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New Data and Recent Updates on Invasive Horticultural Pest Species *Acanalonia conica* (Hemiptera: Auchenorrhyncha) in Romania

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Abstract: As a result of increased trade, transportation, and globalization, the phenomenon of growth regarding the entrance of invasive alien species (IAS) represents a serious concern (including flora, fauna, and microbiota). *Acanalonia conica* (Say, 1830), also known as the green cone-headed planthopper (GCHP), was first identified in the *Chrysanthemum* collection of the Botanical Garden in Iaşi, Romania. The principal objectives of this article are to update the limited data on the presence of *A. conica* in Romania, revealing its occurrence in new areas (East Romania, Iași) and on other host plants that were not previously documented in the United States and Europe, as well as to establish the trends of population evolution, with an emphasis on the peak of GCHP population development during the life cycle on East Romania indoor conditions. The evolution of the GCHP population was established using the recorded data on total counts of adults and nymphs observed from a limited area (greenhouse compartment), checked every two days in 115 days of direct observations. The peak of population was established at late-July (25th to 31st day of the month, 30th week of the year) for the conditions of East Romania and it was the appropriate time to monitor the activity of the species, to estimate the damages in specific crops, and to initiate the specific pest control measures. Current findings are significant not only for the general spread of this species in Europe and in Romania but also for the observations regarding new hosts and the population evolution in a greenhouse habitat for the cultivation of ornamental plants.

Keywords: Botanical Garden Iași; *Chrysanthemum*; distribution; economic impact; green cone-headed planthopper; new record; pest management; population development

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1. Introduction

Taxa introduced or outside of their current geographic distribution and natural dispersal potential are considered alien species, with the potential to significantly affect biological diversity, ecosystem functioning, socioeconomic values, and human health in invaded regions. Several terminologies, such as non-indigenous, non-native, exotic, foreign, new, allochthonous, and neobiota, are used to describe alien organisms [1].

According to Pyšek et al. [2], invasive species are a subset of naturalized/established alien taxa that produce reproductive offspring, often in very large numbers, having the potential to spread exponentially over a large area, thus rapidly extending their range. For conservation purposes, the term invasive usually relates to natural or semi-natural ecosystems or habitats. Most invasive species have an economic impact, as important phytophagous pests for important plant categories, causing enormous economic costs associated with their prevention, eradication, or control measures, but especially through direct production losses [1,3].

Acanalonia conica (Say, 1830) [4], known as the green cone-headed planthopper (GCHP), is an invasive horticultural pest with a wide range of feeding habits, which can infest many plant species found in urban, semi-urban, agricultural, and forestry environments. This

species is noted for being polyphagous on wild or cultivated shrubs, trees, and herbaceous plants, some of which with horticultural value. GCHP originated in North America, where it is widely distributed, ranging from southeastern US to central-east Canada [5], where it occurs on a wide variety of plants [6,7]. GCHP was collected for the first time in Europe, in Venetia (Italy), province of Padua, in June 2003 [8], collected especially on *Budlleja davidii* (Scrophulariaceae) and a few other plants. For Europe, the discovery of this new at that time species was highly significant as it could have been as important as the *Metcalfa pruinosa* pest. This last species appeared in Europe for the first time in 1979 [9], in the Veneto region (province of Treviso), and then spread rapidly throughout Italy and some other European countries. From Italy, in a short time period, GCHP was found in several European countries: Switzerland [10], Romania [11], Slovenia [12], Austria [13], France [14], Serbia [15], Hungary [16], Slovakia [17], Bulgaria [18,19], and Türkiye [19]. Some authors also considered this species as a potential pest of grapevines due to its mechanical damage by female ovipositor when inserting eggs in the wooden tissues of grapevine sprouts, thus causing mechanical damage. Furthermore, these scars can be entry points for bacterial, viral, and fungal infections [16].

In Romania, GCHP was reported for the first time as introduced allochthonous species in 2016 in two regions of Bucharest-Research-Development Institute for Plant Protection (RDIPP) and Research-Development Station for Fruit Growing (RDSFG), only in urban areas on two host species, namely *Crataegus monogyna* (common hawthorn) and *Malus domestica* (apple) [11,20,21], and also in the northern part of Bucharest (Băneasa area) into *Malus* and *Prunus* unmanaged orchards [22]. Since the first report of this species, GCHP was found only in the Bucharest area with growing populations surviving in the climatic condition of the area and increasing in abundance [23], and there were no other reports of this species in other parts of the country [24]. Regarding the possible damages to host plants, the juvenile stages can produce a great amount of wax and honeydew and are often associated with epiphytic fungi (*Capnodium* sp.), thus causing aesthetic and economic damages, especially in shrubs, trees, or ornamental crops [24].

The description of the life history and development stages of GCHP is of interest to the horticultural field and were investigated in detail in southern Illinois, the immature stages were described in detail and the species was also reared in the laboratory [7]. According to Wilson and McPherson [7], the first instars were collected from mid-May to mid-June, both 2nd and 3rd instars were collected from the third week in May to early- July, 4th instars were collected from late-May to mid-August, 5th instars were collected from late-June to late-August, and adults were collected from early-July to late-September. Our observation aims to adjust the life history of GCHP for East Romania conditions, especially for indoor populations of this species, for practical assessments in pest control for ornamental plants.

Therefore, the main objectives of this paper are (1) to update the existing scarce data on *A. conica* (GCHP) in Romania, (2) to report its occurrence in new areas (East Romania, Iași) and on new host plants not reported so far in USA and Europe, (3) to compiles information published by other authors (bibliographic resources) prior to the data collected by the present author, and also, (4) to establish the pattern of population evolution, with the emphasis of the peak of GCHP population development during the life cycle on East Romania indoor conditions.

