Interspecific and intraspecific interactions of *Anastatus reduvii*, an egg parasitoid of the brown marmorated stink bug (BMSB), *Halyomorpha halys* Stål (Hemiptera: Pentatomidae)

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Background

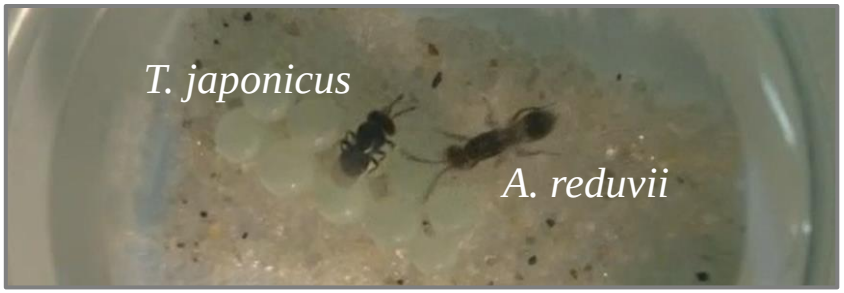
- Brown marmorated stink bug (BMSB), *Halyomorpha halys* Stål (Hemiptera: Pentatomidae) is a widespread invasive pest, introduced in the US in the 1990s from Asia.
- BMSB is polyphagous and causes damage to many economically important plants.
- Sustainable management of BMSB is important

- Indigenous egg parasitoids, such as *Anastatus reduvii* (Howard) (Hymenoptera: Eupelmidae), which exploit BMSB, are promising biocontrol agents
- *A. reduvii* is a generalist egg parasitoid which attacks hosts in five insect orders
- *A. reduvii* effectively parasitizes BMSB eggs

Objectives

Main objective:

To investigate the behavioral changes of *Anastatus reduvii* in the presence of the same species (i.e. another *A. reduvii* individual), as well as in the presence of *Trissolcus japonicus* (a natural enemy of BMSB in Asia)



We specifically focused on the following:

- Time spent by *A. reduvii* ON the egg mass
- Various behavior performed by *A. reduvii* ON and OFF the egg mass and its changes in the presence of other parasitoids
- Effect of host-feeding and probing/ovipositing, performed by *A. reduvii*, on the BMSB egg fate

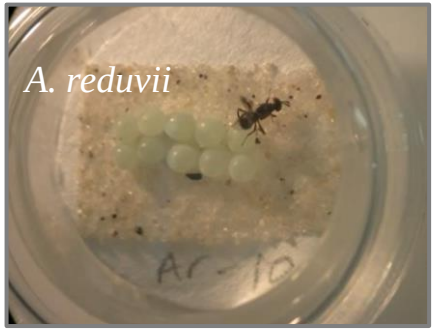
Methods

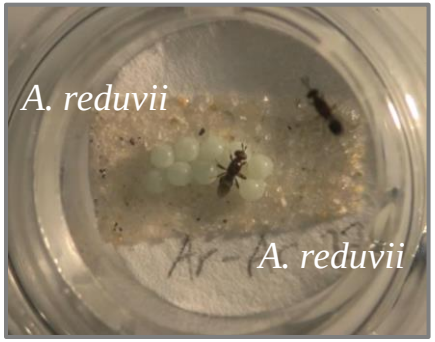
- Competition lab assays: petri dishes, 1.5 cm diameter
- Artificially constructed BMSB egg masses (2 rows of 5 eggs, 24 hours old)
- *Anastatus reduvii* and *Trissolcus japonicus* females were introduced into the arena in the following six treatments (10 reps for each):

1) Control (no parasitoids)
2) ***Anastatus reduvii* only (one adult female)**
3) ***Anastatus reduvii* only (two adult females)**
4) *Trissolcus japonicus* only (one adult female)
5) *Trissolcus japonicus* only (two adult females)
6) ***Anastatus reduvii* and *Trissolcus japonicus***
   (one adult female of each species)

- Each competition trial was video recorded with Canon HD Vixia HF G20 camera; the video recordings were analyzed using Noldus Observer XT software (version 12.5); duration of each video trial ranged from 1-3 hours

