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# Abstract

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## Suitable areas of two introduced predatory mites and their interactions with one native predatory mite in China*

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Predatory mites were the second largest group of natural enemies, where some species have been commercialized and used worldwide for pest biological control. Two important predatory mite species *Phytoseiulus persimilis* and *Neoseiulus cucumeris* have been introduced to China for the control of mite and small insect pests in greenhouses and open fields. However, little was known about their suitable distribution range in China and their interactions with the native and commercialized predatory mites, making their application and commercialization difficult.

*Phytoseiulus persimilis* and *N. cucumeris* mainly occur in the eastern coastal and central provinces of China but the potential distribution range of *N. cucumeris* is predicted to be almost twice as that of *P. persimilis*. Moreover, the potential distribution of *N. cucumeris* is expected to expand in the next 30 to 50 years due to climate changes. We predict that temperature and precipitation in the coldest quarter and average temperature in the driest quarter would be the main environmental variables affecting the potential distribution of *N. cucumeris*. Whereas precipitation, isothermality, average temperature of the warmest quarter and average temperature of the driest quarter would be the most important environmental variables affecting the potential distribution of *P. persimilis*.

These two species showed overlapped distribution with *N. californicus* in China. The identity and density of predators as well as their interactions potentially have significant influence on prey risk. Therefore, the multiple predator effects and their interaction strength were investigated, using the eggs of *Tetranychus urticae* as prey. The functional response and population dynamic model were utilized to quantify the predation rate of single predator and multiple predatory mites. Three predator species all showed type II functional response. Among them *N. cucumeris* was more efficient in controlling the pest mites than the other two species. Paired *N. cucumeris* also showed higher predation rate than paired *P. persimilis* and paired *N. californicus.* The heterospecific combination of *N. cucumeris* and *P. persimilis* were observed to be more efficient than the other two heterospecific combinations. The prey risk was reduced as significant antagonistic multiple predator effects were observed. The species interaction strength (*IS*) was over-estimated by the trophic interaction, with the significant negative non-trophic interaction strength ($IS_{NT}$) was detected. Both the *IS* and $IS_{NT}$ varied significantly across predator assemblage and prey density. Overall, the predator combination with *N. cucumeris* showed higher *IS* and $IS_{NT}$ than the other combination. The *IS* and $IS_{NT}$ decreased with the increasing of prey density.

In conclusion, *P. persimilis* and *N. cucumeris* can be great biological control agents of pest mites, especially in Southwest China. The substantial interference among predators should be considered when predicting the efficiency of biological control of multiple predators.

**Keywords**: predatory mites, suitable distribution area, multiple predator effects, functional response, species interaction strength, biological control

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