2. Materials and Methods

2.1. Study Area, Sampling, and Data Collection

The observations regarding the presence of *A. conica* were performed at "Anastasie Fătu" Botanical Garden of Iași-Romania, 47°11′17.69″ N, 27°33′22.8″ E (DMS system), into the greenhouses used for cultivation of the horticultural varieties of *Chrysanthemum* × *grandiflorum*. The greenhouse where the observations were performed has 80.07 m^2 with a cultivated surface of 40.2 m^2, and a total number of 1184 plants. Horticultural varieties of *Chrysanthemum* 'Princess', 'Zembla Barca Red', 'Crimson Robe', 'Prince de Monaco', 'Escort Roth' were selected for observation regarding the average high of plants and foliar mass

as the number of leaves per plant. To achieve optimal plant growth and maximize yield, the microclimate in greenhouses was closely monitored by indoor control systems. The registered main parameters in the greenhouse were a temperature range of 25 °C–30 °C and a relative air humidity average of 76%. The greenhouse is equipped with a ventilation system in the upper part of the compartment and a drip irrigation system on the ground, and for the period with maximum sunlight, a shading system has been implemented.

Other geographical data for Botanical Garden Iași in brief are: 54–150 m.a.s.l., 9.6 °C as average annual temperature, 518 mm/year average rainfall, 70% relative humidity and 46% sunshine duration [25]. The study area of the Botanical Garden, in terms of soil types, geographical features, slopes altitude, etc., in very varied and, consequently, suitable for a wide range of both indigenous and exotic plants cultivation.

Chrysanthemum species and horticultural varieties are represented in the Botanical Garden of Iași through a number of about 450 taxa, grouped in a unique collection in Romania in terms of size, scientific value, and presentation, being accessible both to the general public and specialists. The *Chrysanthemum* collection was started in 1976, and the number of varieties increased yearly, based on exchanges with other botanical gardens mainly from Eastern Europe, or on the basis of the identification of new varieties on national traditional gardens: 220 horticultural varieties belonging to the *Chrysanthemum* × *grandiflorum* complex and over 200 belonging to *Chrysanthemum indicum*, among which are preserved the varieties obtained at the Botanical Garden of Iași [25].

Taking into consideration the importance of *Chrysanthemum* s.l. collection in the Botanical Garden of Iași, at the local and national level, there are permanent observations regarding the presence of pests and diseases that can damage and affect the culture of this representative horticultural species, to monitor and implement pest control measures in time.

Insect specimens were observed and counted over a four-month period (from middle June to middle October) in 2022 and two types of habitats were surveyed: (1) all areas of the greenhouses in order to detect species associated with cultivated plants into protected indoor habitat; (2) outdoor vegetation near the main field of the greenhouse compartment, for detection of other host plants and insects associated with ornamental plants and vegetation adapted to urban habitats.

The insect sampling of GCHP for determination and preservation was conducted as manual collecting and also with a number of 20 yellow sticky traps, mounted at 1.8 m height, for 80.07 m^2 total surface of greenhouse (240 cm^2 for each cultivation surface of 4 m^2). Into this type of habitat (greenhouse) were used StrendPro sheets with 24 × 10 cm as dimensions, supplemented with different insect collecting tools such as suction sampler (especially for outdoor observations).

The collected specimens were dry prepared and preserved as a private entomological collection of the first author (I-ACo) and also deposited into Hemiptera Collection at Natural History Museum of "Alexandru Ioan Cuza" University of Iași-Romania, being used for the determination and morphological examination of adults and nymphs stages.

2.2. Species Identification

Correct identification of species is required to assess and understand the pattern of an economically important crop ecosystem and it was the first step in conducting further biological research. Both adult and nymph specimens were examined in the laboratory under a SZM2 stereomicroscope (Optika, Ponteranica, Italy), and the photos were taken in the field using a Nikon Coolpix L301 digital camera (Tokyo, Japan). Regarding the assessment of collected specimens, the authors used the descriptions from the key characters used in morphological diagnosis for the species, as well as the illustrations presented in the published literature, completed with confirmation from an entomologist. Bibliography and current taxonomic names were acquired from the FLOW (Fulgoromorpha Lists on The Web) database [26].

2.3. Observations on Evolution of GCHP Population

The green cone-headed planthopper (GCHP) has been recently reported on the European continent as an invasive species, and the data regarding the evolution of populations can offer proper information on controlling the excessive development of this species. The evolution of GCHP population was established using the recorded data on total counts of adults and nymphs observed from a limited area (greenhouse compartment), checked every two days in intervals 22 June 2022, and 4 October 2022 (115 days of observations). The egg stages were not included in observations, and for the clear results on population evolution, no treatment for pest control was used.

This observation interval was established starting with the day on which the first nymph was identified ('catch one' for nymphs-CONy, 22 June 2022) and the day before this observation was marked as 'catch zero' for nymphs-CZNy. After CONy, was marked the day of the first observation of an adult ('catch one' for adults–COAd, 8 July 2022). Similarly, the end of the interval marked the last days with CONy (2 October 2022), CZNy (4 October 2022), COAd (30 September 2022), and CZAd (2 October 2022) to end the observations, and it was concluded that it was the end of the life cycle of GCHP. The observation time was set at every two days, starting with CZNy, for a total period of 115 days, till was reached CZNy on 4 October 2022. All the data regarding the total counts on specific intervals were registered into Excel data sheets and analyzed using the R software environment. For data analysis in the Cartesian coordinate system, the number of days represented the main factor on the *x*-axis (abscissa), and the total counts at two days for nymphs and adults were represented on the *y*-axis (coordinate).

2.4. Identification of New Hosts

With the aim to ascertain the presence of possible pests, ornamental species and shrubs were investigated in different areas of the Botanical Garden around the greenhouse till 500 m, by careful direct visual search for specimens/colonies of GCHP or by examination of symptoms. *Acanalonia conica* was first collected and identified on a new host plant, namely in the *Chrysanthemum* collection of "Anastasie Fătu" Botanical Garden of Iași-Romania. Simultaneously with current research regarding the evolution of the GCHP population into the Chrysanthemum greenhouse, in the present article, a subsidiary observation in outdoor spaces of Botanical Garden Iași was also conducted near the main observation field (the greenhouse compartment). The presence of adults of GCHP on other cultivated plant species was noted, and new host plants were identified and confirmed by a plant taxonomist.

