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Comparative effectiveness of different types of aggregate pheromone traps for monitoring Brown marmorated stink bug - Halyomorpha halys (Stål) (Insecta: Hemiptera: Pentatomidae)

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A B S T R A C T

The discovery of the aggregation pheromone has allowed researchers to design lures which attract the brown marmorated stink bug to the vicinity of the lure types location. For the monitoring three type of traps were Used, 1 – sticky-panel trap, 2 – Rescue trap (Sterling International), 3- Handmade trap constructed by using 1.5 liters plastic bottles. The first individuals of *H.halys* on all three types of traps were observed in April. The presence of the highest number of individuals (adults + nymphs) was observed in the June on the sticky trap. Each month, the number of captured *H.halys* by each type of trap differed significantly from each other (Chi-square - 81.09, df-46, P-value < 0.0011). Also, a significant statistical difference was observed in terms of *H.halys* caught by all three traps during the season (Chi-square - 69.14, df-12, P-value <0.0001). There was also a significant statistical difference between the proportion of adults and nymphs in the captured insects. In particular, in April, May and October, the presence of nymphs was not observed in the traps at all, while more nymphs were observed in July and August . In this case, the sticky trap proved to be the most effective, in June, July, August and September, an average of 22, 45, 37, 14 nymphs were observed on the sticky trap, the rescue trap caught 5, 16, 19, 0, and the handmade trap caught 3, 14, 13, 0 (n=3) accordingly.

Key words: Brown marmorated stink bug (BMSB), aggregation pheromone, traps, monitoring.

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Introduction

The brown marmorated stink bug (BMSB), Halyomorpha halys, is an invasive pentatomid, native to East Asia and spread throughout of the US, Canada, as well as into Europe and become a severe invasive agricultural pest.

BMSB is a highly polyphagous, has a broad host range that includes over 170 plants, many of agricultural importance, including fruit, vegetables, row crops, and ornamentals. It is also a structural pest, with high reproductive output, potentially enabling its spread and success in invaded regions, as large populations invade houses, trying to overwinter. BMSB is capable of long-distance flight [1,2].

Following its first detection 2015*, H. halys* has become a key pest in many crops in West Georgia [3-5] Therefore it is grate possibility, that invasion pest as favored by prolific reproduction, wide host range, lack of specific natural enemies, cold tolerance, global warming, and overwintering skills likely increase and spread in all territory of Georgia [6].

At present BMSB is very active and characterized by the massive increase and formation of focuses in the large tracts of agrocenosies and urban area of Georgia. Management using ecological friendly tools is a promising approach. Natural enemies, biopesticides, special techniques such as banding trees, using aggregation pheromones can reduce amount of pesticide applied. The brown marmorated stink bug is not going to go away, but IPM techniques can limit the damage.

Novoday the situation is quite alarming in Western Georgia (Guria, Adjaria, Abkhazia, Samegrelo-Zemo Svaneti, Imereti, Racha, Lechkhumi,). To date, sustainable control strategies against BMSB is very actual. The development of ecological friendly management strategies against BMSB-*H. halys*, are urgently needed to preserve biodiversity of Georgia.

In recent years, usage of the control method, called mating disruption, for the monitoring studies and control is highly encouraged. Various countries use artificial semi chemicals – pheromones – against many pests insects, including BMSB [7-9]. Using eco-friendly means will help preserve biodiversity and promote ecological balance.

The aim of the study is to develop of ecological friendly management strategies against BMSB-*H. halys* using biotechnological methods.

Material and Methods

Pheromon trap

The determation of the population densities of the *H. halyes* 2020, trap system, with pheromone *Halyomorpha halys* PH-611-1BPD (Russell IPM Ltd Company) (Ethyl (E, Z, Z)-2,4,6-decatrienoate, murgantiol) were installed. A long-term trapping was conducted at hazelnut orchard in Samegrelo region, of Western Georgia. 9 pheromone traps were set up on the 1 hectare (ha). Traps and lures were placed within crops about 2 meters above ground. Captured insects were removed on each sampling occasion which makes counting new arrivals easier. Lures was changed every 10 -12 weeks to get the most accurate results.

