



# Biological Control of *Halyomorpha halys* (Hemiptera: Pentatomidae) Using *Podisus maculiventris* (Hemiptera: Pentatomidae)

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## INTRODUCTION & OBJECTIVES

The spined soldier bug, *Podisus maculiventris* (Hemiptera: Pentatomidae), is a generalist predator native to North America which feeds on many important pests of various crops (McPherson 1980). The brown marmorated stink bug, *Halyomorpha halys* (Hemiptera: Pentatomidae), is an invasive phytophagous pest causing considerable damage to field crops and fruit orchards in North America (Hoebeke and Carter 2003). Currently, *H. halys* management heavily relies on pesticides, and thus identification of potential natural enemies of *H. halys* is an important strategy for integrated pest management. Our field observation suggested the potential of *P. maculiventris* as a biological control agent against *H. halys*. This study was conducted to (1) determine which life stages of *P. maculiventris* can effectively kill *H. halys* life stages and (2) describe the feeding behavior of *P. maculiventris*.

## MATERIALS AND METHODS

**Experiment 1. *P. maculiventris* life stages feeding on *H. halys* life stages:** A laboratory experiment was conducted to assess which life stages of *H. halys* are most vulnerable to *P. maculiventris* feeding. One adult *P. maculiventris* was introduced into a 55-mm petri dish with each of seven different *H. halys* stages as treatment: one *H. halys* egg cluster (an average of 24.4 eggs/cluster), a group of *H. halys* 1<sup>st</sup> instar (an average of 20.5 *H. halys*), five for each of *H. halys* 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup>, 5<sup>th</sup> instars and adults. All *P. maculiventris* used in this study were starved for 24 hours prior to experiment. After 24 hours of *P. maculiventris* introduction, sunken *H. halys* eggs from feeding were counted, mortality of *H. halys* from predation was recorded. The same experiment was repeated with 3<sup>rd</sup> and 5<sup>th</sup> instar *P. maculiventris*. Each experiment was replicated ten times per *P. maculiventris* and *H. halys* life stage combination (i.e. a total of 21 treatment × ten replications).

**Experiment 2. Feeding Behavior of *P. maculiventris* on *H. halys* Eggs and 1<sup>st</sup> Instar:** An observational study was conducted to investigate feeding behavior of *P. maculiventris* (3<sup>rd</sup> and 5<sup>th</sup> instar) on *H. halys* eggs and 1<sup>st</sup> instar. One 1<sup>st</sup> instar or three eggs of *H. halys* were introduced into a 55-mm petri dish. One *P. maculiventris* (3<sup>rd</sup> or 5<sup>th</sup> instar) was placed into the same petri dish. Feeding behavior was recorded for two hours using a DCR-sx40 Sony video camera (Sony Inc., Lake Forest, CA) secured ca. 60 cm above the petri dishes. From the video footage searching and feeding behavior of *P. maculiventris* was analyzed. All *P. maculiventris* used in the study were starved for 48 hours before the experiment. *P. maculiventris* 3<sup>rd</sup> instar and *H. halys* egg repeated 24 times, *P. maculiventris* 3<sup>rd</sup> instar and *H. halys* 1<sup>st</sup> instar repeated 18 times, *P. maculiventris* 5<sup>th</sup> instar and *H. halys* egg repeated 12 times, *P. maculiventris* 5<sup>th</sup> instar and *H. halys* 1<sup>st</sup> instar repeated 12 times.

**Table 1. Mean number of *H. halys* killed by various stages of *P. maculiventris***

<i>P. maculiventris</i> Stage	<i>H. halys</i> Stage*						
	Egg	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	Adult
Adult	8.3 ± 1.45a	4.5 ± 1.03a	1.5 ± 0.33a	0.6 ± 0.00a	0	0	0
5 <sup>th</sup>	7.5 ± 2.68a	4.1 ± 1.45a	1.4 ± 0.84a	0.5 ± 0.53a	0	0	0
3 <sup>rd</sup>	3.9 ± 1.94b	1.2 ± 1.58b	0.1 ± 0.71b	0.0 ± 0.53b	0	0	0

\* Means within a column followed by same letter is not significantly different ( $P > 0.05$ , Duncan's Test).

## RESULTS & DISCUSSION

**Experiment 1. *P. maculiventris* life stages feeding on *H. halys* life stages:** We found that *P. maculiventris* 3<sup>rd</sup> instar, 5<sup>th</sup> instar, and adult were unable to kill *H. halys* 4<sup>th</sup> instar, 5<sup>th</sup> instar and adult (Table 1). *P. maculiventris* adult and 5<sup>th</sup> instar killed significantly more *H. halys* eggs (d.f. = 2,  $F = 11.37$ ,  $P < 0.05$ ), *H. halys* 1<sup>st</sup> instar (d.f. = 2,  $F = 17.07$ ,  $P < 0.05$ ), *H. halys* 2<sup>nd</sup> instar (d.f. = 2,  $F = 12.32$ ,  $P < 0.05$ ) and *H. halys* 3<sup>rd</sup> instar (d.f. = 2,  $F = 4.00$ ,  $P < 0.05$ ), than *P. maculiventris* 3<sup>rd</sup> instar (Table 1).

