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BIOECOLOGICAL FEATURES OF *HALYOMORPHA HALYS STAL* (*HETEROPTERA: PENTATOMIDAE*) IN THE REPUBLIC OF MOLDOVA

Iuliana Rusu, Dina Elisovetcaia, Tudor Nastas

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INTRODUCTION

Since the second half of the twentieth century, virtually every country in the world is facing a global environmental problem – biological invasions of alien insect species. This was facilitated by the active movement of people and goods, the development of world free trade, as well as human influence on the climate, which has led to environmental disorientation.

Colonization of new territories by invasive species depends on their ability to adapt and develop in a new biotic environment. A significant influence on the degree and rate of pest colonization is provided by such factors as the lack of natural enemies and species ability to redistribute energy resources for growth and reproduction. For the entire world community, the invasion of species beyond their historical limits has enormous socioeconomic and environmental implications. Brown marmorated stink bug *Halyomorpha halys* Stal (1855), Heteroptera: Pentatomidae, is one of the most harmful and economically significant quarantine invasive species, having spread to almost every country in Europe, North America, and Asia [15, 17].

The brown marmorated stink bug was first discovered in East Asia, in China, Japan, North and South Korea, Taiwan, and Vietnam [10, 18]. A brown marmorated stink bug arrived in the United States in 1996 and quickly spread across the country. After 20 years, it was discovered in 41 states [4, 7, 9]. A stink bug was discovered in Canada in 2010 [2]. The pest was initially discovered in Europe in Switzerland and Liechtenstein in 2004 [5, 12]. The stink insect was identified more than seven years later, in 2011, in Germany [6], and ten years later, in 2014, in Greece [10]. In the territory of the Eurasian Economic Union, the pest was first registered in 2014 in Russia, on the territory of the city of Sochi [18], and a few years later, in 2017, in Kazakhstan [14]. Currently, an invasive pest range is being formed in southern Russia, in Krasnodar Krai [17].

In 2019, the invasive species was first discovered on the territory of the Republic of Moldova [1].

This pest is a wide polyphage. It can feed on more than 300 plant species from 49 families [13, 16]. The stink bug may be a carrier of phytoplasma diseases that damage a wide range of host plants, in addition to causing direct harm [8].

The goal of this study was to look into some of the biological peculiarities of the brown marmorated stink bug *Halyomorpha halys* under the Republic of Moldova's agro-climatic circumstances.

MATERIALS AND METHODS

The bio-ecological features of *Halyomorpha halys* were investigated in natural phytocenoses in the Republic of Moldova's territory, as well as in the Institute of Genetics, Physiology, and Plant Protection's laboratory.

Weekly monitoring of forage wild and cultivated plants (including ornamental forms) was carried out to identify adults, larvae and ovipositions of natural populations of the pest. Insects collected according to conventional entomological methods (manual collection and removal of imago on aggregate traps pheromone). Collected insects were identified by loupe with -10-fold magnification and by different types of microscopes (MBC-10, MBI-3) based on the sum of the distinguishing particularities of this species [3].

RESULTS AND DISCUSSIONS

We have conducted frequent pest monitoring since the *Halyomorpha halys* stink bugs were discovered in surrounding nations of the Republic of Moldova, due to their economic relevance and severe toxicity. Thus, the first stink bug specimens, primarily larvae of II-III ages, were discovered on *Hibiscus syriacus* L. fam. *Malvaceae* plants in August 2019. Later, as a consequence of visual observation, the pest was identified on additional species of cultural and decorative plants, including a large number of bugs on the white mulberry *Morus alba* L., at the conclusion of the 2019 season and during the 2020 growing season (farming season).

We introduced phytophage into the laboratory culture to research the stink bug's bioecological features in the Republic of Moldova, as well as its entomophagous, in particular egg parasitoids. As a result of the experiments, it was established that in

laboratory conditions it is possible to successfully breed the species *H. halys* when using as feed the fruits of Solanaceae (sweet peppers and tomatoes), berries of some ornamental and cultivated plants (e.g., *Phytolacca americana*, *Sorbus aucuparia* L., *Hippophae rhamnoides* L., *Vitis vinifera* L.), mandarin fruits and young cobs of maize. At the same time, it was noted that the imago and larvae of the marmorated stink bug were reluctant to feed on the juice of the fruit of the apple tree – they were offered a choice of fruits of various varieties and different degrees of maturity. A series of experiments was carried out to identify the most preferred feed with a wide choice.