For the experiments three type of traps were Used, 1 – sticky-panel trap, 2 – Rescue trap (Sterling International), 3- Handmade trap constructed by using 1.5 liters plastic bottles which was filed 250 ml water. To observe *H. halys* movements Camera Yoosee Wireless 1080P were set up, connected to phone and checked daily.

Statistical Analysis

The total numbers of insects responding to the pheromones were analyzed with a Fisher's exact Chi-square test by using GraphPad Prism to determine if the distribution of the insects differed for the trap types and months as well. ANOVA analysis was performed to estimate the proportion of nymphs and adults in captured insects.

Results

Experimental data showed that as the first individuals of *H.halys* on all three types of traps were observed in April. The presence of the highest number of individuals (adults + nymphs) was observed in the June on the sticky trap. Each month, the number of *H.halys* captured by each type of trap (Fig.1) differed significantly from each other (Chi-square - 81.09, df-46, P-value < 0.0011) (Fig.2.).

Fig. 1. *Three type of traps: 1 – sticky trap, 2 – Rescue trap (Sterling International), 3- Handmade trap*

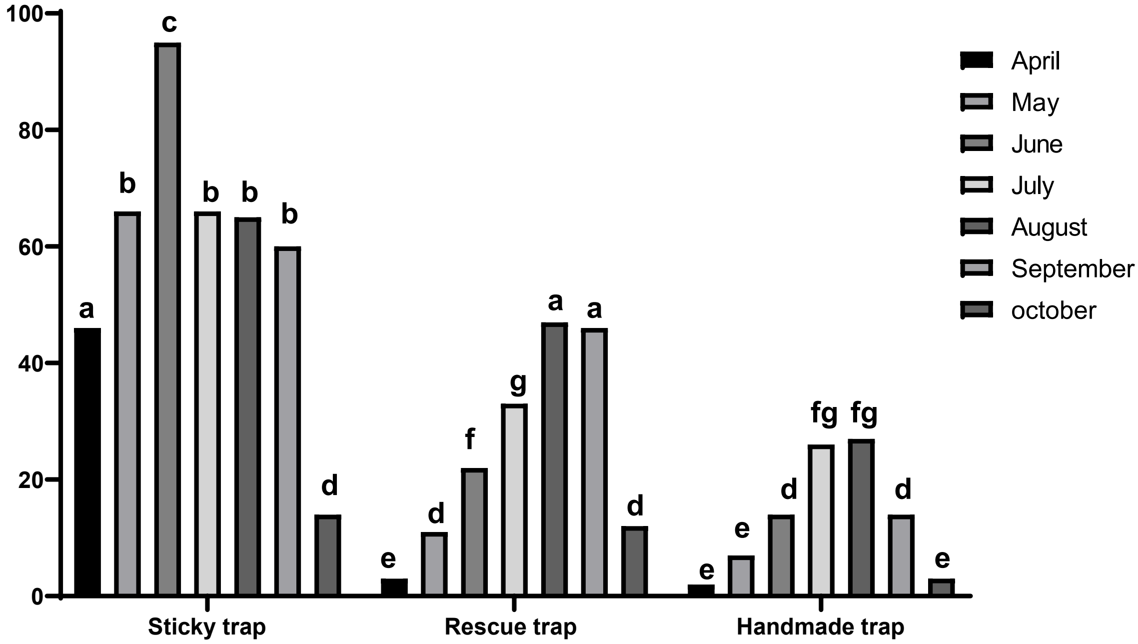

Fig. 2. *(Seasonal response of H. halys adults and nymphs to different trap styles). Total numbers of H. halys captured by three different traps according months. Bars with different letters are significantly different (P<0.05).*

Also, a significant statistical difference was observed in terms of *H.halys* captured by all three traps during the season (Chi-square - 69.14, df-12, P-value <0.0001) (Fig. 3, Table 1).

