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Efficiency of parasitoids and predators of *Halyomorpha halys* and other Pentatomidae in Bavaria

T. Lederer[1], E. Satzl, S. Probst

Abstract

Damage due to Pentatomidae has increased in the last years in European fruit production. Next to indigenous stink bugs the invasive species Halyomorpha halys (Stål) is the main reason for this, a species that caused damage in fruit production only a few years after it was first detected in Europe. Since hope lies on parasitoids for a sustainable control of these pests it was evaluated how these pests are controlled in South-East Germany by antagonists. Antagonists had little impact on egg masses of H. halys and other Pentatomidae, although the impact was higher in hotspots of H. halys. These findings are in line with findings in previous studies, showing that control of H. halys by indigenous antagonists in Europe is little. The two Asian parasitoids Trissolcus japonicus (Ashmead) and *Trissolcus mitsukurii* (Ashmead) were not found in these investigations.

Keywords: *Halyomorpha halys*, Pentatomidae, parasitoids, predators

Introduction

Halyomorpha halys (Stål) was found in 2010 for the first time in Germany (Heckmann, 2012) and appeared in Bavaria no later than 2016. Since its devastating impact on Italy in 2019, the pest has gained interest in Europe (Bulgarini et al, 2021). Alongside, the impact of other Pentatomidae like the invasive species *Nezara viridula* (Linnaeus) and indigenous species like *Pentatoma rufipes* (Linnaeus) and *Palomena prasina* (Linnaeus) has increased in Europe in the last few years (Beliën et al., 2015). Since insecticides have negative impacts on beneficials (Desneux et. al, 2007), other non-target organisms (Liess et. al, 2021) and have limited effect especially on *H. halys*, hope lies on antagonists (Leskey et. al, 2018).

In the case of *H. halys*, most promising antagonists are two parasitoids of Asian origin that have co-evolved with the pest (*Trissolcus mitsukurii* (Ashmead) and *Trissolcus japonicus* (Ashmead)) (Sabatini et. al, 2018). Latter has been found in several European countries, among them Germany (Dieckhoff et. al, 2021). Since *T. japonicus* likely spreads passively with *H. halys* (Dieckhoff et. al, 2021), it is possible that *T. japonicus* is present in Bavaria as well. Also, the limited impact of indigenous parasitoids on *H. halys* (Stahl et. al. 2019) was examined. Little is known about antagonists of European Pentatomidae, e.g., of *P. rufipes* (Powell, 2020), which was a part of the investigations as well.

Material and Methods

Field surveys of the above-mentioned species were conducted in southern Bavaria from July until October 2021 in both agricultural and urban landscapes to assess the number of eggs being parasitized and predated (later Group wild). If an egg mass was found, the number of eggs and the number of predated eggs were counted and furthermore kept in a closed container for a maximum of 20 days to see if parasitoids emerge.

Moreover, egg masses of the three species *H. halys*, *N. viridula* and *P. rufipes* obtained from our rearing were sterilized and stapled on the underside of leaves for three days to attract parasitoids and predators (later Group sterilized).

[1] T. Lederer, Institut für Pflanzenschutz, Bayerische Landesanstalt für Landwirtschaft, 85354 Freising, Germany, tobias.lederer@lfl.bayern.de

Therefore, stink bugs were collected from Munich. They were reared in mesh cages (MegaView science Co. Ltd., Taiwan) with potted common bean plants (*Phaseolus vulgaris* (Linné)) and fed by snow pea (*Pisum sativum* (Linné)) plus sunflower seeds (Helianthus annuus (Linné)) to receive egg masses. *P. rufipes* was additionally fed by sugared water. The food was replaced twice a week, the plants once a week and the cages cleaned every three weeks. The cages were checked daily for egg masses. Egg masses found on Tuesdays until Fridays were sterilized while egg masses found on Mondays were kept in the rearing and put into petri dishes until they reached the 2nd instar. From the 2nd until the 3rd instar nymphs were kept in small cages together with snow pea and sunflower seeds. From the 4th instar nymphs were kept together with adults. The rearing took place in a room with approximately 23 °C and 50 % RH with at least twelve hours of sunlight daily. The above-mentioned eggs found on Tuesday to Friday were sterilized by storing them for at least ten days and a maximum of 15 days in a refrigerator with a temperature of 8 °C to avoid hatching and for better handling (Wong et. al, 2021). After the sterilization egg masses were stapled on the underside of leaves of favoured trees in three urban locations in Munich. Locations were chosen because they either contained high population densities of *H. halys* or they comprised a suitable environment for parasitoids by offering many flowering plants. Egg masses were collected from these locations after three days, afterwards the number of predated eggs was counted. Since the rate of sterilized eggs being parasitized can not be compared adequate with parasitism rates in natural egg masses (Moraglio et. al, 2020), there were left out from the results here.
Groups were compared by a one-way ANOVA (α = 0,05). If the test showed significant differences between the groups Tukey´s HSD was applied. R software (ggplot2 package) was used for statistical analysis and the creation of graphics.