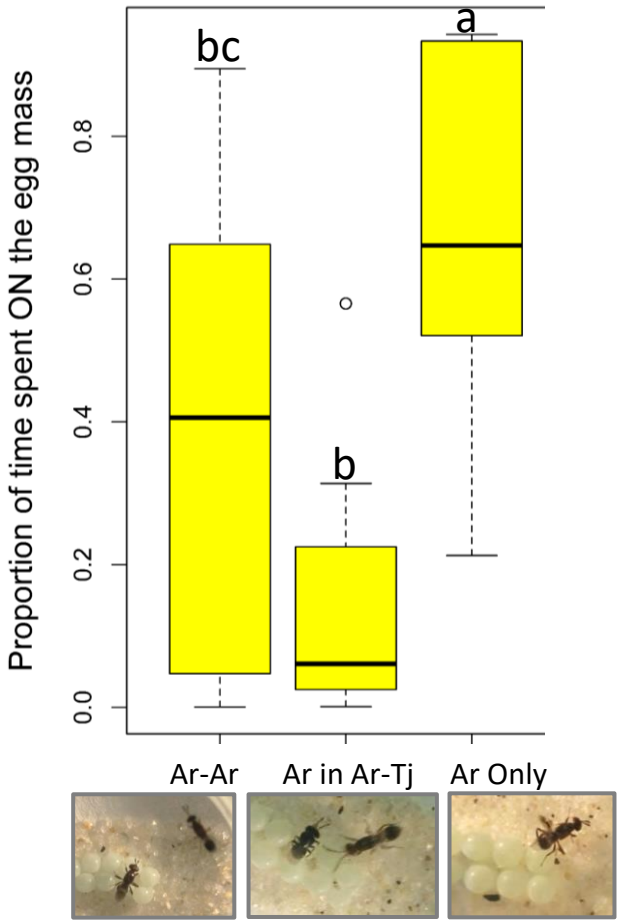
Focus on *A. reduvii*'s "perspective":





**We are presenting the results for these 3 treatments which involve A. reduvii*

Results:
Time spent by *A. reduvii* ON the egg mass



One-way ANOVA:
$F_{2,31}$ =6.738, p=0.004

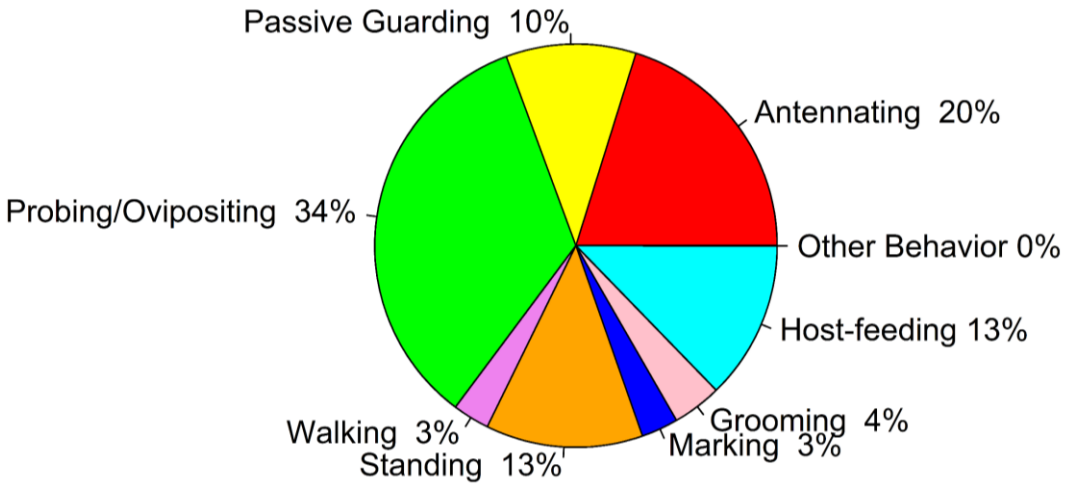
- Overall, *A. reduvii* spent significantly less time ON the egg mass in the presence of either *T. japonicus* (TukeyHSD: p= 0.0028) or another *A. reduvii* (TukeyHSD: p= 0.0496)

