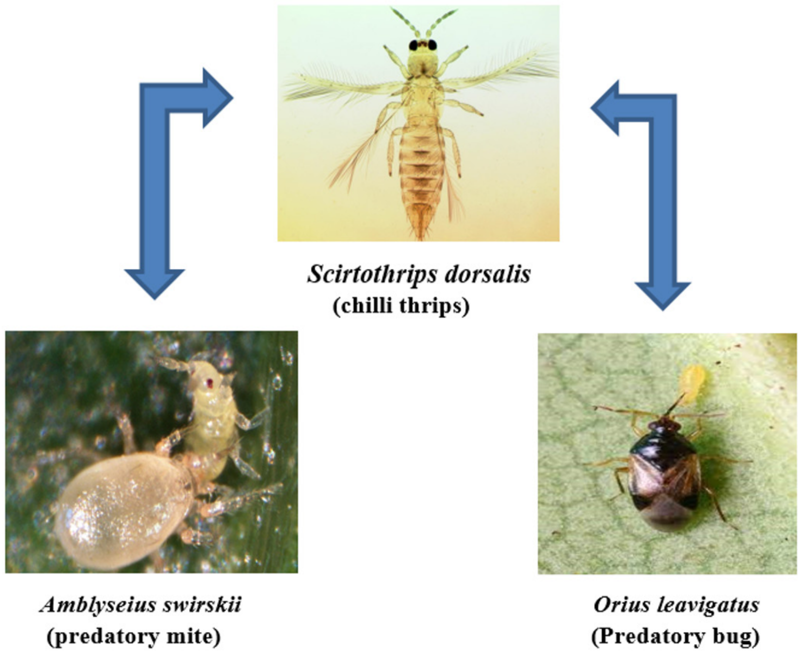
SHORT COMMUNICATION

Evaluation of *Amblyseius swirskii* (predatory mite) and *Orius leavigatus* as biological control agents of chilli thrips (*Scirtothrips dorsalis*)

M.T.M.D.R. Perera, N. Senanayake* and D.M.I.C.B. Dissanayake



Highlights

- Chilli thrips (*scirtothrips dorsalis* Hood) can control by a combination of predatory mite and a bug
- *Amblyseius swirskii* (*swirski-mite*) is the predatory mite and *Orius leavigatus*. *Fieber* is the bug.
- Combination of predators can effectively control Chilli thrips.
- Predators do not proliferate and need fresh releases to every cultivation season.

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Evaluation of *Amblyseius swirskii* (predatory mite) and *Orius leavigatus* as biological control agents of chilli thrips (*Scirtothrips dorsalis*)

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Abstract: Chilli thrips (*Scirtothrips dorsalis* Hood) is the most important pest and cause leaf curl complex in chilli. Farmers misuse pesticides for control; leading to resistant development, high residue levels, and environmental pollution. Laboratory experiments using *Amblyseius swirskii* and *Orius leavigatus* Fieber in combination reduced the thrips population significantly after two weeks. Reduction of biological agents population was statistically significant after four weeks and three weeks in *Amblyseius swirskii* and *Orius leavigatus* respectively. Thus, combined use of *Amblyseius swirskii* and *Orius leavigatus* effectively controlled thrips, but the biological agents did not multiply though bee's honey with pollen was provided as alternate food source.

***Keywords*:** *Scirtothrips dorsalis*; hood; *Amblyseius swirskii*; *Orius leavigatus*; fieber; chilli; biological control.

INTRODUCTION

Chilli (*Capsicum annuum* L.), an economically-important cash crop to Sri Lankan farmers, is grown in a range of agro-ecological regions of the country during the two major cultivation seasons; *Maha* and *Yala* (Menike and Costa, 2017). It is cultivated extensively in the dry zone of Sri Lanka. Among the diseases of chilli, leaf curl complex (CLCC), one of the major biotic threats to the production of chilli in Sri Lanka, dates back to 1938 (Senanayake *et al*., 2012). Almost all of the chilli varieties in Sri Lanka are susceptible to the leaf curl disease of chilli (LCDC) (Senanayake *et al*., 2015).

