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Distribution of Brown Marmorated Stink Bug (*Halyomorpha halys*), Bioecological Features and Control Mechanisms in Batumi (Georgia)

Guguli Dumbadze[1+], Temel Gokturk [2], Lali Jgenti[1], Natia Chelidze[1]*

[1]Department of Biology, Faculty of Natural Science and Health Care, Batumi Shota Rustaveli State, University, Batumi, Georgia
[2]Department of Forest Entomology and Protection/Faculty of Forestry/Artvin Coruh University, Artvin, Turkey
[*]Corresponding author and [+]Speaker: dumbadze.guguli@bsu.edu.ge
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Abstract – The brown marmorated stink bug (*Halyomorpha halys* Stål) is the invasive, polyphagous pest which was first reported in Georgia in 2015. In 2016, the bugs destroyed a significant portion of the hazelnut harvest in western Georgia. 2017 was even more devastating and covered wider area. The objectives of the research was to study the distribution, biological and ecological characteristics of Brown Marmorated Stink Bug (BMSB) in suburbs of Batumi in 2018. The methodology used were- field and route observation, pheromone and mechanical traps and laboratory research methods. In the study is identified the high, medium and low risk areas of pest invasion in Batumi suburb. The research has shown a certain correlation between the frequency of the pest spread and distance of the studied area from the sea level. In the areas of Batumi suburb the BMSB shows two generations (the first - May, 2-10 and the second - from June 25 till July, 10 of 2018). In the agricultural area of Batumi the BMSB cause damage to a wide variety of plants including fruit trees, hazelnut, ornamental trees and shrubs, grapes, small fruits, most vegetable crops, bean, maize corn and ets. In addition *H. halys* is a vector of fungal and bacterial diseases in hazelnut.

Keywords – *Halyomorpha halys Stål* , BMSB, Distribution, Biology, Host plants, Georgia

I. INTRODUCTION

It has been four years since the Brown Marmorated Stink Bug (BMSB) - *Halyomorpha halys* (Stål. 1855), is in the public spotlight in Georgia. This is caused by its maximum number and harmfulness on many agricultural, fruit, forest or decorative plants. During this period, the Ministry of Environment and Agriculture of Georgia, Food Safety Administration officials and practitioners, scientists, relevant regional departments or representatives of other organizations, the population in general, are actively involved in pest control measures.

Halyomorpha halys is an invasive pest with its natural area of distribution in Japan, southern China and Korea, where the pest has a natural enemy and its quantity is naturally regulated. In the late 1990s, its populations settled in North America, and in Europe in the mid-2000s [1;2;3;4;5].

BMSB is a polyphage and greatly damages tree plants, fruit trees and vegetables in its area of distribution. Consequently, it endangers agricultural crops and causes serious environmental and economic damage. It is known that in 2010 alone, the insect caused millions of dollars in damage to the mid-Atlantic region. Maryland farmers have lost 100% of their annual peach crop [1]. In the absence of control, it can cause similar damage to maize, and in the absence of insecticide, BMSB damages more than 30% of tomatoes and peppers in Virginia [6]. Due to its worldwide distribution potential and economic losses to fruits and vegetables, *H. halys* is included in the quarantine list by the European and Mediterranean Plant Protection Organization (EPPO) [7].

In Georgia, *H. halys* population was first noted in 2015 in Abkhazia, from where it spread to the Samegrelo municipality [8], and in the following years it was widely distributed in Guria and Adjara. The first significant loss of nut culture in Georgia was recorded during the 2016 season. The economic loss to nut growers and exporters amounted to approximately 52.7 - 68.6 million USD [9].

One of the crucial steps in fighting against pests is to identify their widespread sites and study the bio-ecological features of the pest in its ecological distribution environment.

Goal and objectives of the study. The goal of the study was to study the biological features of BMSB spreading in the suburbs of Batumi in 2018, in humid subtropical climates, and to identify host plants.

II. MATERIALS AND METHOD

The objectives of the study were to select pest distribution sites and to place pheromone traps; field monitoring of pest breeding and development under natural conditions; study of adult pest forms (adult) and nymphs, structure, growth and development, vitality peculiarities in laboratory conditions; identification of pest host plants in the study area.

Place of research. According to literary data, the pest entered Georgia and spread from the Black Sea coast. Therefore, the outskirts of Batumi, Black Sea coast (Green Cape, Makhinjauri, Urekhi, Kakhaberi, Airport, Makhvilauri) were chosen as the place of study. All survey sites represent settlements associated with the last decade with the city of Batumi, where the land is agricultural. In order to determine the rate of pest distribution, pheromone traps were placed on the following plants: green cape - tangerine plant, Makhinjauri – orange plant, Urekhi - nut bush, Airport settlement- corn plot, Kakhaberi - nut bush, Makhvilauri - Kiwi plant.