**data were averaged across the replicates for each treatment*

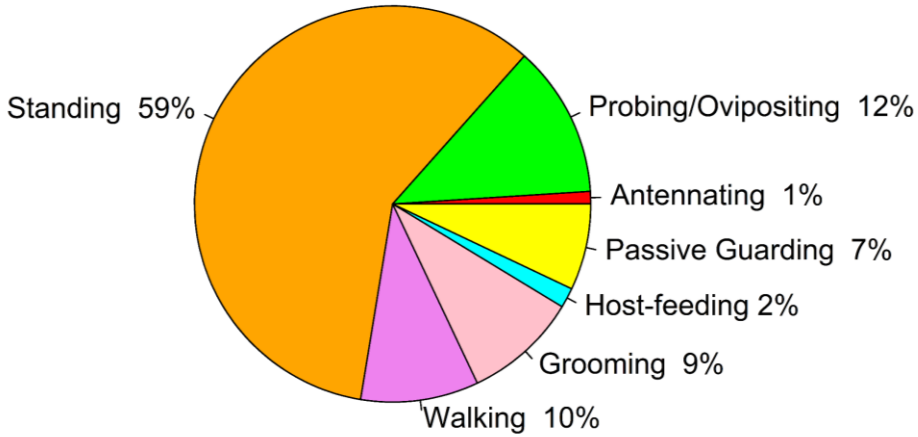
Various behavior performed by *A. reduvii* ON and OFF the egg mass and its changes in the presence of other parasitoids

***A. reduvii* (1 female only)**

ON



OFF



** We recorded up to 9 types of behavior A. reduvii performed when alone*

A. reduvii (2 females, Ar1 and Ar2)

- The duration of each type of behavior was compared between Ar1 and Ar2
- Only oviposition-related behavior ('antennating' + 'probing/ovipositing' + 'host-feeding') showed significant difference between Ar1 and Ar2 in 4 out of 9 replicates.

***A. reduvii* 'dominant type' (Ar_d)**
The duration of oviposition-related behavior is significantly longer than that in Ar_p

***A. reduvii* 'passive type' (Ar_p)**
The duration of oviposition-related behavior is significantly shorter than that in Ar_d

5 out of 9 replicates

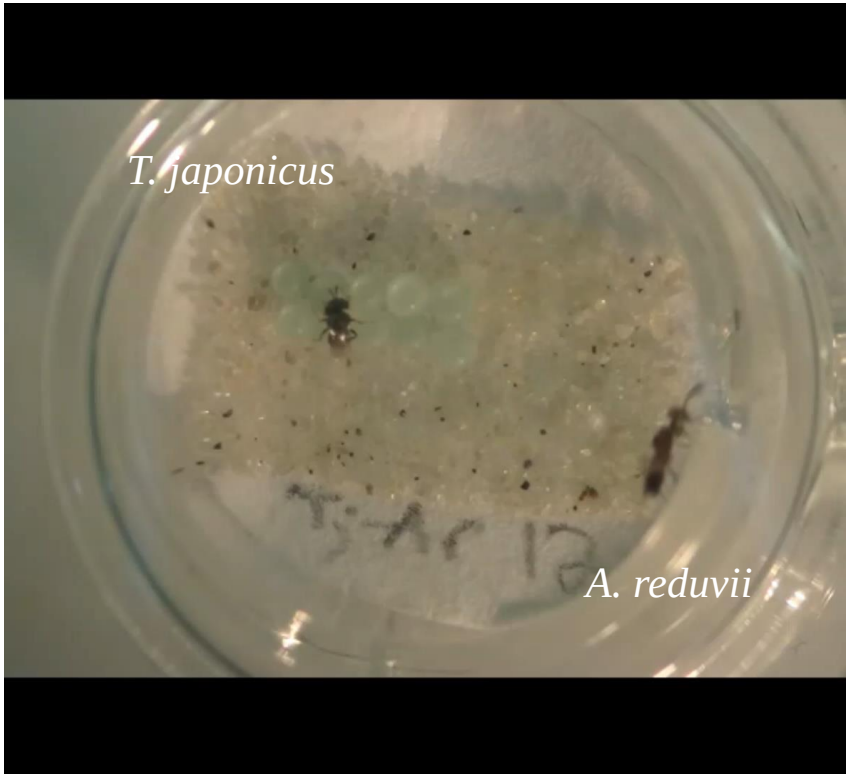
***A. reduvii* performing similar behavior (Ar_s)**
No significant differences in the duration of oviposition-related behavior between Ar1 and Ar2