2.5. Data Analysis

After the sampling of GCHP specimens (adults and nymphs, with observations every two days) and data registration on total counts from a limited area as abundance, statistical data analyses were conducted to obtain an image of population evolution into the specific environmental conditions of Iași-Romania.

Relationships between the number of nymphs or the number of adults and the number of days were assessed using quadratic regressions performed using the R software environment (version 4.2.3., R CORE DEVELOPMENT TEAM 2023) [27]. The data were arranged by days, for a total of 16 weeks (115 days of observations), until the last day when no specimen was observed ("catch zero"), on 4 October 2022. For statistical analysis, the days of the entire period of observations (from 14 June to 4 October, 115 days) were set as direct factors to obtain the relationship between population density and the appropriate time of the year for both adult and nymphs GSHP stages development.

To highlight the general spreading of GCHP in Europe in general, and in Romania with current observations added, our paper compiles information published by other authors (bibliographic resources) prior to the data collected by the present authors. Additional surveys and sampling, as well as geospatial data processing regarding the impact of environmental change on biodiversity, are of major interest to the allochthonous species

in Romania. Distribution data were recorded and processed using tools of mapchart.net https://www.mapchart.net/index.html (accessed on 23 February 2023) for proper visualization of the geographic information system.

3. Results and Discussion

Following the observations and sampling carried out in recent years on the territory of the Botanical Garden Iași, mainly related to insects of horticultural interest and pest control, the presence of specimens of GCHP was detected and observed. In addition, the collected data were supplemented and correlated with information obtained from the scientific literature regarding the general distribution of GCHP at the global and European levels.

The pictures for the specimens of *A. conica* collected in our samples (adults and nymphs) are illustrated in Figures 1a,b and 2a,b. Some particular external features to help the identification of this species are that adults of *A. conica* have a very distinctive bright green color in live specimens (Figure 1a,b), while pinned specimens dispose of pale yellow color. The form is elongated, laterally compressed, with fore wings subrectangular basally. The head is conically produced anteriorly, eyes are usually red or concolorous, with ventral ridge, and antennae 3 segmented. In dorsal view, mesonotum subtriangular. Forewings with venation prominent, reticulate distally; costal vein slightly reflexed at the base. Distinguished from all other species by the distinct conically produced vertex and the elongate lobe-like process in the middle of the 8th abdominal sternite of the female [28]. *A. conica* is a univoltine species, with 5 instar stages/nymphs. The form of nymphs is elongated, subcylindrical, thoracic nota greatly humpbacked, and widest across the metathorax. Body white to light brown, with brown markings and many brown pits. The head is white to light brown with brown markings and pits, eyes red, 9 abdominal segments (Figures 2a,b and 3). The brownish nymphs are usually found with waxy plumes (Figure 2b), which are produced from the abdominal wax glands, on the posterior end [7].

Figure 1. (**a**)—Adult of *Acanalonia conica* (Say, 1830), lateral view; (**b**)—Adult specimen close-up, on *Chrysanthemum* × *grandiflorum* stem (preferred localization of adults). Bar scale–1 cm (Photos A. Cojocariu).

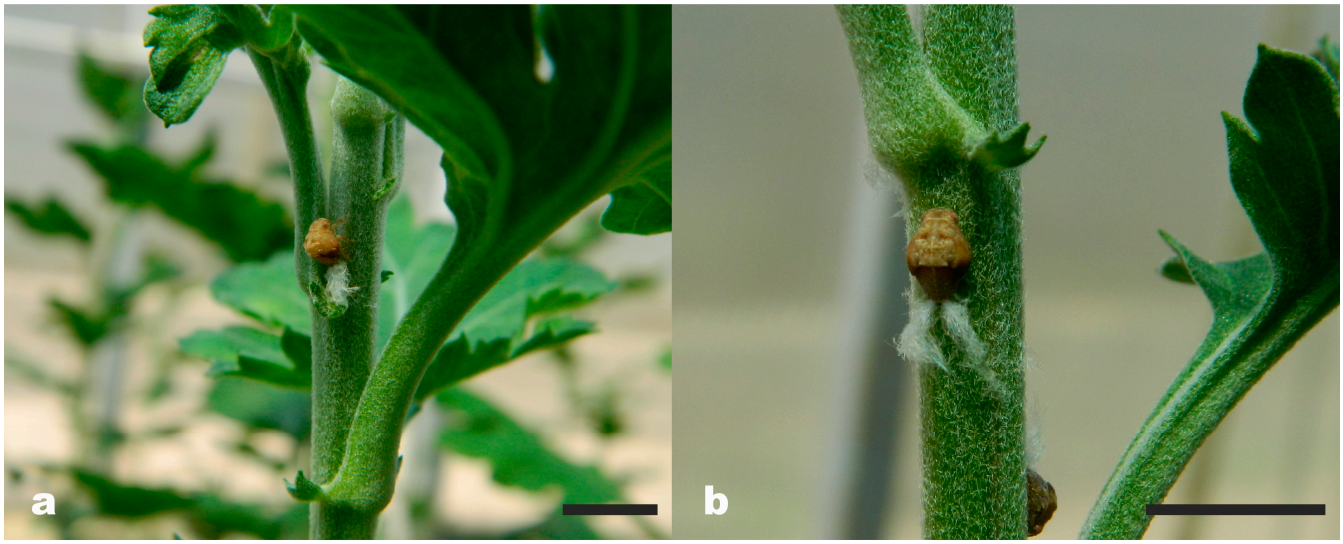

Figure 2. (**a**)—*A. conica*-5th instar nymph; (**b**)—Nymph close-up, with waxy plumes, produced from the abdominal wax glands, on the posterior end. Bar scale–1 cm (Photos A. Cojocariu).

Figure 3. Juvenile stages, from left to right-five instar stages (nymphs) and an adult of *A. conica* on lateral view. Bar scale–1 cm (Photo A. Cojocariu).

3.1. Observations on Evolution of GCHP Population

The first observation of a single nymph exemplar (Figure 4a) was taken on 22 June 2022, and after that date, the observations were performed once every two days, using the direct visual check of each exemplar of plants and data registration/recording (number of specimens observed, stage adult or nymph). The first adult of GCHP (Figure 4b) was observed after two weeks on 8 July.

