



Is *Draeculacephala robinsoni* a new threat to European agriculture? A review on the genus *Draeculacephala* with special focus on their role as vectors of *Xylella fastidiosa*

Rocío López-Gómez^{1,2}, Marina Morente³, Abderrahmane Boucherf⁴, Giada Spadavecchia⁴, Valerio Mazzoni⁵, Marco Valerio Rossi Stacconi⁵, Clara Lago¹, Ewelina Czwieczek⁶, Jordi Sabate⁷, Aranzazu Moreno¹, Daniele Cornara⁴, Alberto Fereres^{1,*}

¹ Instituto de Ciencias Agrarias, Consejo Superior de Investigaciones Científicas, ICA-CSIC, 28006, Madrid, Spain

² Departamento de Producción Agraria, Escuela Superior de Ingeniería Agronómica, Alimentaria y de Biosistemas, Universidad Politécnica de Madrid, 28040 Madrid, Spain

³ Department of Biology, University of Oxford, Oxford, OX1 3PS, United Kingdom

⁴ Department of Soil, Plant and Food Sciences (DiSSPA), University of Bari, Via Amendola 165/A, 70126 Bari, Italy

⁵ Research and Innovation Center, Edmund Mach Foundation, 38098 S. Michele a/A, Italy

⁶ EFSA (European Food Safety Authority), Environment, Plants & Ecotoxicology Unit (PLANTS Unit), Via Carlo Magno 1A, 43-126, Parma, Italy

⁷ Institut de Recerca i Tecnologia Agroalimentaries, Ctra Cabrils, Cabrils, Barcelona, Spain

* Corresponding author: afereres@ica.csic.es

With 2 tables

Abstract: The recent introduction in Europe of *Draeculacephala robinsoni* Hamilton (1967), an alien likely vector of *Xylella fastidiosa* (*Xf*) native to North America, possibly poses a serious threat to European agriculture. *Draeculacephala robinsoni* role in bacterium spread has never been investigated. However, knowledge produced on other *Draeculacephala* species as *D. minerva*, one of the most relevant *Xf* vector in North America, can help understanding where future research efforts should be addressed, and which are the ecosystems most at risk. The species was first detected in 2021 on grasses in northeastern Spain and southern France. The first record prompted a large-scale survey in areas surrounding the first outbreak, leading to the collection of the sharpshooter on perennial ryegrass, rice, oats, and other *Poaceae* from Girona (Spain), to Montpellier (France). The aim of this review is to provide an updated picture on the systematics, biology, ecology, ethology, host range, and the possible role of *D. robinsoni* in the epidemiology of *Xf*-related diseases across the Mediterranean region leveraging knowledge produced on other *Draeculacephala* species. Furthermore, latest data on the sharpshooter's biology, probing behaviour on different plant species, and population dynamics in the infested regions in Europe are reported.

Keywords: sharpshooter; population dynamics; feeding behaviour; disease transmission; *Poaceae*; host range; integrated pest management (IPM)

1 Introduction

Xylella fastidiosa (*Xf*) is a xylem-limited bacterium responsible for several devastating plant diseases, affecting many important crops worldwide (European Food Safety Authority (EFSA) et al 2022; European Food Safety Authority (EFSA) et al. 2024). These include Pierce's disease (PD) of grapevine, almond leaf scorch disease (ALSD), citrus variegated chlorosis (CVC), olive quick decline syndrome (OQDS), coffee leaf scorch (CLS), alfalfa dwarf (ADD), and olean-

der leaf scorch (OLS) (Hopkins & Purcell 2002; Saponari et al. 2017; Sisterson & Stenger 2018). In 1892, the first report on a devastating disease caused by an unknown agent was described in southern California which affected many grapevines (years later named Pierce Disease). In Europe, *Xf* did not raise concerns until 2013 when a dramatic disease outbreak in olives was reported in Apulia, southern Italy (Kottelenberg et al. 2021; Saponari et al. 2019). The Italian epidemic prompted large-scale surveys throughout Europe leading to the discovery of several outbreaks of different *Xf*

subspecies and sequence types (STs) in France (EFSA Panel on Plant Health (PLH) 2015), on imported coffee plants in Switzerland (European and Mediterranean Plant Protection Organization (EPPO) 2015), Germany (European and Mediterranean Plant Protection Organization (EPPO) 2016), Spain (Olmo et al. 2017), and Portugal in 2019 (European and Mediterranean Plant Protection Organization (EPPO) 2019). Besides the Americas and Europe, *Xf* is currently present in Israel (Zecharia et al. 2022), Iran (EFSA Panel on Plant Health (PLH) 2015), Turkey (Güldür et al. 2005), Lebanon (Choueri et al. 2023), China (Guo et al. 2024) and Taiwan (Su et al. 2013).