**The behavior for Ar types were analyzed separately*

	Ar (2 females)						1Ar & 1Tj		1 Ar	
Behavior	Ar-Ar						Ar in Ar-Tj		Ar Only	
	Ar_d		Ar_p		Ar_s					
On/Off the egg mass	On	Off	On	Off	On	Off	On	Off	On	Off
Grooming	1%	13%	3%	6%	1%	12%	4%	13%	4%	9%
Walking	16%	41%	66%	45%	11%	48%	12%	26%	3%	10%
Standing	10%	42%	1%	49%	3%	26%	14%	56%	13%	59%
Antennating	9%	<1 %	4%	<1 %	5%		6%	<1%	5%	1%
Probing / Ovipositing	51%	<1 %	9%		47%	13%	15%		34%	12%
Host-feeding	13%	<1 %	<1%		9%	<1%	5%		13%	2%
Marking									3%	
Passive Guarding									10%	
Other Behavior									<1%	
Antennate other parasitoid	<1%	<1 %	1%		23%	<1 %	<1 %	<1 %		
Aggression					4%	<1%	1%	<1%		
Retreat					<1 %	<1 %	42 %	4%		
Walk on other parasitoid			<1%		<1%	<1%				

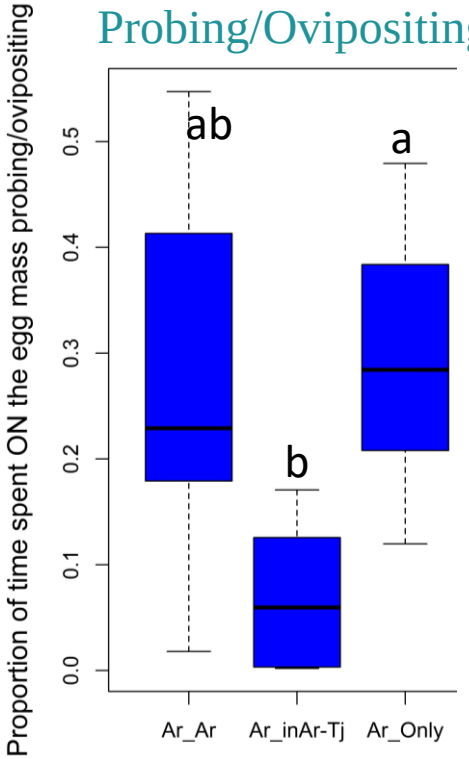
*A. *reduvii* performed up to 4 new types (■) of behavior in the presence of other parasitoids

Aggression in *A. reduvii* and *T. japonicus*

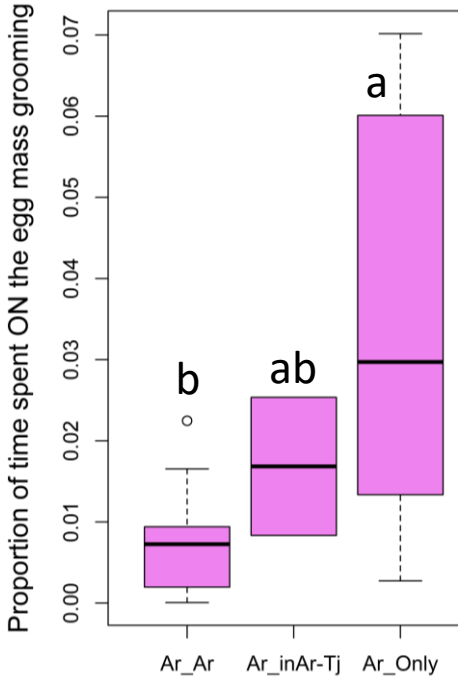


Overall changes in behaviour performed by *A. reduvii* ON and OFF the egg mass in the presence of other parasitoids