Before the establishment of the GCHP population into the greenhouse, along with the first observation of a single nymph (Figure 4a), there were some remarks on the presence of *Metcalfa pruinosa* on *Chrysanthemum* × *grandiflorum* crop. A delay of four weeks was noted between *Metcalfa* and *Acanalonia* development, and after that, there was a co-development of these populations.

The number of counted specimens revealed an important peak of development between 25 July and 31 July 2022, both for adults and nymphs-Daily Observation Average (DOA) 18.6 and 10, respectively, starting from a single specimen of the nymph in the interval 20 June–26 June 2022 (Figures 5 and 6). This observation of dynamics can give important information regarding the evolution of GCHP populations in the specific condition of an indoor culture of ornamental plant species.

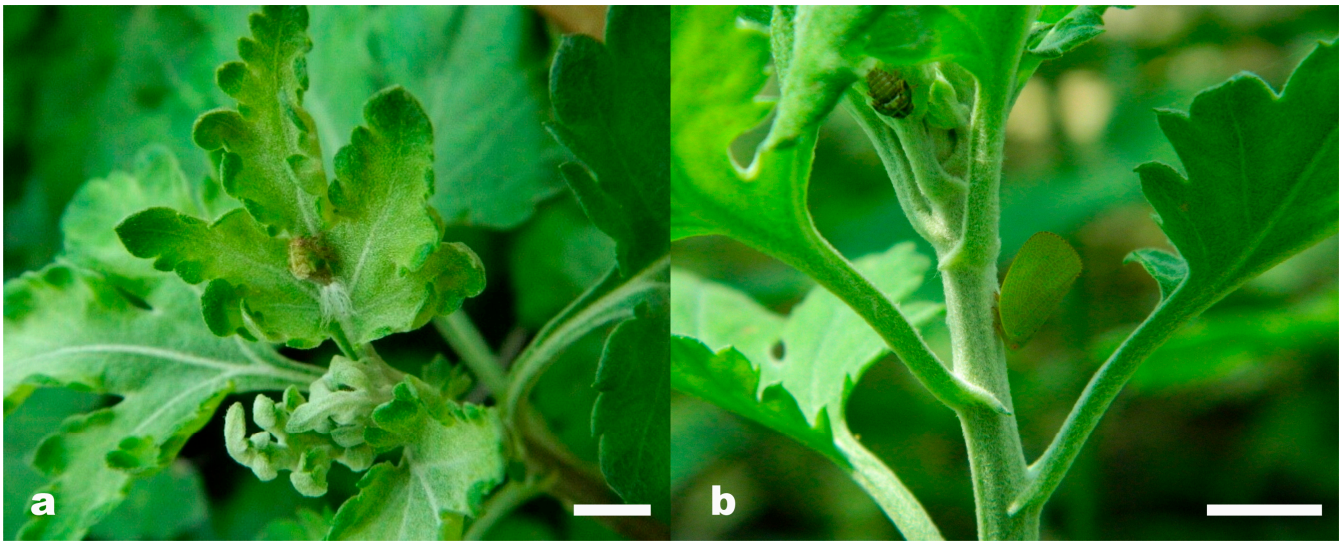

Figure 4. (**a**)—First observation of a single nymph exemplar (CONy, 22 June 2022) on top of the stem of *Chrysanthemum* × *grandiflorum* cultivated indoor/greenhouse at Botanical Garden of Iași-Romania 47°11′17.69″ N, 27°33′22.8″ E (DMS system); (**b**)—First observation of an adult exemplar (COAd) on July 8th, 2022. Bar scale–1 cm (Photos A. Cojocariu).