For this purpose, the imago and the stink bug larvae (from the second age) were given a «simultaneous» choice of 10 feed options (Hibiscus twigs, young corncobs, fruit of apples, tomatoes, sweet peppers, mandarins, grape berries, silkworms, rowans and phytolacca). As a result, it was found that the larvae and the imago stink bug had the highest preference for the fruits of silk, sweet pepper, mandarin, phytolacca, rowan and young cobs of maize.

In the course of the experiments, it was proved that the release of the laboratory population from the hibernation in 2020 was observed in the first decade of March. Two weeks later, the first stink bugs mating was registered, and after another 9 days, egg-laying began. That is, the duration of the period from the emergence of adults from hibernation to the beginning of oviposition was about 23-25 days.

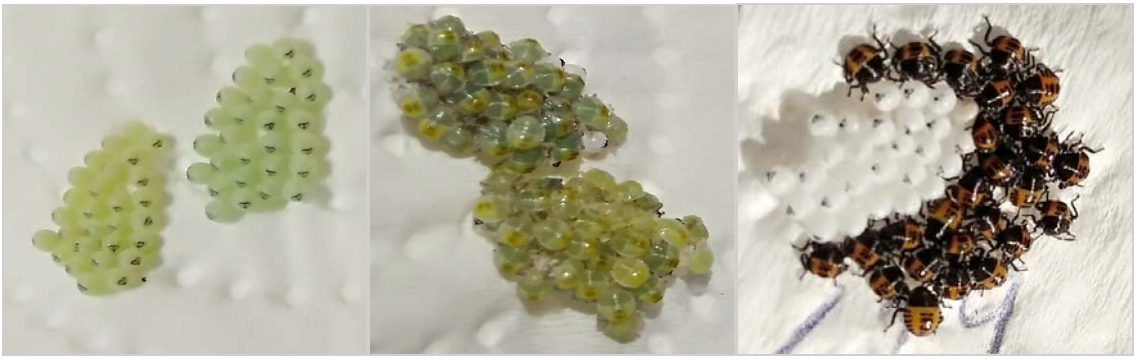
The number of eggs in ovipositions ranged from 25 to 32, although in the vast majority of cases (up to 95 percent of ovipositions), the female lays 26-29 eggs wedge-shaped (Fig. 2, a). Once every 5-14 days, the female lays one oviposition. Female fecundity ranged from 76 to 292 eggs per female in the laboratory population, with an average of 240 eggs per female.

Eggs are palegreen in color, rounded, ranging in size from 1.3 to 1.6 mm. The period of maturation of eggs at 24 ± 2°C lasted 5-6 days. The proportion of hatched larvae from the first few egg-laying, obtained under laboratory conditions, ranged from 82 to 97%. Subsequently, with few exceptions, hatching of larvae from the eggs of the laboratory population of *H. halys* reached 100%. It should be noted that the high percentage of hatching of larvae contributes to the rapid growth of the population density.

When hatched, *H. halys* larvae are pale yellowish orange, with darker strokes striolas on the back and points on the side of the abdominal segments. Through hour-two the larvae become orange-red-brown, which lasts (remained) until the molting at the second age (Fig. 2).

a. b. c.

Fig. 1. Ontogenetic stages of *Halyomorpha halys* Stal (a. larva of older age and freshly-molded imago; b. larvae of older age on *Hibiscus syriacus*; c. Imago on *Morus alba L*). Photo: Elisovetcaia D.



a. b. c.

Fig. 2. Preimaginal stages of *Halyomorpha halys* Stal (a. wedge-shaped ovipoitions before hatching; b. hatching of larvae from eggs; c. first instar larvae grouped around egg-laying). Photo: Elisovetcaia D.

Larvae of the Ist instar drink water willingly. However, they can do without water and without additional diet (nutrition) for up to 2 days - at air temperatures up to 25-28^{o}C. It was noted that in the first day (24 hours) after hatching, the larvae, as a rule, do not leave their oviposition, but gather in a group or in a semicircle and sit motionless (Fig. 2, c). Starting from the second instar, the larvae become active. During the day, they quickly run around the plants in the cage, and if necessary, they can even jump high enough. They have very tenacious and strong legs. The body coloration of the 2nd instar larvae is grayish-black, with well-distinguishable light stripes on the legs. The antennae of the larvae, like the imago, have a characteristic coloration for the species – base and apex of the IV, and the base of the V segments of the antenna are white (Fig. 1).