Depending on the purpose of the study, the following methods were used: routing, visual inspection, observation and description, method of using pheromone and various mechanical traps, and laboratory research method. For the

purpose of research on pest growth and development, bio-ecological peculiarities, they were observed directly on plots, in the field conditions, as well as in specially made boxes of $1m^3$ made of transparent plastic.

The study conducted in 2018. On April 15-16, 2018, 2 pheromone traps with sticky tapes, totally12, was placed on each of the selected areas, approximately 500 meters away from each other, to determine the prevalence rate of Asian BMSB, with a total of 12 pieces.



Figure 1-4. Placement of pheromone traps (Photos by G. Dumbadze)

Until the end of May, at the end of each week, the pest observed in the trap was counted. According to US experts, fixing 10 or more pests on the insect trap per week is considered to be a critical site of pest distribution, i.e. a high-risk zone, in the case of 5 pests - medium risk zone and 0-2 pests - low risk zone. After spraying with chemical insecticides, observations were conducted twice a month in June. Finally, the inspection was carried out at the end of October.



Figure 5-6. Pheromone traps in Makhvilauri and Green Gape, 30.06.2018 (Photos by G. Dumbadze).

III. RESULTS AND DISCUSSION

III.1. Frequency of pest distribution

The results of the monitoring of pest distribution in the study areas are presented in the first table.

It can be seen from the table that in the suburbs of Batumi, the frequency of pest distribution is much higher in Makhvilauri and Green Cape, with relatively few in Makhinjauri and Urekhi. Pest prevalence is low in Kakhaberi and Airport settlements (Table 1).

Different frequencies of pest populations in separate locations in Batumi require further research by scientists. Thus, along the distance from the seaside, the number of pests was gradually increasing in the study sites.

Table 1. The fixed number of BMSB in a pheromone traps. 2018

Research area	Exp. plots	Data of pests control in 2018									Average frequency of the pest distribution
		23.04	30.04	7.05	14.05	21.05	30.05	15.06	30.06	25.10	
Greengape	1	12	23	34	41	53	62	76	88	103	54.67±10.14 p=0.0011
	2	9	17	23	34	42	57	68	74	89	45.89±9.23 p=0.0011
Makhindjauri	1	11	21	24	29	36	47	63	68	74	41.44±7.541 p=0.0006
	2	7	13	19	27	34	49	53	56	63	35.67±3.8 p=0.0008
Urekhi	1	4	7	13	20	29	34	39	42	47	26.11±5.25 p=0.0011
	2	5	11	16	21	27	30	34	38	43	25±4.24 p= 0.004
Kakhaberi settlement	1	2	5	7	7	8	11	13	15	18	9.55±1.701 p= 0.0005
	2	7	12	14	16	19	19	20	22	25	17.11±1.82 p=0.0001
Airport settlement	1	3	5	6	11	17	22	28	35	41	18.67±4.59 p=0.0036
	2	2	5	9	14	16	25	27	29	32	17.22±3.5.27 p=0.0012
Makhvilauti settlement	1	11	17	23	29	37	46	62	87	114	47.33±11.49 p=0.0034
	2	10	18	19	24	33	34	41	63	87	36.56±8.16 p=0.0012

III.2. Key pest settlement sites (plants) in the study areas

In the experimental plots, we have studied the host plants and agricultural crops that are prevailed by the pests.

It should be noted that except for the pest fixed in the pheromone trap, a large number of it is found on the plant itself. The pheromone traps were attached to the citrus plants, nut bushes, kiwi plants, walnut trees, corn fields, Japanese loquat (*Eriobotrya japonica*) and peach plants. Most of the pests were concentrated at the plant, although other parts of the study area, the vegetable crops also contained their copies.

In the study area, BMSBs were found on the loquat tree for the first time. 2018 was distinguished by the high yield of this crop and for almost a whole month, the pest was richly observed on the plant. Then, a large number of pests were fixed to the nut bushes. The pest makes a hole on the immature fruit of the nut by means of its trunk, from which it receives the softened contents and feeds. Then the various fungi settle in the fruit and the fruit is completely damaged.

High prevalence of pests in the study areas was also observed on kiwi plant, persimmon, tangerine, apple and pear, peach, fig, walnut tree, agricultural crops - peas, corn, paprika, tomato and more. Pests (both adult and nymphs) are fed by plant leaves, twigs, especially fruit pulp and skin. The visual symptoms of damage to the plants by the BMSB varies widely among different plants. In many vegetables, including beans,

peppers, tomatoes and eggplants, the damage is expressed in white spots and the vegetable tissue is deep and soft.