Probing/Ovipositing



Grooming

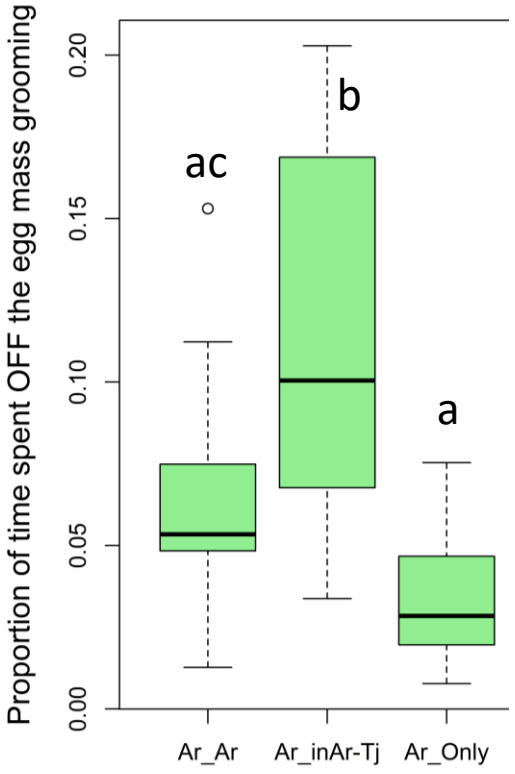


ON

- *A. reduvii* spent significantly less time probing/ovipositing ON the egg mass in the presence of *T. japonicus* but not in the presence of another *A. reduvii* *(χ^2=7.96, df=2, p-value=0.018)*

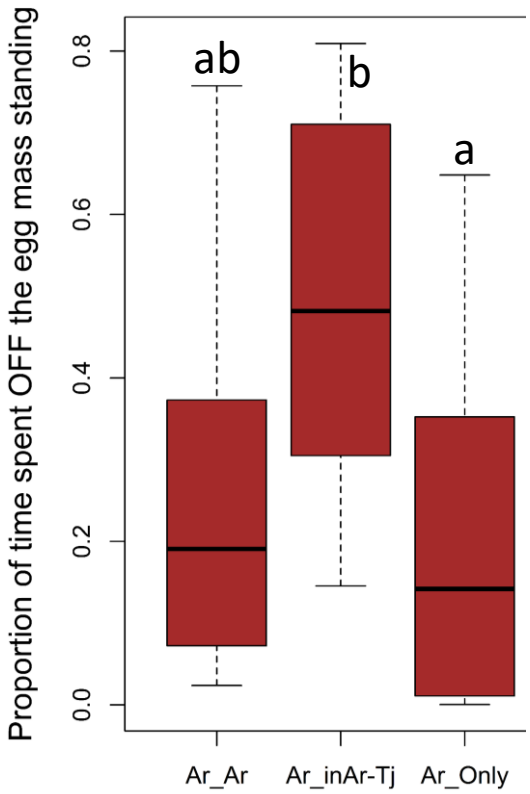
- *A. reduvii* spent significantly less time grooming ON the egg mass in the presence of another *A. reduvii* but not in the presence of *T. japonicus* *(χ^2=7.54, df=2, p-value=0.023)*

Grooming



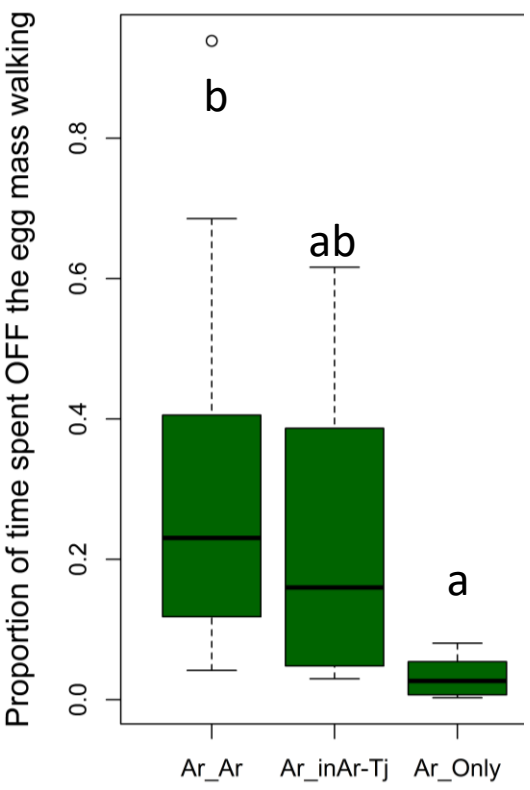
- *A. reduvii* spent significantly more time grooming OFF the egg mass in the presence of *T. japonicus* but not in the presence another *A. reduvii* (χ^2= 12.78, df=2, p-value= 0.001)

Standing



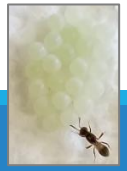
- *A. reduvii* spent significantly more time standing OFF the egg mass in the presence of *T. japonicus* but not in the presence of another *A. reduvii* (χ^2=6.17, df=2, p-value =0.04)