Results

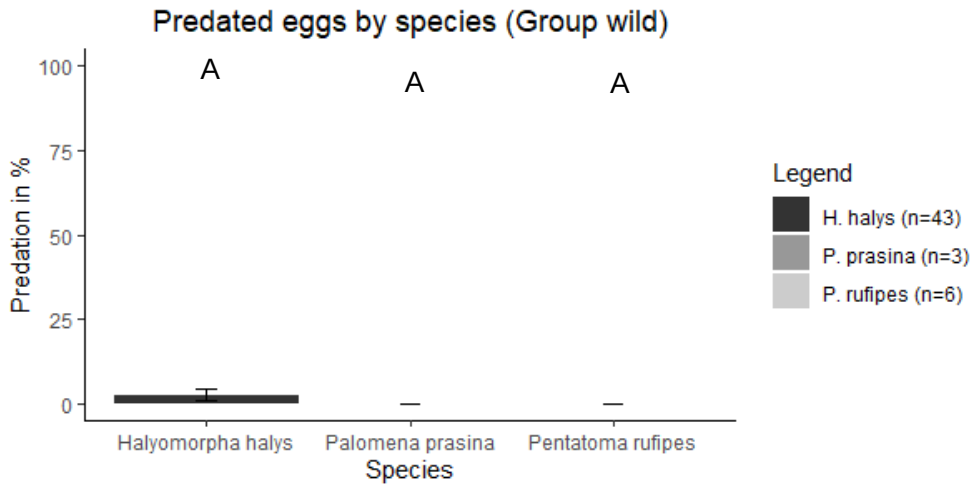

Figure 1: Bars of the mean predation ± SE of wildly found egg masses of the three Pentatomidae *H. halys, P. prasina* and *P. rufipes*. Bars with shared letters were not significantly different from each other.

23 egg masses were found in agricultural landscapes and 29 egg masses were found in urban landscapes. Egg masses found in the wild were predated by very limited amounts (*Figure 1*). That was the case for every species, even though it must be noted, that the sample size of *P. prasina* and *P. rufipes* was very small. In fact, only four egg masses were being attacked by predators and in only one egg mass more than 50 % of the eggs were devoured (all in *H. halys*). A low predation rate was found both in agricultural and urban landscapes. The mean predation rate on *H. halys* egg masses was 2.6 %.

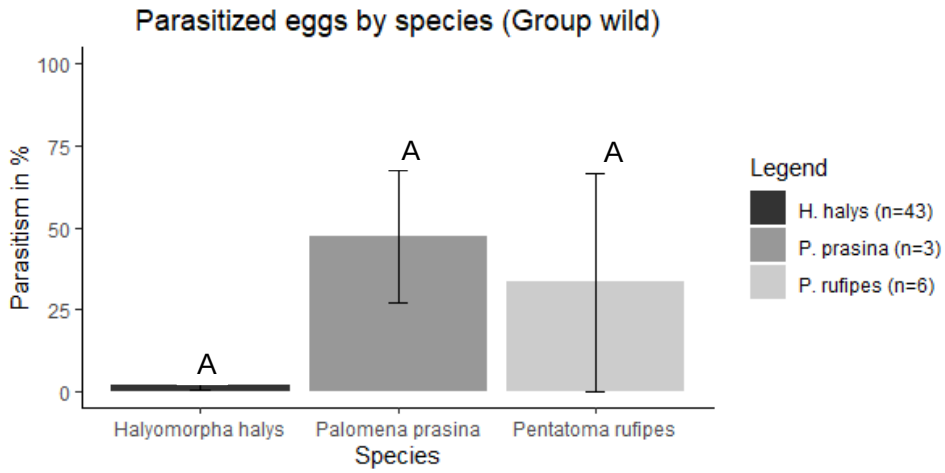

Figure 2: Bars of the mean parasitism ± SE of wildly found egg masses of the three Pentatomidae *H. halys, P. prasina* and *P. rufipes*. Bars with shared letters were not significantly different from each other.