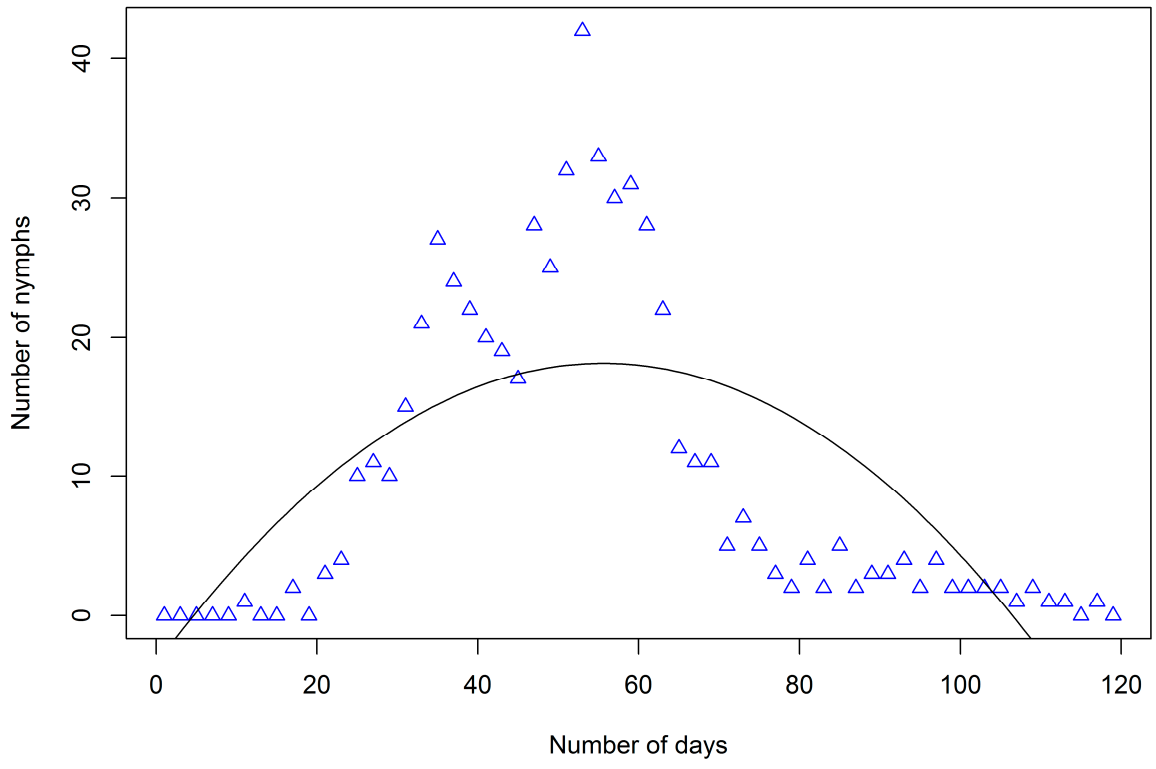

Figure 5. GCHP nymphs' population evolution-relationships between the number of nymphs and the number of days (quadratic regressions) and population amplitude pattern (blue triangles represent the number of nymphs as direct total counts from limited area of *Chrysanthemum* greenhouse at Botanical Garden Iaşi; day 1 settled as 'catch one' for nymphs-CONy, 22 June 2022, and last day as 'catch zero'-CZNy, 4 October 2022).

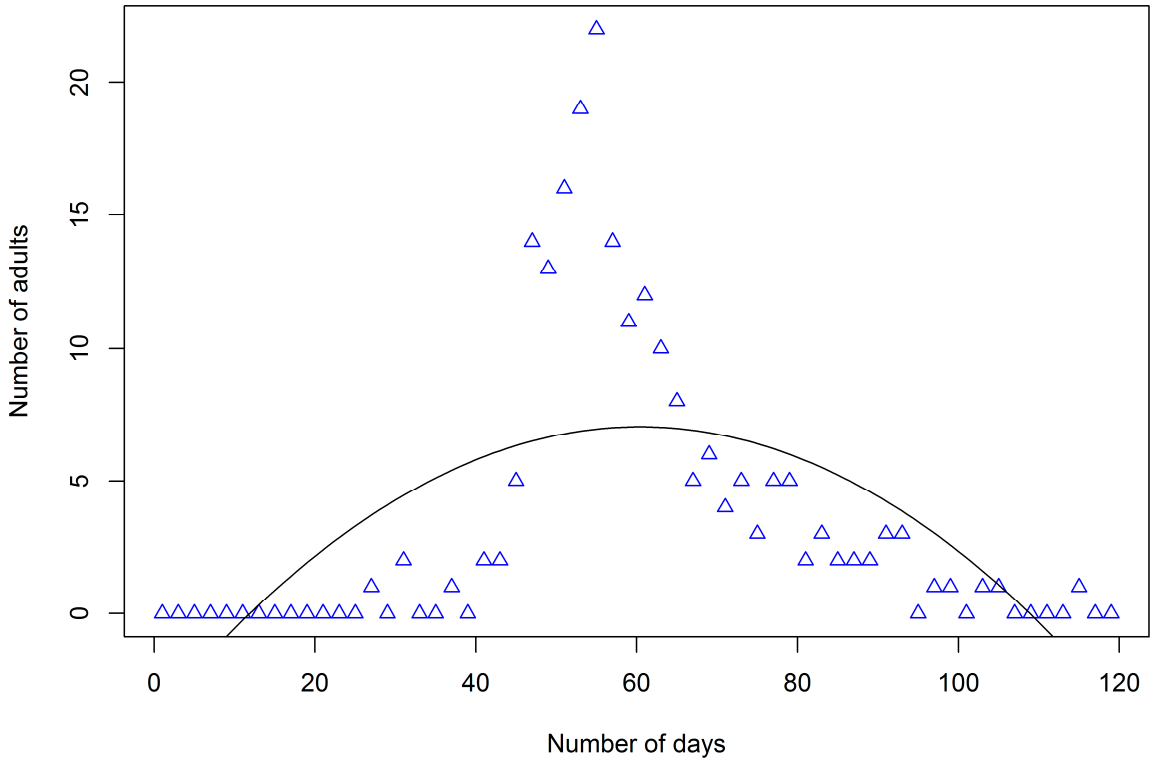

Figure 6. GCHP adults' population evolution-relationships between the number of adults and the number of days (quadratic regressions) and population amplitude pattern (blue triangles represent the number of adults as direct total counts from limited area of *Chrysanthemum* greenhouse at Botanical Garden Iași, and on yellow sticky traps; day 1 settled as 'catch one' for adults-COAd, 8 July 2022, and last day as 'catch zero'-CZAd, 2 October 2022).

The peak of the population was established at the end of July (25th to 31st day of the month and 30th week of the year) for the conditions in East Romania and it was appreciated to be the appropriate time for monitoring the activity of the species and to estimate the damages in specific crops. There were no repeated life cycles observed for the entire period of observations, and population-cycle amplitude increased roughly linearly (Figures 5 and 6).

The study of the population of specimens showed a clear and relatively stationary annual cycle in the population, as well as no presence between late-September and mid-June, with one outbreak of this univoltine species per year. The cycles result from population overshoot. Our results confirm the observations of Wilson and McPherson [7] for GCHP as univoltine species. Understanding life-cycle evolution of GCHP into East Romania conditions, especially for indoor conditions, is relevant for pest control because some insecticides only work at an appropriate life stage of the insect [21].

Peaks of populations were 70 to 132 times higher than at their lowest levels (70 for adults–1 on Week 5, Week 14, Week 15 to maximum 70 specimens observed on Week 7, and 132 for nymphs–1 on Week 2 to maximum 132 specimens observed on Week 7). According to the natural succession of stages, a gap of two weeks was observed between the first nymph and the first three adults, and, at the end of the cycle, a short gap of one week.

The seasonal occurrence in Romania is slightly shorter (late June to early October) compared to Wilson and McPherson findings [7], where the life cycle of GCHP nymphs and adults in Illinois was established as mid-May to late September.

3.2. European Distribution of GCHP with Emphasis on Host Plants or Generic Habitat

Since the first report of GCHP in Europe in 2003, this species seems to follow a trend of extension into other countries, year by year, especially in South Europe (Figure 7), the

spreading of GCHP being accelerated in the past ten years as the number of record data in new areas and on new host species. Current names of host plant species listed for countries is presented in accordance to WFO. 2023. World Flora Online. http://www.worldfloraonline.org. accessed on 31 March 2023 [28].