**Experiment 2. Feeding Behavior of *P. maculiventris* on *H. halys* Eggs and 1<sup>st</sup> Instar:** We observed that *P. maculiventris* intermittently pierced and then retracted its stylet from the egg or 1<sup>st</sup> instar *H. halys*. This behavior was repeated multiple times before sustained feeding started. *P. maculiventris* positioned stylet into the side or underneath of the egg mass or 1<sup>st</sup> instar (Figs. 1-3). We also observed that *P. maculiventris* fed on multiple eggs one at a time before moving onto the next egg within the cluster; generally, outer eggs were eaten first. When *P. maculiventris* fed on the 1<sup>st</sup> instar *H. halys* it lifted the 1<sup>st</sup> instar off the surface using its stylet (Fig. 3). *P. maculiventris* also used its stylet to rotate the *H. halys* during feeding (Fig. 4). The body of *H. halys* 1<sup>st</sup> instar became concave during feeding and then shriveled and curled in from the ventral side (Fig. 5).

## CONCLUSION

*P. maculiventris* has the ability to kill eggs and younger instars (1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> instars) of *H. halys* effectively (Table 1). However, *P. maculiventris* could not kill 5<sup>th</sup> instar and adult *H. halys*, which inhibits their potential to control *H. halys* adults emerging from overwintering sites or moving into an orchard or field crop early in the season. Additional field tests and choice tests should be conducted in order to assess the potential of *P. maculiventris* as a biological control agent against *H. halys* in the field.

## LITERATURE CITED

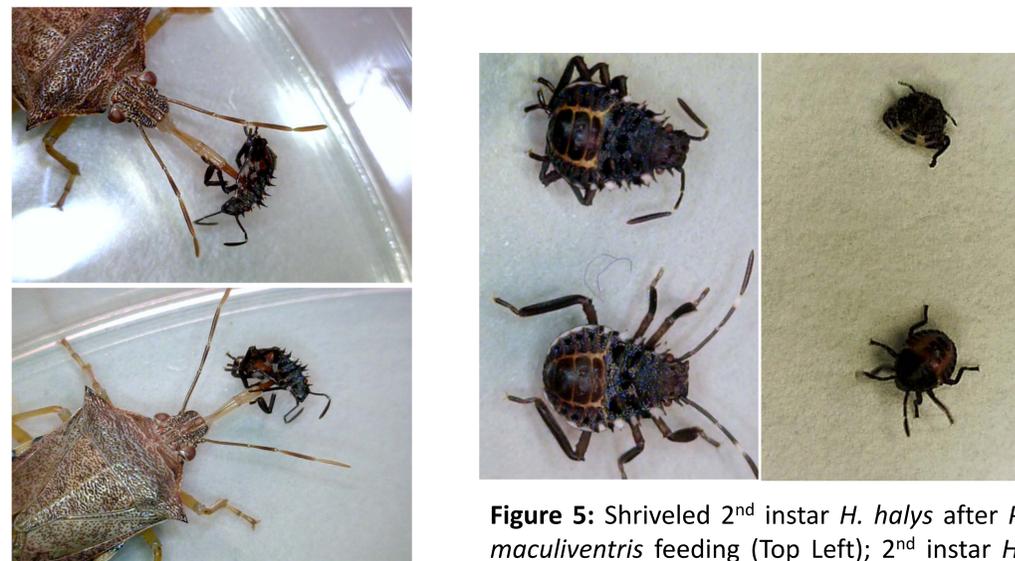
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**Figure 1:** *P. maculiventris* 3<sup>rd</sup> instar feeding from side of *H. halys* egg. **Figure 2:** *P. maculiventris* 4<sup>th</sup> instar feeding on side of *H. halys* egg. **Figure 3:** *P. maculiventris* adult lifting while feeding on 1<sup>st</sup> instar of *H. halys* from the underneath.



**Figure 4:** Adult *P. maculiventris* rotating 2<sup>nd</sup> instar of *H. halys* with stylet while feeding. **Figure 5:** Shriveled 2<sup>nd</sup> instar *H. halys* after *P. maculiventris* feeding (Top Left); 2<sup>nd</sup> instar *H. halys* without being fed on (Bottom Left); shriveled 1<sup>st</sup> instar *H. halys* after *P. maculiventris* feeding (Top Right); 1<sup>st</sup> *H. halys* without being fed on (Bottom Right).