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Citizen science-based distribution update of invasive *Corythucha* species in Italy

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SUMMARY

Globalisation has resulted in the introduction of alien species into new regions at an unprecedented rate. Some of these species become naturalised and pose a risk to the environment, agriculture, and human health. Insects represent one of the most invasive taxa with several disease vectors as well as agriculture and forest pests. Amongst the latter, *Corythucha* species are considered emerging pests since their life-history traits and host plant trade are helping their rapid spread. Therefore, early monitoring and reporting of highly invasive insect species are fundamental to implement pest management actions aimed at curtailing environmental and socioeconomic damage caused by these species. To this end, I updated the currently known distribution of alien *Corythucha* species invading Italy using a citizen-science approach, which is an easily repeatable approach that can be applied to other invasive species. In total, 234 records were retrieved from online databases/platforms, including five from the recently arrived invader *C. marmorata*. Most observations were made in summer and autumn in the months of August and September. The presence of *Corythucha* species was confirmed in newly invaded areas of Italy, demonstrating that citizen-science repositories are useful first-line tools to detect biological invasions, thus favouring rapid management.

INTRODUCTION

Alien species are species directly or indirectly introduced by humans and their activities into an environment outside their native range (Pyšek et al. 2020). Alien species, once naturalised, can become invasive if they alter the structure and functioning of the invaded environment and, in turn, its biotic communities. Specifically, invasive species are the second leading driver of biodiversity loss (Gentili et al. 2021) due to competition, hybridisation with native counterparts, predation, and pathogen spreading (Bellard et al. 2016; Laurimaa et al. 2016). Amongst the 100 worst invasive alien species, 17% are terrestrial invertebrates (second only to terrestrial

plants; Luque et al. 2014), mainly insects. Insects belong to a taxon of major concern in invasion biology (Zhao et al. 2023), since several insect species are a threat to native biodiversity, vectors of animal/human and pathogens (Lounibos 2002; Eigenbrode et al. 2018; Lozada-Chávez et al. 2025), or pests to agriculture and forestry (García-Lara and Saldivar, 2016), sometimes adapting to human-modified landscapes (e.g., agricultural and urban areas; Lozada-Chávez et al. 2025). Despite this, the EU Regulation 1143/2014 blacklists only five insect species, whose impacts are of conservation concern for autochthonous biodiversity (https://circabc.europa.eu/ui/group/4cd6cb36-b0f1-4db4-915e-65cd29067f49/library/79885406-e439-4961-ab2e-717191190f34/details; accessed on 26.03.2026), but both the European and Mediterranean Plant Protection Organization (EPPO: https://www.eppo.int) and the Italian public council responsible for the protection of plants and their products from alien organisms (i.e., the "Servizio Fitosanitario Nazionale") list several other insect species as "quarantine pests", thus requiring active monitoring and immediate reporting (Marianelli et al. 2019). In addition to the concern for biodiversity and public health, invasive insects are associated with huge economic losses, and a relevant proportion of this economic burden derives from agricultural pests (Bradshaw et al. 2016). Invasive lace bugs belonging to the *Corythucha* genus (Hemiptera: Tingidae) are considered emerging pests worldwide because of their rapid spread and colonisation of new geographical areas, mainly due to trade and movement of their host plants (Kato and Ohbayashi 2009; Mori et al. 2023). *Corythucha* species are small insects possessing piercing-sucking mouthparts used to feed primarily on woody plants. The sycamore lace bug *Corythucha ciliata* is a tingid native to North America and is specialised on *Platanus* spp. (Platanaceae). Females lay 80−160 eggs and after approx. 3 weeks of embryonic development first-instar nymphs hatch followed by four additional nymphal instars (Öszi et al. 2005). Adults are small and flat (average body length = 3.7 mm; average body width = 2.8 mm; Mutun 2009), with whitish wings bearing brown markings on the tumid elevations of the hemelytra (Miller 2004). The species overwinters under the outer bark of the host tree or in other nearby shelters. In Europe, *C. ciliata* arrived in 1964 in Italy (Servadei 1966), from where it spread to other European countries (Tzanakakis 1988; Pellizzari and Dalla Montà 1997; Mattson et al. 2007), as well as outside Europe (Mutun 2009). Heavy sycamore lace bug infestations of *Platanus* spp. trees can lead to their eventual death, thus increasing tree managing costs as well as the risks related to falling trees, especially in (peri-)urban areas (e.g., Way and Balogh 2022). In addition to the direct damage to plants, *C. ciliata* can also transmit pathogenic fungi (Li et al. 2016). Furthermore, Izri et al. (2015) have reported a case of dermatosis caused by *C. ciliata* after blood-feeding on a person.