We found that at 25°C, the duration of the period before molting at age II was 3-4 days, and at age III - from 4 to 8 days. The period between molting of larvae at instars IV and V was 6-8 days. Larvae of the V (last) age of the first spring generation of the stink bug developed over 16 days. Later this period was significantly reduced. At the same time, it was noted that the duration of the larval stages depended directly on many factors - primarily on the air temperature, also on the type and quality of feed. At the same time, under the same conditions of breeding, the development period of larvae from the same oviposition can still differ very significantly. Early larvae survival in laboratory conditions was found to be as high as 100 per cent and decreased slightly from molting to molting, about 70-80% in older larvae at a density of 100 individuals of IV-V instars per l^{3}. It was found that individuals of *H. halys* can be kept and bred at a fairly high density - about 250-300 larvae of I-II instar per l^{3}. However, the larvae of older instars still need to be settled in smaller groups, because the high density of individuals in the cages significantly reduces the proportion of surviving larvae. With overpopulation of cages, in addition to other negative aspects, cannibalism is on the rise, especially when the individual is molting. The high rate of hatching and survival of *H. halys* individuals contributes to a significant increase in the population density, which in turn poses a significant threat to host plants.

The imago of the brown marmorated stink bug is larger than other members of the bedbug shield family. Their body is pear-shaped, slightly flattened, 12-17 mm in length [18]. In our experiments, measurements have shown that the body length of adult individuals was on average 15-17 mm. The coloration of the imago is mostly brown - the head, pronotum, scutellum, and elytra have light "inclusions", that visually creates a marbled tint (Fig. 1, c). The underside of the body is light, milky white or pale brown, sometimes with gray or black edges. During molting, both larvae and imago have a milky-white tint of integuments, which gradually darken and acquire a coloration characteristic of this phase of insect development (Fig. 1, a).

The harmfulness of the brown-marbled bug is currently well understood in the areas of its earlier penetration [12, 15, 18]. However, in most of the new pest harborage area of *H. halys*, especially in the Republic of Moldova, its harmfulness is still under study. However, this phytophagous has already been ranked among the most dangerous pests of polyphagous. In the agroclimatic conditions of the Republic of Moldova, the imago and larvae *H. halys* can cause particular harm to grapes, maize, and Solanaceae (tomatoes, peppers) as well as leguminous and some other economically important crops. In order to identify possible oviparasites (egg-parasites) of *H. halys*, we have exhibited stink bug ovipositions on various plant species (apple, grape, hibiscus, mulberry, etc.) for 4-5 days from the moment of their laying by females under laboratory conditions.

In the literature, there is evidence of high efficacy for brown marmorated stink bugs species such as *Trissolcus halymorphae* Yang and *Tr. japonicus* (Hymenoptera: Scelionidae). For example, some authors indicate that 50 per cent of pest eggs are contaminated by these entomophagous in northern China [11]. In the Republic of Moldova, representatives of family Scelionidae is quite common, among them most actively infect the eggs of stink bugs *Trissolcus grandis* (Thomson, 1860) and *Telenomus chloropus* (Thomson, 1861) (Hymenoptera: Scelionidae). To date, nearly 40 species of stink bug hosts have been identified, including both indigenous and invasive species of stink bugs – *Pentatomidae* and other families – *Dolycoris baccarum* Linnaeus, 1758*, Aelia* Fabricius, 1803, *Graphosoma lineatum* Linnaeus, 1758 (Heteroptera: Pentatomidae), *Eurygaster integriceps* Puton, 1881 (Heteroptera: Scutelleridae). Therefore, the search for native species of telenomin egg parasite and their use to reduce the number of brown marmorated stink bug in the conditions of the Republic of Moldova, this may prove to be a very promising and effective means. However, despite large-scale studies carried out in 2020, infected with telenomus or other local parasitic insect, the eggs of *H. halys* have not been detected to date.

CONCLUSIONS

Our research has shown that the invasive species *Halyomorpha halys,* which entered the Republic of Moldova in 2019, due to their bio-ecological peculiarities and due to the influence of climate change and anthropogenic factors, many cultural and ornamental plants may be seriously threatened. Special attention should be paid to the study of entomophagous, especially eggs parasites of pests, which will allow in the future to successfully

control the number of dangerous phytophagous in the republic.

ABSTRACT

Monitoring of invasive species *Halyomorpha halys* in the conditions of the Republic of Moldova during the growing seasons of 2019-2020. has shown that phytophagous has settled in a new habitat, inhabits both cultural and ornamental plants, and is able to rapidly increase the population density. It can pose a serious danger to many economically significant crops, - in particular for maize, grapes, Solanaceae. The high level of harmfulness of the stink bug under new conditions necessitates the study of bio-ecological peculiarities as well as searching for efficient autochthonous species of entomophagous to control the number of pests.

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AUTHORS' ADDRESS

RUSU IULIANA, ELISOVETCAIA DINA, NASTAS TUDOR - Institute of Genetics, Physiology and Plant Protection, R. Moldova, E-mail: julianarusu@gmail.com