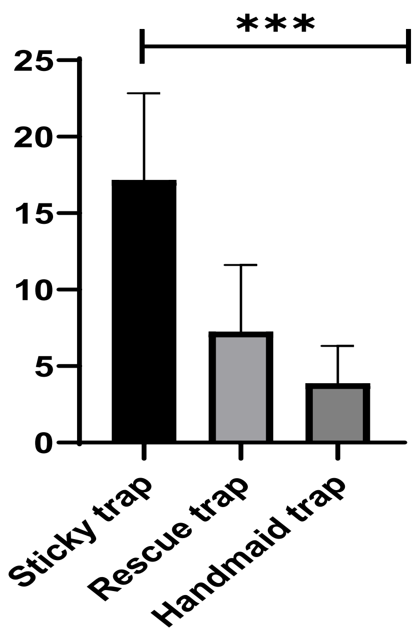

Fig. 3. *The total number of captured H. halys baited with tree different trap type*

There was also a significant statistical difference between the proportion of adults and nymphs in the captured insects (Table 2.). In particular, in April, May and October, the presence of nymphs was not observed in the traps at all, while more nymphs were observed in July and August (Fig. 4). In this case, the sticky trap proved to be the most effective, in June, July, August and September, an average of 22, 45, 37, 14 nymphs were observed on the sticky trap, the rescue trap caught 5, 16, 19, 0, and the handmade trap caught 3, 14, 13, 0 (n=3) accordingly.

Table 1. *Tukey's multiple comparisons between total numbers of captured H. halys*

	Mean Diff,	95,00% CI of diff,	Significant?	Summary	Adjusted P Value
Sticky trap vs. Rescue trap	9,917	6,899 to 12,93	Yes	****	<0,0001
Sticky trap vs. Handmaid trap	13,29	10,27 to 16,31	Yes	****	<0,0001
Rescue trap vs. Handmaid trap	3,375	0,3570 to 6,393	Yes	*	0,0247

Table 2. *Comparative analysis among adults and nymphs captured by using different trap style*

	Sticky trap		**Rescue trap**		**Handmade trap**	
	Adult	Nymph	Adult	Nymph	Adult	Nymph
Mean±SE	42±8,4	16,9±7,1	19,1 ± 5,3	5,7 ± 3,1	9,4±2,1	4,1±2.3
Confidence Level (95,0%)	20,6	17,2	13,0	7,7	5,0	5,7