The oak lace bug *C. arcuata* is another tingid species native to North America with invasive capacity associated with the rapid spread of infestations and severe damage to oak trees (Bernardinelli 2006). *Corythucha arcuata* was first identified in Northern Italy in 2000 (Bernardinelli and Zandigiacomo 2000), from where it spread being reported two years later in Switzerland (Forster et al. 2005), and Turkey (Mutun 2003). Since then, several other countries have been reached by the oak lace bug during its human-driven range expansion (Paulin et al. 2020; Bălăcenoiu et al. 2021). While in its native range *C. arcuata* is not considered a pest, in Europe the scarcity of native predators, combined with its capacity to feed on most European oaks, give the species great invasive potential, thus worsening the "oak decline" (Thomas 2008).

The chrysanthemum lace bug *C. marmorata* is the most recent exotic tingid native to North America to have arrived in Europe (Italy; Dioli et al. 2022). The chrysanthemum lace bug feeds on both cultivated and wild Asteraceae (e.g., *Chrysanthemum*, *Aster*, *Arctium* and *Solidago* genera) (Kato and Ohbayashi 2009), thus posing a threat to the floristry industry as well as the environment. Moreover, *C. marmorata* feeds on plants of agronomic interest, thus representing a potential threat to agriculture as well (Kim and Kil 2014). In Italy, the species has a sporadic and fragmented distribution, despite it is reasonable to assume that in the future it will expand its range, eventually reaching other European countries. In fact, *Corythucha* species have proven high dispersal capacities due to phenomena such as the adults' ability to fly long distances, spreading through vehicles, and the trade of host plants.

Recently, the "rules for the protection of plants from harmful organisms" − formalised in the Italian Legislative Decree 19/2021 – require the reporting of previously unrecorded species in each Italian region to the "Servizio Fitosanitario

Regionale" (i.e., the regional plant protection service). Additionally, this Legislative Decree underlines the necessity to keep the distribution of harmful alien taxa updated (Mori et al. 2023). To fulfil this necessity, in this work I combined observations made by experts with citizen-science evidence to update the currently known distribution of alien *Corythucha* species invading Italy. For this purpose, online citizen-science platforms allow data to be collected at low cost (Sogliani et al. 2023) and have proven to be reliable tools for the early detection of biological invasions (Encarnação et al. 2021; Sogliani et al. 2021), as well for detecting newly invaded areas (Connors et al. 2022; Mori et al. 2023).

MATERIALS AND METHODS

In January 2024, I conducted a data collection campaign from the citizen-science platforms iNaturalist (https://www.inaturalist.org/) and Ornitho (https://www.ornitho.it/), as well as from online databases validated by experts (Forum Natura Mediterraneo [FNM]: www.naturamediterraneo.com; Forum Entomologi Italiani [FEI]: www.entomologiitaliani.net. Accessed on 02.01.2024) and social networks (i.e., Facebook, Instagram, TikTok). I collected records of *Corythucha ciliata*, *C. arcuata*, and *C. marmorata* occurring in Italy. I considered only records from 2000 to 2023 supported by photographic evidence of sufficient quality to correctly identify the species and research-grade records. Each photograph was examined by experts for species identification using the main morphological characteristics of adults (Miller 2004; Golub and Soboleva 2018; Dioli et al. 2022). The distribution of each *Corythucha* species was mapped using the software R (v4.3.2, R Development Core Team 2023) through the ggplot2 package (Wickham 2011).

RESULTS

From 2000 to 2023, 234 records of *Corythucha* species in Italy were gathered. *Corythucha ciliata* was the most frequent species (n = 156) uploaded to online databases/platforms, followed by *C. arcuata* (n = 72) and *C. marmorata* (n = 5) (Supplementary Fig. S1). Most records (n = 211; 90.17%) were collected from the iNaturalist repository, while the others were retrieved from Facebook, FNM, and FEI (Supplementary Fig. S2). No data were available on Ornitho, Instagram, and TikTok. Georeferenced records from iNaturalist were used to generate the updated map of the current distribution of the three *Corythucha* species invading Italy (Fig. 1).

Most observations (73.50%) occurred in summer and autumn, followed by spring and winter (Fig. 2). Just over half (52.99%) of the observations were recorded in the months of July, August, and September (Fig. 2; Supplementary Fig. S3).

The first *C. ciliata* record occurring in Italy uploaded on the considered online databases was detected in Savona (Liguria) in 2006. One year later, the first record of *C. arcuata* was observed in Sondrio (Lombardy), while the new invader *C. marmorata* was reported on FEI in 2021 in Lecco (Lombardy). The yearly distribution of the retrieved records is available in Supplementary Figure S4 and shows an increasing trend of observations over time. This likely reflects temporal biases in online reporting effort and platform availability, rather than the actual timing of the species presence in Italy.

Regarding the detection in Italian regions, *C. ciliata* and *C. arcuata* were detected by this approach in fourteen and eight regions, respectively, while *C. marmorata* was found only in Lombardy (Supplementary Table S1).

