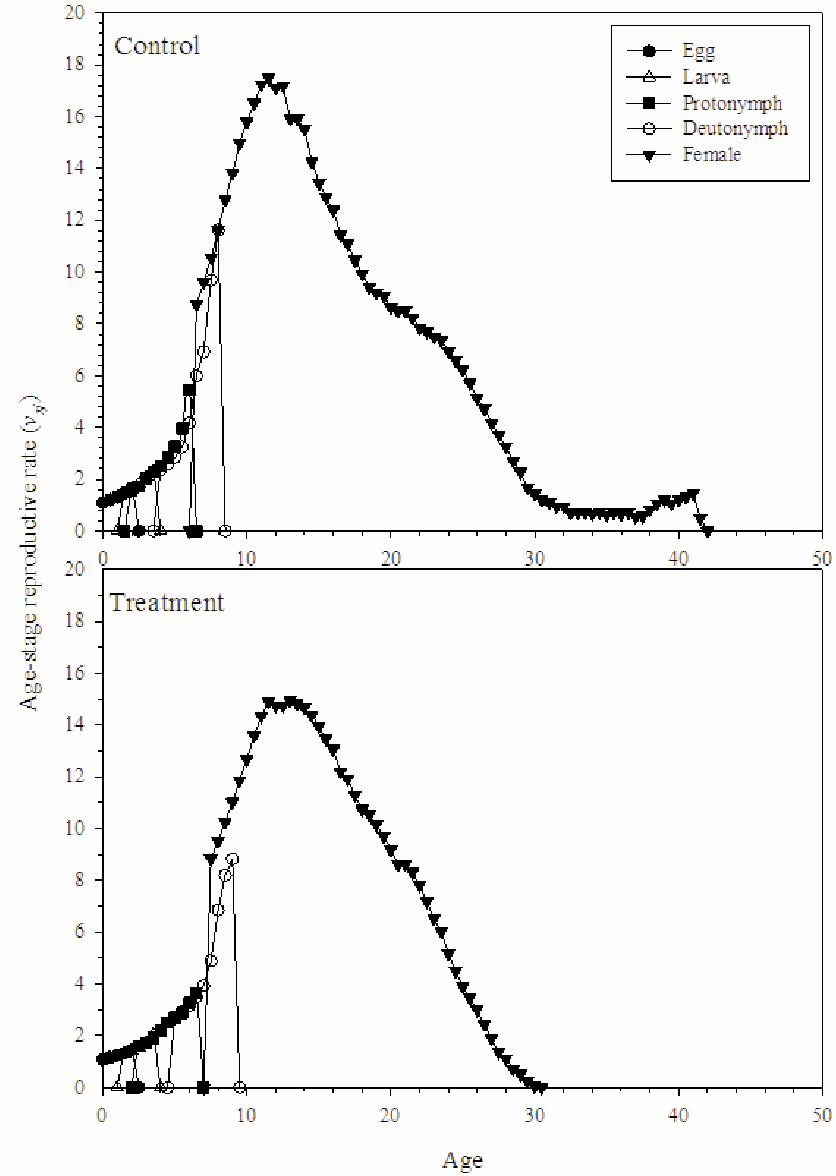
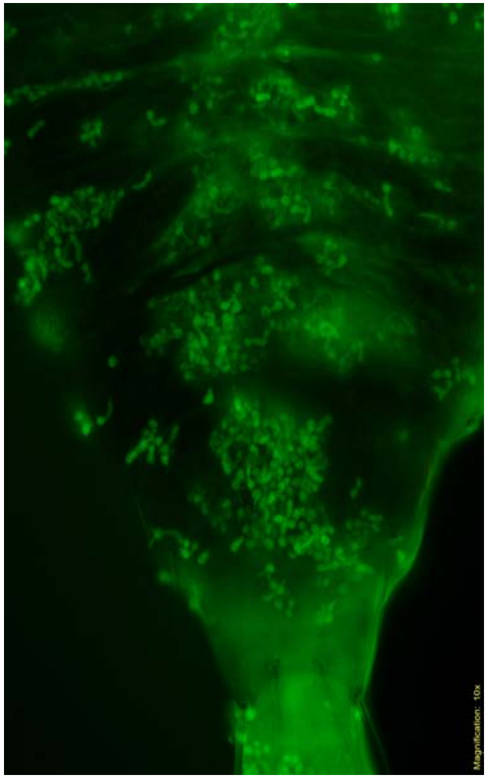
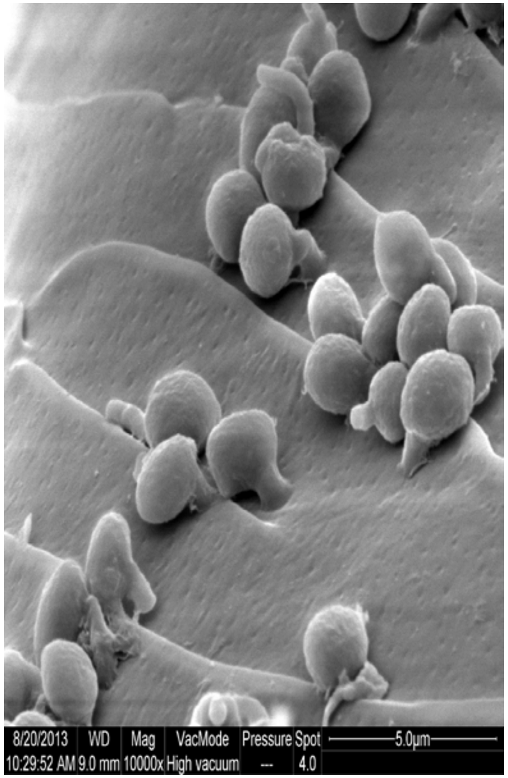


