



## Non-consumptive effects of predation risk on prey population regulations: empirical evidence from the invasive spider mite *Tetranychus ludeni*\*

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*Tetranychus ludeni* Zacher is an invasive pest from Europe. It infests more than 300 plant species, including many economically important crops such as bean *Phaseolus vulgaris* L. (Fabales: Fabaceae), eggplant *Solanum melongena* L. (Solanales: Solanaceae), and many other cucurbitaceous plants. Gotoh *et al.* (2015) predict that this species could replace *T. urticae* to become a major crop pest in the world. It is often assumed that the success of biological control using predators is achieved through direct predation. However, it is still largely unknown whether predation risk could contribute to the effectiveness of prey biological control. In the present study we investigated the effects of cues from the predatory mite *Phytoseiulus persimilis* and killed *T. ludeni* on life history traits and offspring fitness of *T. ludeni*, providing novel knowledge for evaluation of the non-consumptive contribution to the biological control of *T. ludeni* and for future development of new spider mite control methods using these cues. We demonstrated that the cues from the predators and killed prey shortened the longevity by more than 23% and oviposition period by more than 35% and reduced the number of eggs laid by more than 31% in *T. ludeni* females. These cues also significantly reduced the intrinsic rate of increase and net population growth rate and prolonged the time to double the population size. Furthermore, in response to predator cues females significantly delayed their lifetime production of daughters and laid significantly smaller eggs. Offspring from predator-exposed mothers developed significantly more slowly. Our findings strongly suggest that the non-consumptive mortality caused by cues from both predators and killed prey can significantly reduce prey fitness, suppressing their population and lowering their damage to crops. The earlier prey death caused by these cues could result from the energetic costs of natural enemy avoidance (Luong *et al.* 2017), decrease of foraging rate or food intake (Hermann & Thaler 2014) and increase of oxidative damage (Janssens & Stoks 2013). The present study partially supports previous reports that non-consumptive impacts of predation risk on prey are transgenerational (Tariel *et al.* 2020). Our study provides critical information for evaluation of biological control effectiveness using predators and paves the way for identification of chemical odors from the predator and killed prey and development of new materials and methods for the control of spider mite pests.

**Keywords:** predation risk, biological control, Phytoseiidae, Tetranychidae

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