Chilli thrips, *Scirtothrips dorsalis,* are presently considered as one of the most important causal agents of the chilli leaf curl complex in Sri Lanka. *S. dorsalis*, is native to South Asia and has become a pest of horticultural crops worldwide. Discolored or disfigured plant parts implies the presence of *S. dorsalis* and their severe infestation creates the tender leaves and buds of chilli plants brittle and complete defoliation and total crop loss is expected (Amin, 1979). *S. dorsalis* can infest 100 or more plant species, including pepper, tea, strawberries, tomatoes, and many vegetables, fruit, and ornamental crops.

Chilli thrips attacks other economically important crops like citrus, cotton, jute, potato, tea, and grapevine (Jeppson *et al*., 1975). The thrips feed on plants by lacerating epidermal and mesophyll tissues of the leaf, thus it causes considerable yield loss to the chilli crop (Fernando and Peiris, 1957). Thrips feeding produces numerous symptoms including streaks, small white patches, and silvery speckling on vegetative, flower and fruit parts and results in premature flower fall, pollen depletion, leaf shedding, leaf deformity and leaf galls.

Thrips reproduction is parthenogenetic. Whether partial or total, the various species are either arrhenotokous or thelitokous or, as indicated by most authors, females are always diploid and males haploid (Lewis, 1997). Temperature and moisture influence the number of generations that may occur per year. Females insert their eggs inside the plant tissue or on or near leaf veins, terminal plant parts, and floral structures. Pupation occurs in the soil. Temperatures near 20 °C, the development from egg to adult takes approximately 19 d, if temperatures exceed 25 °C, it takes only 13 d.

Although thrips are most commonly controlled with insecticide applications (Morse and Hoddle, 2006), information regarding the chemical control of *S. dorsalis* is limited. Seal *et al*. (2006) showed chlorfenapyr (5%), spinosad (25 g/L SC), and imidacloprid (70% WS) were relatively effective (*e.g.* 88% pest reduction compared to controls), although the performance of novaluron (100 g/L EC), abamectin (0.15 EC), spiromesifen (240 SC), cyfluthrin 5% EW, and azadirachtin (95%) were inconsistent unless applied weekly. Therefore exclusive reliance on synthetic insecticides is not a sustainable option for *S. dorsalis*, because of high costs and necessity of repeated applications, risks developing pesticide resistance with rapidly reproducing thrips populations (Herron *et al*., 2007).

Welter *et al*. (1990) surmised an economic injury level of 16 thrips/leaf for *F. occidentalis* and 94.5 thrips/leaf for *T. palmi* in cucumber. Kawai (1986) estimated economic injury levels of 4.4 adults/leaf, 0.17 adults/leaf,

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and 0.11 adults/flower of *T. palmi* in cucumber, aubergine, and sweet pepper, respectively, assuming that 5% yield loss of undamaged fruits is tolerable.

In Sri Lanka, vector control for controlling chilli leaf complex using synthetic chemicals without proper diagnosis of the causal organisms results in a resurgence of the pests, phytotoxicity, destruction of earthworm, killing of pollinator insects, and presence of a high amount of pesticide residue on harvested fruits and has many other drawbacks (Peiris, 1953). Farmers are tempted to misuse and overuse chemical insecticides leading to resistant development, high level of insecticide residues in the harvest, and health hazards. Moreover, it also pollutes the environment. Biological control methods are now receiving more attention, since these alternative methods, compared to chemical control, are energy-saving, non-polluting, ecologically sound, and sustainable. Microbial insecticides are already used in agricultural systems and knowledge of the biology and ecology of the diseases has greatly increased in recent years. The potential yield of chilli in the Dry Zone of Sri Lanka is 3 t/ha, the average dry chilli yield has been reported to be 1.0 t/ ha (Senanayake *et al*., 2015) and it is mainly due to pests and diseases encountered by the crop.

In order to develop an economically feasible strategic management plan to reduce unwarranted loading of pesticides in the chilli ecosystem, a thorough knowledge of the available enemy complex of the target pests is very essential. Biological control of thrips involves combining a range of beneficial insects and protecting plants from pest damage and population build-up and measures can be taken early in the growth cycle ensuring that the predatory mites are omnipresent on the plants This is important as these predators only eat the very small larvae and will not feed on adult thrips (Dogramaci *et al*., 2011). Many research studies conducted thus far have used two biological agents for the control of Thrips. *Amblyseius cucumeris* predatory mite is the common predatory mite used in temperate countries though in the summer months, they switch to *Amblyseius swirskii* which can thrive well and will eat larger thrip larvae. In this study two biological agents imported from Koppert Biological Systems, Netherlands were evaluated for the control of thrips in chilli plants.