Fig. Age-stage-specific reproductive value (v_{xy}) of *N. barkeri* on untreated and *B. bassiana*-infected first instars of thrips

conidia appeared fluoresced green on the cuticle of *F. occidentalis* at 40× magnification



germinated conidia on the cuticle of *F. occidentalis* at 100× magnification



germ tube penetrating the cuticle

Fig. Germination and infection of *B. bassiana* conidia on the cuticle of first instar larvae of *F. occidentalis* (12 h) using fluorescence microscopy techniques and scanning electron microscope

Combined *Beauveria bassiana* with predatory mites for control of *Frankliniella occidentalis*

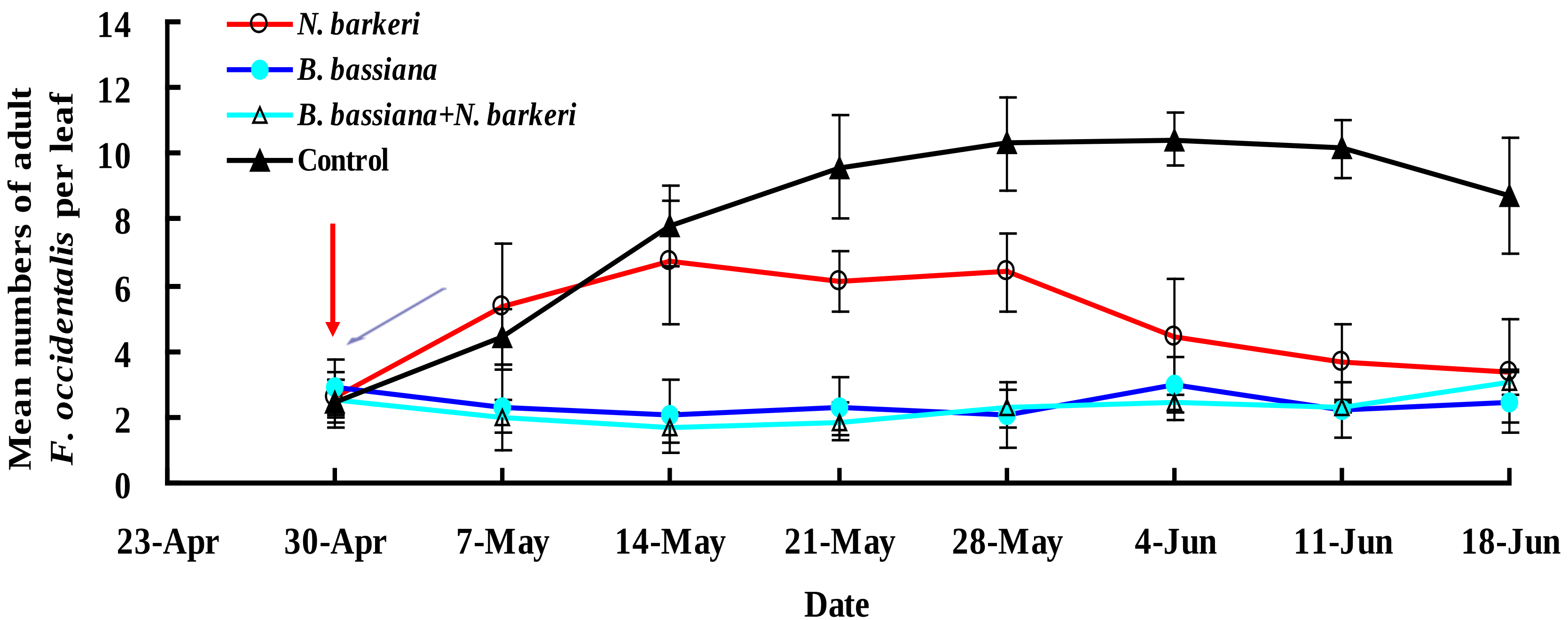


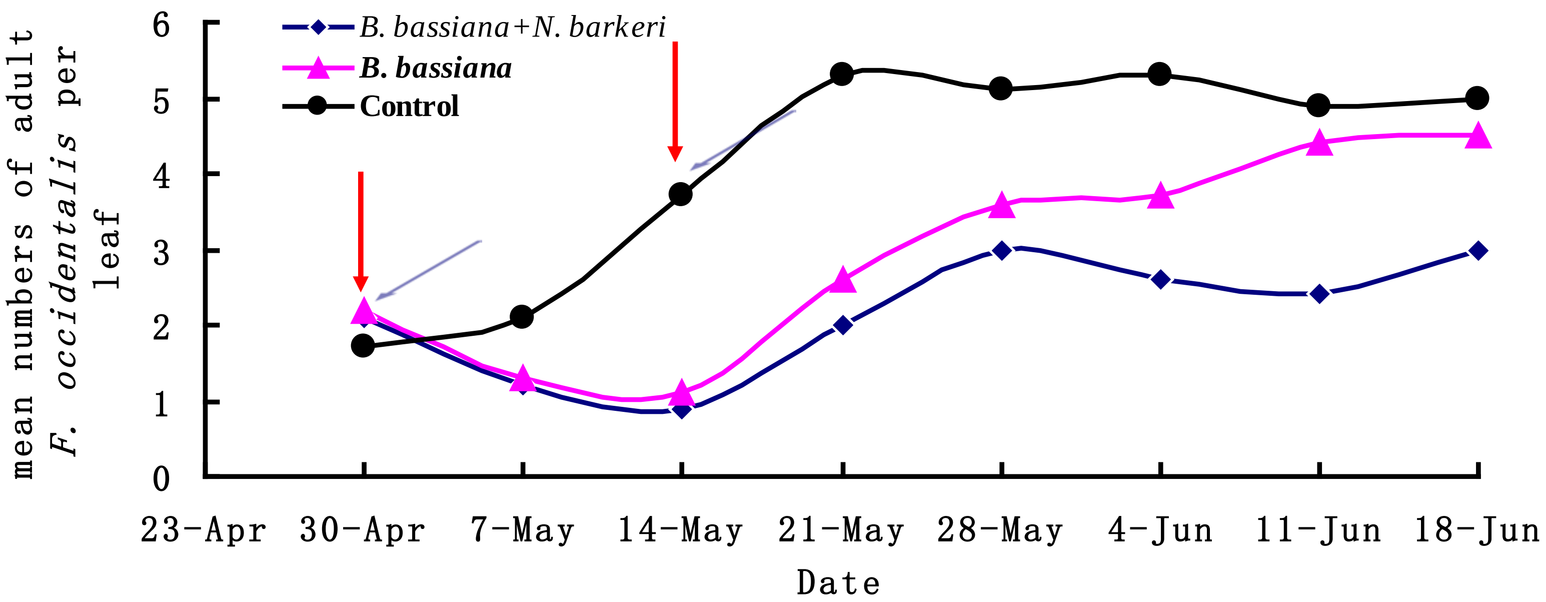
Fig. Population fluctuations of live adult *F. occidentalis* on cucumber plants weekly in different treatments in the greenhouse experiment.

Initial densities of *F. occidentalis* was investigated immediately prior to the experiment on day 30-Apr. *B. bassiana* was sprayed at 1×10^7 fungal conidia mL^{-1} of SZ-26 Suspensions, *N. barkeri* were released at density of 100 per plant simultaneously at the first time (30-Apr) and second time (14-May).

Table Mean density of live *N. barkeri* in treatment of *N. barkeri* alone and combined *B. bassiana* with *N. barkeri* on caged cucumber plants in the greenhouse