Walking



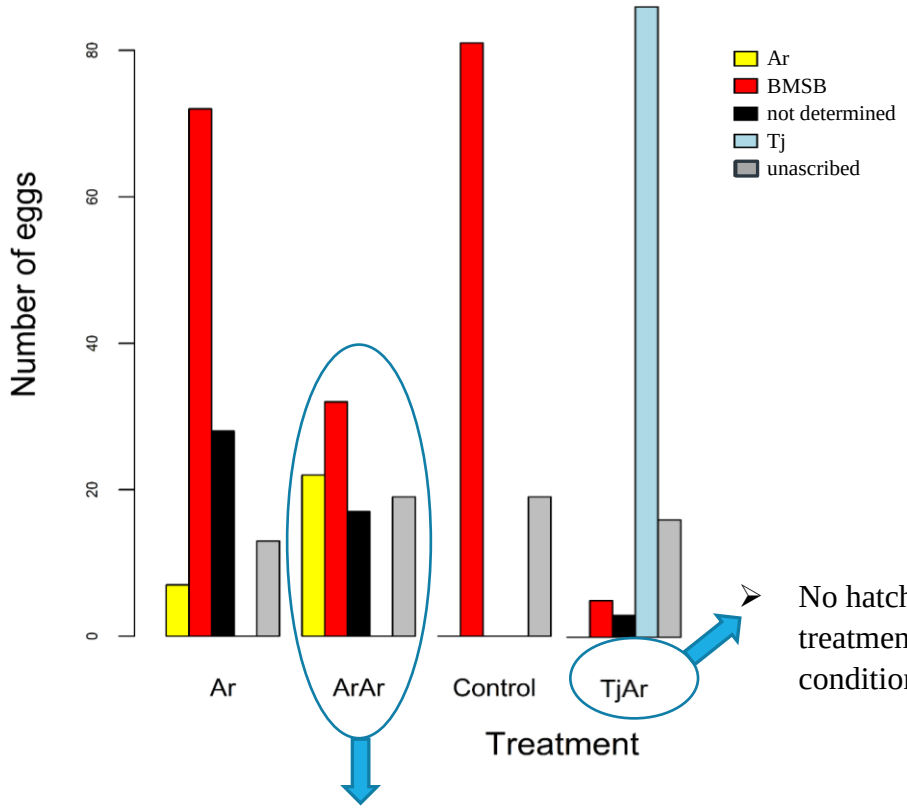
- *A. reduvii* spent significantly more time walking OFF the egg mass in the presence of another *A. reduvii* than that in the presence of *T. japonicus* (χ^2=13.89, df=2, p-value=0.0009)

OFF



Host-feeding, probing/ovipositing, and BMSB egg fate

- The BMSB numbers in "Ar-Ar" are decreased for more than 50% compared to that in the control and "Ar_Only" – treatment.



- No hatched *A. reduvii* in Tj-Ar treatment in the lab (under field conditions?)

- In the presence of another *A. reduvii*, both host-feeding and probing/ovipositing showed significant association with eggs outcome, and specifically with hatching *A. reduvii* ($\chi^2 = 23.973$, $df = 2$, $p < 0.0001$; $\chi^2 = 30.255$, $df = 2$, $p < 0.0001$)

**Host-feeding and probing data are shown for Ar-Ar treatment only*

Preliminary conclusions

- *A. reduvii* becomes overall more active performing more grooming and walking, as well as new types of behavior in the presence of other parasitoids
- *A. reduvii* spent significantly less time ON the egg mass in the presence of another *T. japonicus* but not *A. reduvii*
- *A. reduvii* spent more time probing/ovipositing on the egg mass in the presence of another *A. reduvii* than that in the presence of *T. japonicus*
- ~50% reduction of BMSB hatchlings when 2 *A. reduvii* females are present

Implications for biocontrol of BMSB by *A. reduvii*

- These are lab-based results which suggest some insights on what might happen in the field
- It looks like competition with another *A. reduvii for* BMSB eggs is not as strong as that with *T. japonicus*
- However, increase in *A. reduvii* numbers may result in more hatching of *A. reduvii*
- This may change when *T. japonicus* is present (future direction)

Thank you!

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