MATERIALS AND METHODS

The experiment was conducted at the laboratory of the Plant Quarantine Unit of the Department of Agriculture (DOA), Peradeniya. Chilli plants are raised in the greenhouse as per the recommended practices of the DOA and two months old and flower-initiated plants were selected for the experiment. The protocol for experimentation was developed by scientists of Koppert Biological Systems, Netherlands, and used in the experiment. These plants were kept inside the mass rearing insect cages of thrips, *S. dorsalis* (Figure 1 a), for 3 weeks for them to lay eggs and infest the plants. After this treatment, three plants each are kept per insect cage and three insect cages (03 replicates) were used, as per the protocol given by the Koppert Biological System scientists. Another three insect cages with three infested plants each were prepared as control treatment. Koppert Biological System, Netherlands recommended the combined use of two biological agents namely, *A. swirskii* (SWIRSKI-MITE) (Figure 1 b) and *O. laevigatus* Fieber (THRIPOR) (Figure 1 c) and live insect samples were imported and used directly in the experiment. The recommended dose of the biological agent by the Koppert scientists was to introduce four insects per plant (12 per cage). Accordingly, biological agents were introduced to test plants, and the chilli plants were maintained as per the recommended practices of the Department of Agriculture except for pest control. The insects were provided with cotton wool swabs dipped in 10% bee's honey with pollen solution as additional feed.

After five days of treating plants with biological agents, the insect counts of thrips (adults and nymphs) and biological agents were taken from 10 leaves per plant (30 leaves/replicate). Because of the small size of thrips, a hand lens (× 20) was used. Data collection was repeated at seven-day intervals for five weeks. Since the experiment was conducted under controlled conditions inside the laboratory, the treatment to treatment variation of different parameters is minimal. Hence, data were statistically analyzed considering as RCB design with three replicates using SAS package.

(a) *S. dorsalis* (b) *A. swirskii* (c) *O. laevigatus*

Figure 1: Chilli thrips (a) and their biological agents (b, c).

RESULTS AND DISCUSSION

Thrips are a serious pest in chilli crops feeding on cell sap and also responsible for virus infections as well. A heavy infestation of *S. dorsalis* in chilli plants changed the appearance to what is called "chilli leaf curl". However, in this experiment, thrips in the control treatment did not show severe symptoms of the pest attack because the number remained non-significant even after six weeks. The number of thrips in this experiment was not high (1.7 thrips/leaf) to cause any serious damage as explained above by Amin (1979) because had there been any leaf drop, the thrips count should have reduced due to death as they experience food shortage (1.7 thrips/leaf at a release rate of 4 thrips/plant). The threshold level of thrips in cotton in Punjab in India is 8-10/leaf (http://www.pestwarning.agripunjab.gov.pk/economic-thresholds#Vegetables).

The results obtained are presented in Table 1. The data indicated that the number of thrips in chilli plants reduced significantly after two weeks of the introduction of biological agents indicating their effectiveness in controlling the chilli pest ($P = 0.05$). However, the biological agents did not multiply in the laboratory conditions where insect cages were kept probably because of poor food supply and/or the environmental conditions are not conducive for their multiplication, though there is a solitary indication of an increase of swaskki mites one week after introduction. The overall indication, however, is that the number of biological agents counted from 10 random leaves reduced week after week in the case of *A. swirskii* and of *Orius leavigatus.* This can probably be due to lack of food as the number of thrips got reduced. Dogramaci *et al.* (2011) working on *A. swirskii* and *O. insidiosus* indicated that they are effective predators of chilli thrips and, speculate, other thrips on a range of pepper varieties. They indicated that thrips populations were always maintained at an equivalent or lower levels under predator combination treatments compared with single predator treatments. Farkas *et al.* (2016) surmised that the infestation level of thrips when low, suggests that release of a single predator could be applied effectively while maintaining the thrips below the threshold value of damage in greenhouse in sweet pepper.