DISCUSSION

Globalisation has escalated the introduction of alien species, with invasive insects posing significant threats to biodiversity, agriculture, and public health. Lace bugs are emerging pests, and despite being manageable by either chemical (Bălăcenoiu et al. 2021) or biological control − for instance − by the use of entomopathogenic fungi (e.g., Sevim et al. 2013; Kovač et al. 2020) or nematodes (Julià et al. 2020) – updating alien distribution and early detection of new invasion records from *Corythucha* spp. species (and invasive insects in general) are essential for the implementation of rapid management actions aimed at controlling or even eradicating individuals before their additional dispersal in uncolonized areas or their establishment as self-sustaining populations. This is especially important for the "quarantine species" and pests listed on the EPPO Alert List. Despite the fact that currently none of the three *Corythucha* species are on the list, the forest pest *C. arcuata* was formerly inserted in it (https://gd.eppo.int/taxon/CRTHAR/categorization). In the present work, I show the potential of citizen-

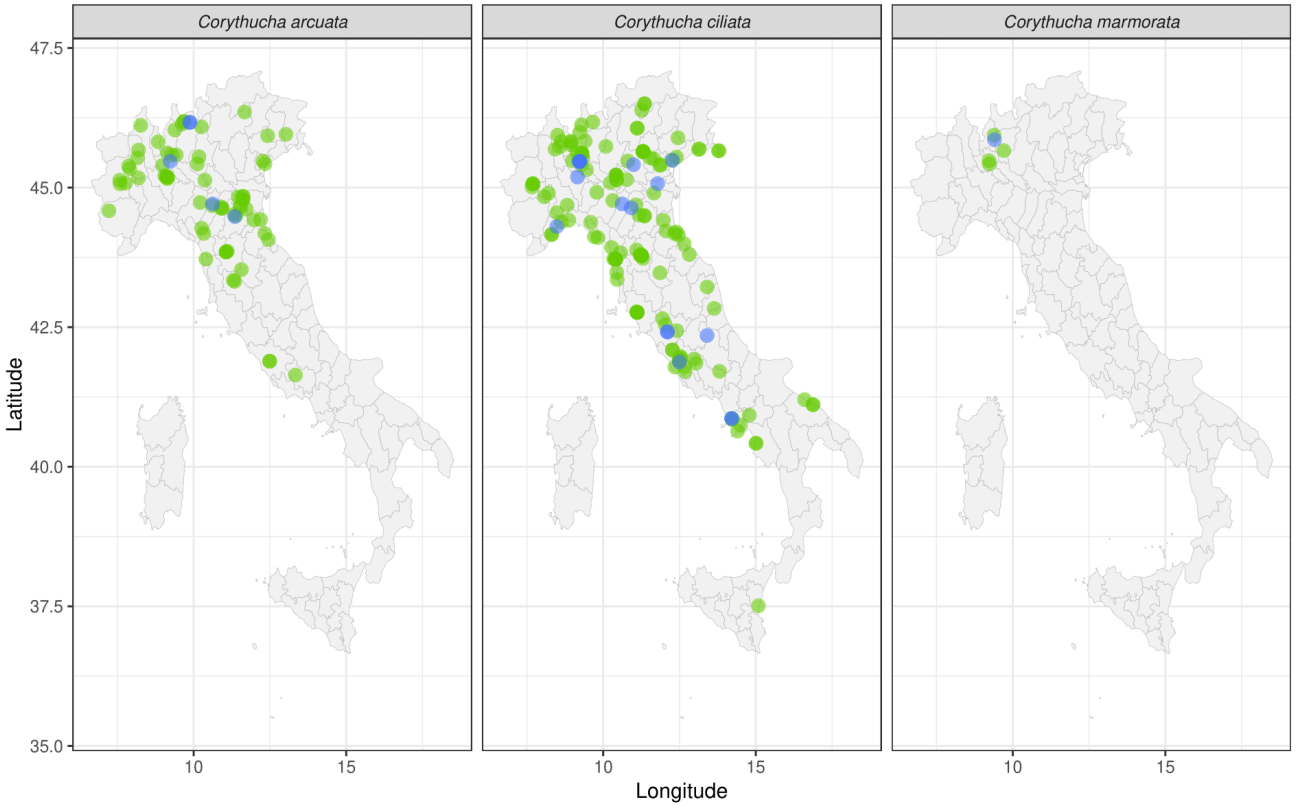

Figure 1. Citizen-science-based updated distribution maps of the three alien *Corythucha* species present in Italy. Green circles refer to georeferenced records from iNaturalist.org, while blue circles refer to other sources, without precise coordinates.