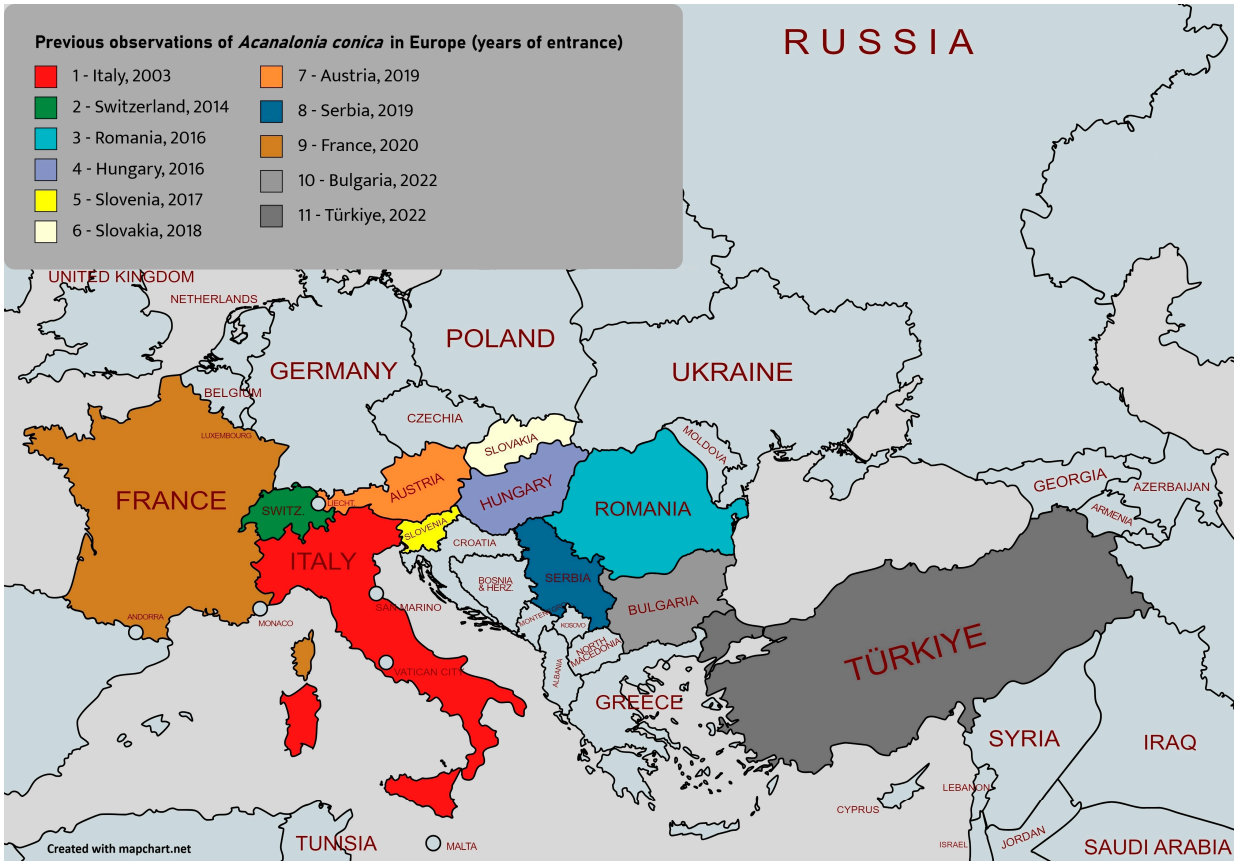

Figure 7. Distribution map of *A. conica* in Europe, MapChart tools https://www.mapchart.net/ (accessed on 23 February 2023) (previous observation in Europe, including the year of first report in different countries). Previous data for Romania–only three mentions: Bucharest, 2016; Ciofliceni–Ilfov County as human observation on iNaturalist, 2022, and Botanical Garden of Iași, 2022, current paper data.

- Italy: 2003-Venetia (Padua), Host plants: *Buddleja davidii* and few other species [8]; 2006-Lombardia (Northern Italy), Host plants: *Morus* sp., *Ulmus* sp., *Urtica dioica* [29]; 2006-Brenta river (Padua), Host plants: *Buddleja davidii*, *Amorpha fruticosa*, *Corylus avellana*, *Cornus sanguinea*, *Prunus* sp., *Urtica dioica*, *Parietaria officinalis*, *Humulus lupulus*, *Solanum nigrum*, *Chenopodium* sp., *Xanthium italicum* [30,31]; 2008-Rivoli Veronese (Verona), Figino Serenza (Como), Voghera (Pavia), Host plants: *Rubus* sp., *Cornus sanguinea*, *Humulus lupulus*, *Ulmus* sp., *Morus* sp., *Urtica dioica* [32]; 2009-Friuli Venezia Giulia-Pordenone, Gorizia, Host plants: *Rubus ulmifolius*, *Cornus sanguinea*, *Sambucus nigra*, *Alnus glutinosa*, *Salix alba*, *Ulmus minor*, *Robinia pseudoacacia*, *Broussonetia papyrifera*, *Corylus avellana*, *Acer campestre* [33]; observations between 2012 and 2013-Oltrepò Pavese (Pavia), Piacenza-San Lazzaro, Host plants/generic habitat: Vineyard (*Vitis*), *Corylus avellana*, *Urtica dioica*, *Morus* sp., *Prunus domestica* [34]; observations between 2009 and 2012-Friuli Venezia Giulia, Host plants/generic habitat: agricultural area, *Cornus sanguinea*, *Robinia pseudacacia*, *Rubus fruticosus*, urban area [35]; 2013-Ronchi dei Legionari (GO), Veneto orientale, Host plants/generic habitat: private garden (*Vitis*, *Acer campetre*, *Hibiscus* sp.), private garden in urban area (*Punica* sp., *Olea*