Further, Arthurs *et al*. (2009) reported that *A. swirskii* can be a promising mite in managing chilli thrips on pepper after evaluating two phytoseiid mites, *N. cucumeris* , and *A. swirskii.* Predatory mite, *A. swirskii* is very effective generalist predatory mite as an excellent biological control agent and has been used in controlling whiteflies, thrips, and spider mites causing serious damage to economically important crops grown either in greenhouses or in open field (https://www.buglogical.com/spider-mites-page-3.html). In our experiment also we used a combination of biological agents as proposed by the Koppert Biological Systems but yet it is important to investigate the possibility of using *A. swirskii* alone in controlling thrips under tropical conditions prevailing in Sri Lanka.

The control treatment initially had a population of 22 thrips/10 leaves (2 thrips/leaf) which is far below the economic threshold population. Welter *et al*. (1990) proposed an economic injury level of 16 thrips/leaf for *F. occidentalis*. Dogramaci *et al*. (2011) surmised *Orius insidiosus* adults have been observed to feed on all the developmental stages of thrips, and since it is a generalist predator which feeds on aphids, mites, moth eggs, and pollen, its population does not decline when there are periodic drops in the thrips population. This could be the reason for not having a significant drop in the population of *Orius leavigatus* also in our experiment till the 4th week after introduction when there is a significant drop in population of thrips after two weeks of introduction.

In Table 1, the populations of biological agents and the chilli thrips in the treatment and control showed there is a distinct population decrease of all insects except for

Table 1: Mean insect count/10 leaves/plant (Average of three replicates) after introducing the biological agents; *A. swirskii* (SWIRSKI-MITE) and *Orius leavigatus* (TRIPHOR).

Date	No. of Thripsin Treatment (adults + nymphs)	No. of A. swirskii	No. of O. leavigatus	No. of Thrips in Control (adults + nymphs)
Introduced	17.67 (11 - 22)^{a*}	4.00^{a}	4.00^{a}	22.00 (18 - 26)
1 WAI**	10.67 (9 - 13)^{b}	7.00 (4 - 9)^{a}	7.22 (5 - 7)^{a}	12.33 (8 - 17)
2 WAI	5.33 (4 - 6)^{c}	4.33 (3 - 6)^{a}	5.89 (4 - 7)^{a}	14.66 (8 - 22)
3WAI	6.33 (4 - 8)^{c}	3.00 (2 - 4)^{a}	3.22 (3 - 4)^{a}	18.00 (14 - 23)
4 WAI	3.00 (2 - 4)^{c}	3.33 (3 - 4)^{a}	3.00 (2 - 4)^{b}	31.00 (25 - 37)
5 WAI	2.67 (2 - 3)^{c}	1.67 (1 - 2)^{b}	2.33 (2 - 3)^{b}	17.00 (14 - 20)
	2.0 (1 - 3)^{c}	1.33 (0 - 2)^{b}	1.33 (1 - 2)^{b}	20.66 (17 - 26)
SED	4.135			

*Figures represented by the same letter is not significantly different statistically from each other.
WAI** = Weeks after introduction; Data range is given in Bracket.
SED = Standard error difference

the control treatment, which suggests the effectiveness of the combined use of biological control agents in controlling chilli thrips. Even though Koppert Biological Systems suggest the use of two agents, it is necessary to test them individually under our conditions because the farmer has to incur high costs for importing and using biological agents. In global literature (Arthurs *et al*., 2009; Dogramaci *et al*., 2011), *A. swirskii* is rated as a very effective generalist predatory mite and an excellent biological control agent for thrips control, the possibility of using *A. swirskii* alone in chilli thrips control needs to be investigated.

CONCLUSION

In conclusion, the data revealed that a combination of biological agents of *A. swirskii* and *Orius leavigatus* is effective in controlling chilli thrips, but the biological agents do not multiply under local conditions even with the supply of bee's honey with pollen as supplementary food. Therefore, the fresh introduction of biological agents needs to be done in every cultivation season under local conditions.

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DECLARATION OF CONFLICT OF INTEREST

The authors hereby declare that there are no competing interests OR the existence of a financial/non-financial competing interest for the manuscript.

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