



Biocontrol as a key element for the sustainable management of the Brown Marmorated Stink Bug

Lara Maistrello

*Department of Life Sciences, University of Modena and Reggio Emilia, Via G. Amendola 2,
42122 Reggio Emilia, Italy*

E-mail: lara.maistrello@unimore.it

Extended abstract: The Brown Marmorated Stink Bug (BMSB), *Halyomorpha halys* Stal (Heteroptera, Pentatomidae), native to Eastern Asia, is a highly polyphagous pest, which primarily threatens fruit and vegetable crops. Due to its high invasive capacity facilitated by human activities and trade (Maistrello et al., 2018), it is rapidly spreading around the world. Invasive populations causing severe damage to agricultural crops occur in North America and southern Europe (Leskey and Nielsen, 2018; Maistrello et al., 2017; Maistrello et al., 2018). In Italy, BMSB has rapidly become the most important key pest in fruit orchards (Maistrello et al., 2017) and losses in fruit production in 2019 were estimated at € 588 million (CSO Italy, 2020).

BMSB management is extremely difficult due to the high polyphagy, high mobility of all instars, high reproductive potential and overlapping of different instars and generations during summer (Costi et al., 2017). To try to counter BMSB invasions in the fields, the use of broad-spectrum insecticides has significantly increased, severely disrupting previous integrated pest management (IPM) programs and causing negative economic and environmental impacts in the invaded countries. Alternative approaches aimed at reducing the use of insecticides include prevention by means of exclusion netting and behaviour-based strategies such as “attract and kill”, trap-crop and IPM-Crop Perimeter Restructuring (IPM-CPR) (Akotsen-Mensah, 2020). However, none of these strategies proved to be both fully successful and easily applicable in different contexts.

Long-term and more sustainable management strategies include augmentative and classical biological control with native and exotic antagonists, respectively. However, specific regulations in both North America and Europe prohibit/restrict the use of exotic biocontrol agents. In its native range, BMSB eggs are attacked by egg parasitoids of the Scelionidae family, specialized in the parasitization of stinkbug eggs (e. g., *Trissolcus* spp. and *Telenomus* spp.), and by generalist species of the genus *Anastatus* (Eupelmidae) and *Ooencyrtus* (Encyrtidae). *Trissolcus japonicus* (Ashmead), is the dominant species in China while *T. mitsukurii* (Ashmead) is the key parasitoid in Japan (Yonow et al., 2021).

Field surveys conducted in invaded countries using fresh/frozen sentinel eggs or naturally laid egg masses of BMSB revealed potential for biocontrol by some native egg parasitoids species and the existence of adventive populations of the exotic parasitoids. Specifically, *T. japonicus* has been found in the USA, Canada, Switzerland, Germany and northern Italy, while *T. mitsukurii* is present with actively expanding populations in northern Italy, Slovenia and France (Kaser et al., 2019, Zapponi et al., 2021). In the USA, the biocontrol approach is to enhance the efficacy of *T. japonicus* through mass rearing and subsequent releases only in the states where adventitious populations have been found.

In Italy, the devastating economic impact caused by the BMSB on fruit production had prompted the amendment of the law that transposed the "Habitat Directive". Finally, in 2020, a decree of the Italian Ministry of Environment and the Protection of the Land and Sea authorized

T. japonicus for the biocontrol of BMSB, leading to one of the largest biocontrol projects ever attempted in Italy and Europe. Coordinated by the Central Phytosanitary Service and the CREA-DC, the BMSB Biocontrol Action Program was implemented in the individual regions that applied for authorization with a concerted work involving various institutions (regional and local phytosanitary services, IPM technicians, universities and other research institutions, companies, farmers' associations). Numerous investigations at release points and other areas have been carried out by collecting masses of eggs laid naturally by BMSB and other stinkbugs, with the aim of verifying the spread and efficacy of *T. japonicus* and *T. mitsukurii* on BMSB eggs and their effects on non-target species. The results of the first two years of the program provide optimistic prospects due to both the successful settlement of the released *T. japonicus* and the strong expansion of the adventive exotic parasitoids, as well as the concrete contribution of the native parasitoid *Anastatus bifasciatus*. Besides, the impact of the exotic parasitoids on non-target hemipterans was negligible. Further investigations are needed to understand the overall efficacy of parasitoids and the time required to achieve a significant reduction in BMSB populations, pursuing the goal of implementing sustainable management of this invasive species on affected crops.

Key words: brown marmorated stink bug, invasive species, fruit orchards, native parasitoids, exotic parasitoids, *Trissolcus japonicus*, *Trissolcus mitsukurii*

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