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BOOK OF ABSTRACTS

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BugMap, a citizen science approach to monitor the spread of the invasive Brown Marmorated Stink Bug *Halyomorpha halys* (Hemiptera: Pentatomidae)

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Highlights

- Understanding the dynamics of invasive alien pests in a newly invaded region can help limit their spread and prevent overwhelming outbreaks
- The involvement of volunteering citizens in this scientific inquiry allows the efficient gathering of a large amount of data and the spatio-temporal modeling of *H. halys* in recently invaded region

Introduction

The invasive Brown Marmorated Stink Bug *Halyomorpha halys* is becoming one of the most alarming alien pests worldwide. The title is earned through polyphagy, multi-voltinism and a capacity of long distance dissemination, causing enormous agricultural damages (Leskey et al., 2012). A promotion to public nuisance pest was also due to its tendency to overwinter in man-made structures.

The presence of *H. halys* in the Province of Trento was first reported in 2016. The close association of overwintering *H. halys* with humans prompted volunteer citizens to help track the invasion. Therefore, we designed a mobile application, BugMap, to capitalise on this aspect, involving citizens in a process that would allow the efficient gathering of a large amount of data, and a faster understanding and reaction to the invasion.

The presence of suitable hosts in Northern Italy such as apples, grapes, small fruits and others renders the situation even more critical. Thus, spatial analysis and distribution modelling are employed to better understand the invasion dynamics of this pest.

Material and methods

BugMap reports are received as a citizen filled form on the number of specimens, the detection site (building, means of transport, garden or agricultural cultivation), along with photographs that allow the validation of the sightings. These reports were coupled with data from traps deployed in various locations in Trento, to account for presence and absence of *H. halys* (http://appmeteo.fmach.it/bugMap/). As described by Capinha and Anastácio (2011), environmental features with potential effect on *H. halys* distribution were selected i.e. Digital Elevation Model with a resolution of 10 meters, land-use, hydrography and forest tracks; all available at the Autonomous Province of Trento cartographic portal (http://www.territorio.provincia.tn.it/portal/server.pt/community/cartografia_di_base/260/cartografia_di_base/19024).

From the Digital Terrain Model (DTM), the slope was derived using GRASS GIS version 7. All data have been resampled at 100 meters resolution to increase the speed of calculation in Maxent using the jackknife test for assessing variable contribution.

Multivariate plotting in R was also done to test for correlation among the above-mentioned GIS layers and other variables including finding method (visual or trap), distance from railways, lakes, rivers and main streets, as well as the detection location in buildings or gardens.

Results and discussion

Understanding landscape factors -both natural and anthropogenic- that facilitate the spread and establishment of alien pests is a critical element in invasion dynamics and biology. The fresh infiltration of *H. halys* in Trentino offers an excellent opportunity to determine factors affecting the colonisation process, and provides insight into developing novel control strategies against this pest.

Maxent model showed an accuracy of 0.97, estimated with the ROC curve. The variables that contributed the most to the distribution of this species were elevation and distance from houses, accounting for 49.29 % and 42 % respectively. These results illustrate the suitability of Trento for hosting *H. halys*, particularly in terms of altitude, ranging from 190-300 metres above sea level. Additionally, there is a strong association with urban development, whereby this bug finds numerous overwintering sites and green refuge areas surrounding houses and buildings, further facilitating population build-up.

Moreover, plotting the distance from main streets and rivers with respect to the finding frequency, displays that most sightings were reported at a distance usually not exceeding 200 metres. These results corroborate the findings of Maistrello et al. (2016), verifying the "Hitchhiking" behaviour exhibited by *H. halys*, which could be enhancing the colonisation process.

Furthermore, our observations indicate that the number of BugMap reports was higher during autumn, the period when *H. halys* aggregates in buildings to overwinter, and is therefore in close association with humans. Whereas in April-May, fewer reports were recorded, this is probably due to the dispersal of the bug away from watchful citizens, onto host plants where it mates and develops through 1 or 2 generations. These observations are in agreement with the described biology of the species in several states in the USA (Leskey et al., 2012).

Although still young and in its early stages, BugMap has proven to be a resourceful tool, capable of involving citizens in the scientific inquiry. More importantly, it allows the gathering of a large amount of data in a cost and time effective manner, which is readily helping scientists understand and better react to this alien invasion.

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