*ANOVA single factor, *P value - 0,000125, df-5*

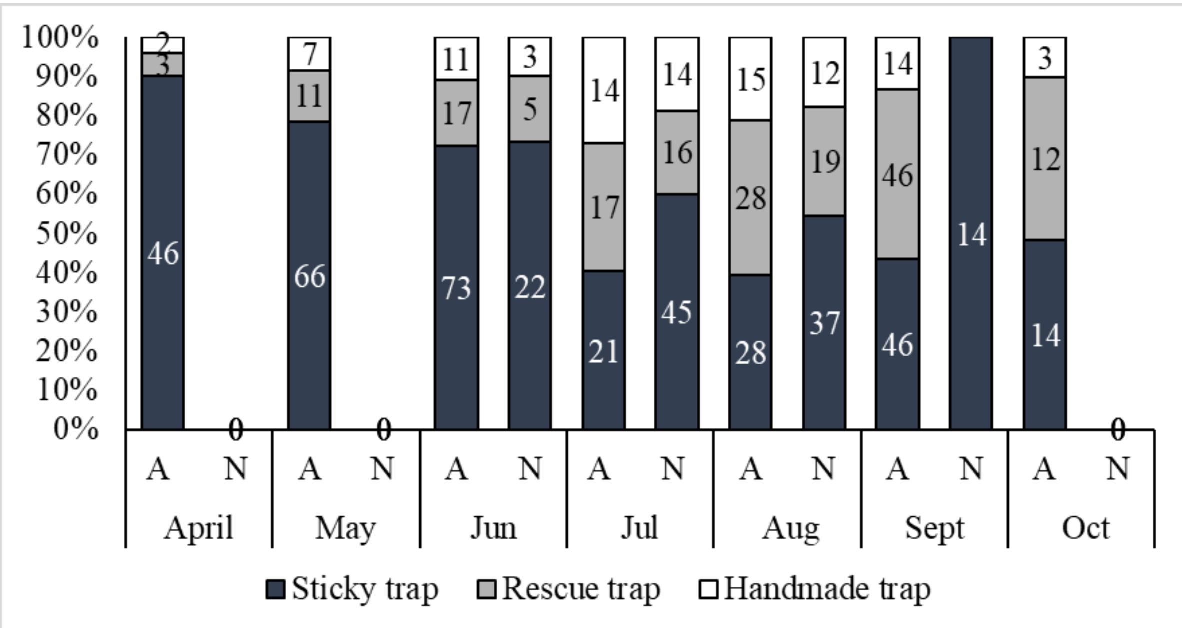

Fig. 4. *Proportion of captured adults and nymphs by different trapping style according months*

Discussion

The discovery of the aggregation pheromone has allowed researchers to design lures which attract the brown marmorated stink bug to the vicinity of the lure location. When combined with traps, including black pyramid traps and sticky traps, the lures can allow growers to determine when stink bug populations are at levels that warrant pesticide applications [10]. Additionally, an attract-and-kill approach is under development, which aims to use the pheromone lure to attract stink bugs to specific trees which are then sprayed with pesticides [11].

The effect of trapping locations is clearly an important factor that may restrict interpretations of stink bug phenology [12]. To address this, research that monitors endemic stink bug populations in and around production systems (rather than invasive species around transitional facilities) will help to validate the findings presented here. Trap placement within the canopy significantly affects BMSB catch [13] and other placement factors (e.g. in orchard versus in hedgerows, or within native versus non-native hosts) may be similarly important. Additionally, the lures used in this study attracted a broad range of stink bugs, but are unlikely to attract other species evenly [14, 15].

The pheromone-based tools developed for *H. halys* may beemployed for monitoring of the species. In the development of commercially viable lures, there are several important considerations. For example, unlike many species of Lepidoptera where highly purified pheromone is needed [10], *H. halys* does not require highly purified pheromone; other stereoisomers of 10,11-epoxy-1-bisabolen-3-ol (murgantiol) do not elicitinhibition of response, and the species is even possibly attracted to stereoisomers not naturally found in the wild [16]. This suggests that impure blends of the main pheromonal components may be used without impairment of biological activity. In addition, there is adose-dependent response in attraction to both the aggregation pheromone [11] and EEZ-MDT [17], such that more pheromone results ingreater number of adults and nymphs captured. Finally, it is important that a lure be long-lasting so that it requires little maintenance during the growing season. The original rubber septa lures used with *H. halys* pheromone for research purposes required changing every 2 weeks, where as currently available commercially formulated lures with the *H. halys* aggregation pheromone recommend changing once every 4 weeks (AgBio, Inc.) or once every12 weeks (Tre´ce´, Inc), and a lure may be for thy coming in the near future that will remain attractive over the entiregrowing season for 16 weeks (Short and Leskey,unpublished data). Prior work has demonstrated that commercially available EEZ-MDT lures last a maximum of four weeks [18]. Commercially availablelures have demonstrated season-long attraction of *H. halys* throughout the USA when changed regularly [15], as well as in the species' native range in the Republic of Korea [19, 20].

Conclusion

The discovery of the aggregation pheromone has allowed researchers to design lures which attract the brown marmorated stink bug to the vicinity of the lure types location. The results obtained revealed that, Rescue *Halyomorpha halys* PH-611-1BPD pheromones lures are very effective types of traps for monitoring *H.halys* population. Overall, our results suggest that *H. halys* monitoring traps can be further improved to reduce cost and labor associated with deployment and maintenance.

Acknowledgments

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