Sampling date	Mean number of *N. barkeri* per leaf (mean±SE)	
	N. barkeri	*B. bassiana* + *N. barkeri*
7 May	3.1±0.3a	2.8±0.5a
14 May	3.4±0.4a	3.7±0.4a
21 May	5.2±0.6a	4.5±0.7a
28 May	5.1±0.6a	5.5±0.5a
4 June	3.7±0.4a	4.1±0.5a
11 June	6.0±0.8a	7.1±0.9a
18 June	4.1±0.8a	4.5±0.4a

Note: Sample size for each sampling date was twelve leaf lobes per plant in six plants. Spray application and *N. barkeri* release were carried on 30 April and 12 May.
Small letters within a row followed by the same letter are not significantly different.



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Conclusion

- *Beauveria bassiana* SZ-26 successfully infected *F. occidentalis* within 60 h
- *Neoseiulus barkeri* displayed effective defense against *B. bassiana*.
- Life table parameters of *N. barkeri* were strongly affected when fed on infected *F. occidentalis*.
- There were obvious interactions between *B. bassiana* and *N. barkeri* with little synergistic effects for *F. occidentalis* biological control when combined both simultaneously.
- The application of *B. bassiana* in combination with *N. barkeri* at certain intervals was suggested.

Thank you for your attention!

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