Fig. 7-8. Hazelnut harvested on the trial plot in Makhvilauri settlement (Photos by G. Dumbadze).

The tissue of the tangerine fruit is damaged as well, the skin is softened and the colour is changed. The fruit of the persimmon was also severely damaged, they fell down until the early maturity, or, due to its damage, the fruit became unfit for food. The damage on peaches are visible, depths are easily identifiable by the resin on the fruit; the fig fruit was damaged and got rotten.

The pest also caused great damage to the maize crop, damaged grains became darker and unsuitable.

In order to observe the growth and development of the pest, the pest placed in transparent plastic boxes made by us, completely damaged the bean plant in a week, the leaves were fallen off the plant and germinated two weeks later (see Figure 9).



Fig. 9-11. Bean plant damaged by BMSB, fruits of persimmon and fig in the laboratory condition (Photos by G. Dumbadze).

III.3. Results of observations on the growth and development of BMSB

At the end of April 2018 (18-25.04.) adult pests left the buildings and they were observed in the study areas. Once in the environment, the females couple and begin laying eggs on the underside of the leaves. The eggs are clustered with an average of 28 eggs. The newly laid eggs are light green in colour, they slowly turn white, the shell becomes firm and ripen. Depending on the temperature, the nymphs were hatched from the egg at different study sites for 5–15 days after laying. The hatched nymphs went through five stages of adult development. After hatching, the insects remained on egg mass for 5-6 days. We think they were still getting nutrients for early development. Their colour was reddish, orange or black. The second stage nymphs moved to the leaves and fruits of the host plant and began active feeding. According to the literature, the third, fourth and fifth stages of nymph development coincide with the 12th-13th, 19th-20th and 26th-27th days [3; 10].

In 2018, BMSB identified two breeding cycles in the study areas. The first - from wintering to the new generation, which was observed from the beginning of May, and then the second generation, in July-August, when insects of all ages, nymphs and adults of different sizes were identified.

The observation of BMSB development was carried out in 1m3 boxes of transparent plastic prepared by us. They were located in a covered area, protected from direct sunlight and high temperature area for sufficient aeration and light. The lid of the box was arranged to allow air to flow. Inside we mainly placed a growing plant of beans, as well as nut branches and various fruits for feeding. There was water in the box to create enough moisture.

At the time of observation, the pest was actively fed by the plant for the first week, then many of them were found near the lid of the trial box, after 2 weeks pest duplicates died. We think this was caused by insufficient aeration, which slowed the distribution process in the trial version. This killed several females who were ready to lay eggs.



Fig. 12-14. BMSB in the trial box: Fig. 12-13 During feeding; Fig. 14. The pest on the roof of a trial box.

Thus, the pest in the trial box could not be replicated. If the experiment continues, we think it would be better to replace the lid with a thin grid to enhance aeration.

It should be noted that during the trial period, the State (Ministry of Agriculture; Food Safety Service) conducted the chemical application of the study sites three times. In the autumn, when the pest is heading for buildings, basements, roofs and more to search for shelter [6], we used mechanical traps to estimate the number of those survived from the thermal fog. Pheromones were observed inside them to attract insects. We placed plastic traps on trial plots, under trees, branches, and the cardboard traps - on the outside of the roofed structures (balconies, garages, etc.), protected from the rain. There were no pests in the traps placed in the plot at Kakhaberi and Airport settlements. A relatively higher number was observed in Makhvilauri and Green Cape (Table 2).



Fig. 15-16. Mechanical traps we made for attracting BMSB

As for cardboard traps, we opened them at the end of January. It should be noted that a large number of pests accumulated around the trap (due to the pheromone inside), on the walls of buildings, which required their mechanical destruction. After checking the cardboard boxes, they were burned with a pest.

Table 2. Number of pests caught with plastic traps in the study areas

№	Experimental plot	Number of caught pests by mechanical traps	
		In plastic traps	In cardboard traps (21.01.2019)
1	Green Gape	24	41
2	Makhindjauri Settlement	11	19
3	Urekhi	12	7
4	Kakhaberi settlement	0	0
5	Airport Settlement	0	5
6	Makhvilauri Settlement	32	54

IV. CONCLUSION

Within Batumi, high, medium and low frequency areas of BMSB distribution were allocated. The number of pests is gradually increasing along the coast of the study area.

Because of the pest, the nut crop was almost completely destroyed in the study areas, the fruit and vegetable crops were significantly reduced.

At study sites, *H. halys* showed two cycles of generation. The first generation was observed in early May and the second in July-August, when insects of all ages, nymphs and adult's of different sizes were identified.

In artificial conditions (plastic box) the growth and development of the pest was hindered, most of it died and could not be reproduced.

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