sp., *Rosmarinus* sp., *Rosa* sp.) [36]; 2015-Eastern Veneto and Friuli Venezia Giulia, Host plants: *Robinia pseudacacia* [37].
- Switzerland: 2014-Ticino, Agno, Host plants/generic habitat: green area [10].
- Romania: 2016-Bucharest (Southern Romania), Host plants/generic habitat: urban area, *Crataegus monogyna*, *Malus domestica* [11,20,21]; 2020-northern part of Bucharest (Băneasa area), Host plants/generic habitat: two unmanaged orchards of apple and plum [22]; 2022-human observations uploaded on the online biodiversity platform iNaturalist (https://www.inaturalist.org/ accessed on 23 May 2023): Ciofliceni–Ilfov County, South Romania; 2022-Botanical Garden of Iași, Host plants/generic habitat: in greenhouses of *Chrysanthemum* × *grandiflorum* collection, outdoor on *Tamarix ramosissima* (present study).
- Slovenia: observations between 2017 and 2018, Miren, Nova Gorica, Host plants/generic habitat: abandoned sand pit area, ornamental bush [12].
- Austria: 2019-Mirnsdorf, Graz, Liebenau, Leibnitz (Styria), Klagenfurt (Carinthia), wall of a house; private garden (*Buddleja* sp., *Raphanus sativus*); Host plants/generic habitat: garden centre trading with plants imported from Italy, mainly on *Buddleja* sp.; nursery garden [13].
- Serbia: 2019-Novi Sad (Vojvodina, northern Serbia), Host plants/generic habitat: vicinity of a city nursery garden (*Prunus salicina*), nearby small-leaved lime (*Tilia cordata*) [15].
- France: 2020-Auzeville-Tolosanne (Haute-Garonne), Host plants/generic habitat: near private garden (*Lonicera* sp., *Vitis* sp., *Rubus* sp.) [14].
- Slovakia: observations between 2018 and 2021-Galanta, Cabaj-Čápor, Host plants/generic habitat: garden centre trading; *Photinia davidiana* [17].
- Hungary: observations between 2016 and 2021-Alibánfa; Soroksár Botanical Gardens Budapest; forest between Debrecen and Pallag municipalities; Újfehértó; Debrecen; Budapest; Host plants: *Acer campestre*, *Humulus lupulus*, *Rubus fruticosus* [16].
- Bulgaria: 2022-Burgas province, town of Malko Tarnovo, Host plants/generic habitat: near the firestation, on *Clematis vitalba*, *Styphnolobium japonicum*, *Robinia pseudacacia*, *Maclura pomifera*, *Philadelphus* sp., *Amorpha fruticosa*, *Tamarix gallica* [18,19].
- Türkiye: 2022-Istanbul (Asian part), Aktaş Boğazici Evleri Yolu, Uskudar, record from iNaturalist, a social network of naturalist citizen scientists (kuthan_c 2020, https://www.inaturalist.org/observations/68909108 accessed on 23 May 2023) [19].

As it is shown in Figure 7, Romania is in line with the other ten countries from South Europe in which GCHP has been found, in some of them being present for more than 19 years (Italy) or with a 10 (5 as mean) or more years gap between the first entrance in other countries (Switzerland—11 years, Romania and Hungary—13 years, Slovenia—14 years, Austria and Serbia—16 years, France—17 years, Bulgaria and Türkiye—19 years). Therefore, it seems rather surprising that the species had not been recorded earlier in some countries. In many invaded countries of Western and Central Europe, GCHP has spread quickly and developed into a potential agricultural and horticultural pest [16,35,36]. In Romania, this species seems to be present into the Eastern point of Europe in Botanical Garden of Iași (present study).

3.3. Distribution in Romania

Along with individuals of GCHP, specimens belonging to another species of Hemiptera of American origin were also observed with varying frequency, namely citrus flatid planthopper *Metcalfa pruinosa* Say (Hemiptera, Flatidae). This species is native to North America (Nearctic realm), but it is today found throughout Europe (Austria, Britain, France, Italy, Hungary, Romania, Slovenia, Poland, Switzerland, and Moldova), in the Neotropical realm, and in South Korea [9].

In Romania, GCHP was reported as introduced allochthonous species in 2016 in two regions of Bucharest-Research-Development Institute for Plant Protection (RDIPP) and Research-Development Station for Fruit Growing (RDSFG), only in urban areas on two

host species, namely *Crataegus monogyna* (common hawthorn) and *Malus domestica* (apple) [11,20,21], and also in northern part of Bucharest (Băneasa area) into *Malus* and *Prunus* unmanaged orchards [22]. Since the first report of this species, the green cone-headed planthopper was found only in the Bucharest area with growing populations surviving in the climatic condition of the area and increasing in abundance [23], and there were no other reports of this species in other parts of the country [24]. In summary, host plants or generic habitat namely urban area, *Crataegus monogyna*, *Malus domestica* [11,20,21]; 2020-northern part of Bucharest (Băneasa area), with host plants or generic habitat: two unmanaged orchards of apple and plum [22]; 2022-Ciofliceni–Ilfov County (human observation on iNaturalist), 2022-Botanical Garden of Iași, with new host plants and generic habitat: in greenhouses (indoor conditions) of *Chrysanthemum* × *grandiflorum* collection, and outdoor on *Tamarix ramosissima* (present study).

The observations in Botanical Garden Iași are thus among the few mentions of this allochtonous species in Romania and show the potential of GCHP for expansion in the country, thus further observations should be expected soon in Romania. This species seems to have the characteristics of a highly invasive agricultural pest, with a similar impact as *Metcalfa pruinosa* (citrus flatid planthopper), which became a serious pest in Europe [30]. The polyphagy of GCHP suggests it could become a local pest, especially on ornamental plants in urban areas. GCHP species are expected to have an important impact on the horticulture and agriculture fields, because they can produce damage to plants, by sucking for feeding, or by transmitting systemic pathogens, and producing white wax and honeydew secretions that reduce the physiological functions of plants [20].

GCHP has not yet been reported to have caused major damage to crops or horticultural plants in Italy despite its 19 years long presence [31]. Likewise, in Romania, this species did not have great economic importance until now, due to the low number of specimens, and low population densities [21].