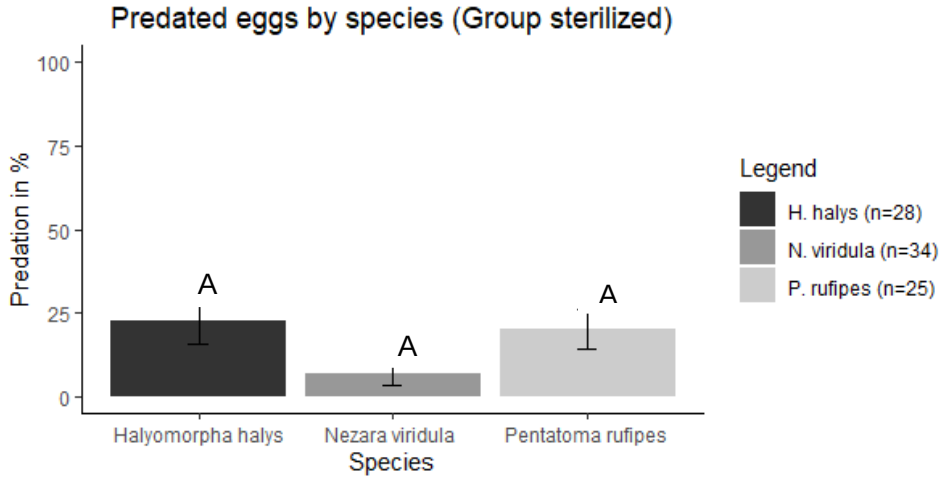

Figure 3: Bars of the mean predation ± SE of wildly found egg masses of the three Pentatomidae *H. halys, N. viridula* and *P. rufipes*. Bars with shared letters were not significantly different from each other.

Parasitism rates of egg masses from *H. halys*, *P. prasina and P. rufipes* found in the wild differed among the species (*Figure 2*, not statistically significant). Eggs from *H. halys* were mostly unaffected by parasitoids (mean parasitism rate 1.9 %). Results gained in the two indigenous Pentatomidae *P. prasina* and *P. rufipes* were higher but must be locked at with caution due to the low sample size number.

Proportions of sterilized eggs attacked by predators varied between the species *H. halys, N. viridula* and *P. rufipes* (*Figure 3*). Eggs of *N. viridula* were eaten to a lesser extent than the other two species (mean = 7.0 %, not statistically significant). The mean predation rates of *H. halys* and *P. rufipes* were comparable (22.7 and 20.3 %). Some (10x) egg masses were eaten completely by predators. Nevertheless, more than 50 % of the egg masses of all species were not touched by predators.

Discussion

The small number of predated eggs in *N. viridula* could have been due to its high number of eggs per egg mass (Ø 67 eggs per egg mass) compared to the other species. The small sample size of the wildly found egg masses of *P. prasina* and *P. rufipes* restricts possible conclusions from this part of the investigations. However, both predators and parasitoids of *H. halys* had little impact on the pest in the investigated area in 2021, especially on egg masses found in the wild. These results are in line with other findings in Europe (Leskey et. al, 2018), which as a result led to the current focus on the two Asian parasitoids *T. mitsukurii* and *T. japonicus* as possible biocontrol agents of *H. halys* (Dieckhoff et. al, 2021). We did not find either of these parasitoids. Since sterilized egg masses were stapled on trees with high densities of *H. halys* and predation in these areas was higher than in wildly found egg

masses, there seems to be an increasing predation rate with increasing population size of *H. halys*. This effect was quite small in 2021 but the predation might increase in the next years, as both populations increase. Finding out which species were mostly responsible for the control and to see if the effect increases in the future are possible future investigations next to a more precise search for *T. mitsukurii* and *T. japonicus* in Bavaria.

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