Figure 2. Monthly and seasonal distribution of *Corythucha* records in Italy uploaded between 2000 and 2023.

science in fulfilling the above-mentioned demands. The citizen-science approach employed has inherent advantages and disadvantages. The disadvantage lies in the impossibility of always identify precisely small and visually similar species from photographs, as exemplified by *Corythucha* species. However, this approach offers a valuable starting point for experts and regulatory agencies, providing information for planning and implementing targeted fieldwork. While *C. ciliata* has already been reported to be present in all Italian regions including the two main islands (Mazzon and Girolami 2000), *C. arcuata* and *C. marmorata* have a more scattered distribution, and their range expansion may be prevented by timely detection. This study brings to light the case of *C. marmorata* as the most recent *Corythucha* species arrived in Italy. The first appearance of *C. marmorata* in Europe dates to October 2022, when the species was found in the province of Lecco, Italy. Photographs were uploaded on the Forum Entomologi Italiani, so Dioli and colleagues promptly collected individuals from the field and validated the observation (Dioli et al. 2022). However, on the multi-taxon citizen-science database iNaturalist.org, from where most of the data for this work were retrieved, a *C. marmorata* individual was reported in July 2021 in the same province, more than a year before the first official report by Dioli and colleagues. Despite direct

observation being fundamental in insect identification, the consistency of the phenotype and the absence of similar species in Italy (such as *C. morrilli*; Dioli et al. 2022) suggest the great potential of citizen-science (see also Pélissié et al. 2023). So, early records from citizen-science platforms can represent a crucial first-line approach, offering a timely alert for experts and regulatory agencies to initiate further monitoring and, once presence confirmed, management actions to mitigate the potential environmental and socioeconomic impacts of invasive species.

In conclusion, the integration of traditional and molecular monitoring techniques (such as eDNA; Valentin et al. 2018; Larson et al. 2020) with citizen-science, which can act as a tool for initial alerts, is recommended. Moreover, informing stakeholders about the potential danger these species may represent for agriculture and forestry could facilitate the acceptance of guidelines/policies restricting the trade and introduction of, for instance, plant specimens potentially infested by other invasive insect species or recently introduced ones (like *C. marmorata*), since naturalisation is facilitated by high propagule pressure. Finally, this work represents an easily repeatable approach that can be applied to species of greater agricultural and forestry interest, thus fostering their management.

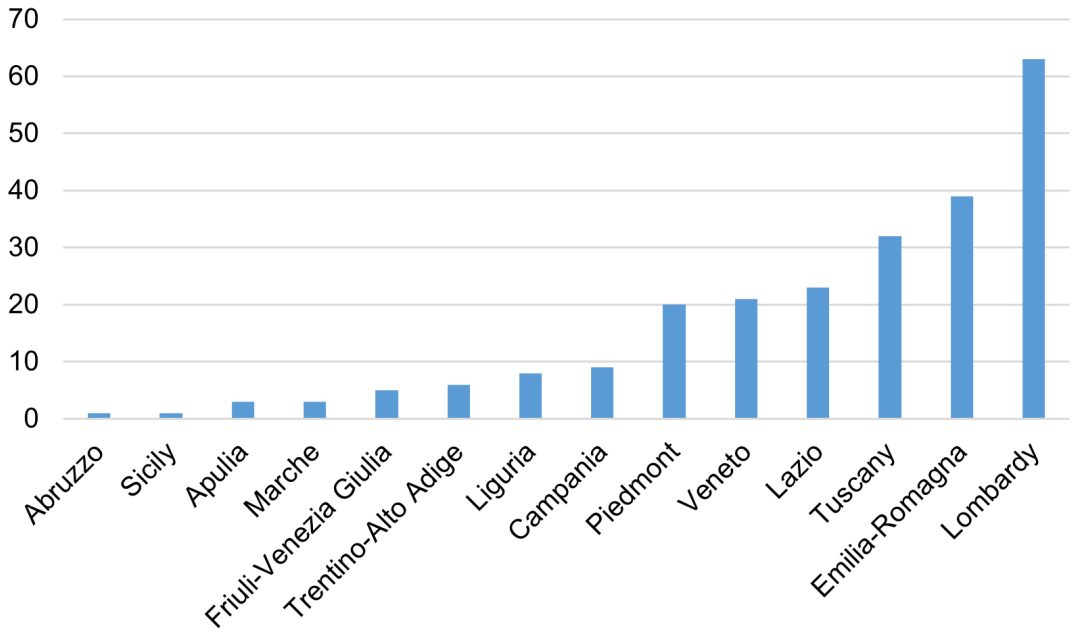

Figure 3. Counts of *Corythucha* records per Italian region.

DATA AVAILABILITY

The dataset analysed in this study is publicly available in Zenodo repository associated with the persistent identifier DOI: https://doi.org/10.5281/zenodo.10520397. Raw data are publicly available on the online citizen-science platforms considered in this study.

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