The introduction of the new pest species GCHP in Romania must be considered accidental and the pathways for these introductions are not always easy to identify. Nevertheless, they are frequently assumed, particularly for species that depend on plants with significant economic value, such as crops or (most importantly) decorative/ornamental plants. In this study, GCHP most likely have been introduced into Eastern Romania by ornamental plant trade. The trend is alarming, but not surprising, as global trade policy continues to facilitate the global spread of neobiota [38].

Therefore, it is important to immediately prevent similar introductions with ornamental plants trade, and limit its expansion, mainly through biological control. The detection and information about the presence, abundance, and contextual distribution of GCHP, as well as monitoring research, have an important role in general or local pest control to protect vulnerable crops. Data regarding the dynamic of populations can offer proper information to control the excessive development of this species. The lack of natural enemies in our country can be considered a cause for the future massive development of the populations of GCHP in Romania, along with the frequent imports of ornamental plants for urban green space planning practices [21]. It is recommended to thoroughly monitor agricultural shipments containing host plants of these species.

GCHP has several traits supporting quick establishment at newly invaded sites, such as a lack of natural enemies, high ecological tolerance, including a broad list of host plants, high survival rate under specific conditions (for example in indoor conditions greenhouses).

Although during the research period the presented species did not cause severe damage, not even at the local level, it has the potential to become an important pest of the plant species on which it grows. For this reason, it is necessary to deepen the understanding of the biology and ecology of the species in the conditions stated here.

In Romania, the compilation of the database is updated with a preliminary list of invasive and potentially invasive species of terrestrial invertebrates in Romania and of identified entry routes at least for selected species from the DAISIE list [39,40]. The classification system for the initial introduction of non-native species into a new region of

Romania follows the framework of Hulme et al. [41]. Allochthonous species can, as a direct or indirect result of human activity, reach and enter a new region through three broad mechanisms: the import of goods, arrival of a transport vector, and natural spread from a neighboring region where the species is itself allogenic. GCHP is listed in main category 3 (Transport-Contaminants) and sub-category Contaminants on plants, and in category 6 (Unaided-Natural dispersal across borders of alien species that have been introduced through pathways 1 to 5) [40]. Under the framework of the invasion stages according to Colautti & MacIsaac [42], a nonindigenous species may be localized and numerically rare (stage III), widespread but rare (stage IVa), localized but dominant (stage IVb) or widespread and dominant (stage V), and identifying the stage of a particular nonindigenous population (NIP) is likewise dependent on spatial scale. GCHP in the few localities from Romania can be included in stage IVa, as terminology suggested to be explicitly used in specific studies regarding the invasive alien species (IAS) [42].

3.4. Host Plants

In the USA (Illinois), the host plants for GCHP are listed, for 53 species (or taxa) in 30 families [6,7]. For Europe, the host plants are more diverse, less specific species of plants being included, namely 43 species (or taxa) belonging to 25 families.

Although Romania is one of the largest grapevines growing countries in Europe and in the world, and GCHP is reported as an important invasive species in *Vitis* sp. crops, there are still no reports on the presence of this species in the extended cultivated field with *Vitis* in Romania [43,44]. The most common species observed as host plants are *Malus* sp., *Prunus* sp., and *Crataegus monogyna*.

Our observation adds to the previous references on host plants, with the inclusion of two new species–*Chrysanthemum* × *grandiflorum* and *Tamarix ramosissima*. The population of GCHP on *Tamarix ramosissima* was very low, at about 300 m from the main greenhouse with *Chrysanthemum* × *grandiflorum*. At the Botanical Garden of Iași, there is an important outdoor field with the collection of *Chrysanthemum indicum*, but our observations did not remark the presence of GCHP in the year in which the study took place.

The increase in the establishment of allochthonous invertebrate species is anticipated to continue over the next few decades as global trade continues to expand [45]. Environmental change, including landscapes and climate, with ever-increasing worldwide transport links, is predicted to increase the arrival problems and spread of invasive species in Europe [46]. The commercial pathway of the host plants appears to be the main method of introduction for allochtonous species. In the case of GCHP, it has a quite low host plant specificity (43 species or taxa belonging to 25 families of host plants), and, consequently, the development is not limited by the presence of allochtonous ornamental host plants, although the range is expected to remain mainly to anthropic habitats, such as nurseries, parks, gardens, and city areas.

4. Conclusions

This paper updates the existing data on *A. conica* (GCHP) in Romania, reporting its occurrence in new areas (East Romania, Iași, "Anastasie Fătu" Botanical Garden, 47°11′17.69″ N, 27°33′22.8″ E: DMS system) and on new host plants not reported so far in the USA and Europe. The peak of population was established at the end of July (25th to 31st day of the month and 30th week of the year) for the conditions in East Romania and it was the appropriate time to monitor the activity of the species and to estimate the damages in specific crops. In addition to the known European host plants listed so far, we report the first recorded case of its feeding on *Chrysanthemum* s.l. and *Tamarix ramosissima*. Understanding the life-cycle dynamics of GCHP is relevant for pest control because some insecticides only work at the appropriate life stages of the insect.

As for other invasive species, the detection and information about the presence, abundance, and contextual distribution of GCHP, as well as monitoring research, have an important role in general or local pest control management to protect vulnerable horticul-

tural crops. Data regarding the dynamic of populations can offer proper information on controlling the excessive development of this species. The lack of natural enemies in our country can be considered a cause for the future massive development of the populations of GCHP in Romania, along with the frequent imports of ornamental plants for urban green space planning practices.

Regarding the economic impact of the species in Romania, damage to plants cannot be taken into consideration, as the insect populations developed at low densities at this moment. Despite this, the establishment of the species in Romania is a very important issue because it has proven to be a species with great adaptive potential to different climatic and environmental conditions.

Given the scarce data on GCHP in Romania, and the confirmed spreading into new areas of the country, further study is required to complete the background and particular occurrence of GCHP in Romania. Furthermore, our data is ongoing with the laboratory observation on the presence of parasites and parasitoids, to highlight the importance of the natural enemies in our country, and to control the excessive development of this species into horticultural crops.

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