Xylella fastidiosa is solely transmitted by xylem-sap feeding insects (Frazier 1965), which belong to the order Hemiptera, suborder Cicadomorpha, superfamilies Cercopoidea (spittlebugs and froghoppers) and to the family Cicadellidae, subfamily Cicadellinae (sharpshooters) (Cornara et al. 2019). In the American continent, the main vectors of *Xf* are sharpshooters, and most of the research is focused on these insects' species, with 39 species and 19 genera listed as vectors of *Xf* in America (Almendra-Paxtian et al. 2021; EFSA Panel on Plant Health (PLH) 2015; Redak et al. 2004). In contrast, in Europe, only a few species of sharpshooters are present, usually restricted to humid areas, being *Cicadella viridis* the only one widespread in the region (EFSA Panel on Plant Health (PLH) 2015; Wilson et al. 2009).

Given the limited sharpshooter distribution, spittlebugs are considered the main vectors of *Xf* in all the European bacterium outbreaks detected so far (Cornara et al. 2019). However, the recent introduction in Europe of *Draeculacephala robinsoni* Hamilton (1967), an alien likely vector of *Xf*, poses indeed an additional threat to European agriculture and further research is needed to understand its possible contribution to the bacterium spread in European ecosystems (Rösch et al. 2022). *Draeculacephala robinsoni* was initially detected in 2021 in the northern coastal area of Girona (Spain) and southern France (Banyuls sur Mer), near the Pyrenees frontier. Recent information from the Plant Health Department of Occitanie (France) reports that *D. robinsoni* has moved north up to the region of Lattes, near Montpellier. In Spain, the insect has spread south since its first detection and has reached Punta de la Tordera, at the coastal border of Girona and Barcelona provinces.

Knowledge on the *Draeculacephala* genus, including data on one of the most studied vectors of *Xf*, i.e. the Green (or Grass) Sharpshooter (GGs) *Draeculacephala minerva* Ball (1927), a species closely related to *D. robinsoni*, can help understanding where future research efforts should be addressed, and which are the ecosystems most threatened. Specifically, here we provide an up-to-date picture on the systematics, biology, ecology, host range and *Xf*-transmission biology for the species belonging to the genus *Draeculacephala* with a focus on *D. robinsoni* and its possible contribution to *Xf* spread across the Mediterranean region in economically important crops as grapevines, olive,

stone fruits and citrus. Furthermore, new information on the life cycle and population dynamics of *D. robinsoni* in infested regions of Spain (Girona), are provided.

2 Taxonomy and systematics of the genus *Draeculacephala*

The genus *Draeculacephala*, belonging to the family Cicadellidae, subfamily Cicadellinae, comprises 27 identified species worldwide. These species naturally occur throughout the temperate and tropical zones of North and South America, from Alaska to Argentina including the Caribbean, being particularly abundant in the eastern United States and Canada (Dietrich 1994). In North America, *Draeculacephala* spp. has been detected in Mexico and United States of America (Arizona, California, Hawaii, Nevada, New Mexico, Oregon, Texas and Utah), and the regions of Quebec and Cape Breton Island in Canada (European and Mediterranean Plant Protection Organization (EPPO) 2024). In Central America and the Caribbean, it has also been found in Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama (European and Mediterranean Plant Protection Organization (EPPO) 2024). Currently, the distribution of the genus *Draeculacephala* is restricted to the Americas except for the recent detection of *D. robinsoni* in Europe, where it is currently present in southern France and northeastern Spain (Rösch et al. 2022) (Table 1).

The taxonomic description of new species of *Draeculacephala* has traditionally been controversial due to the late use of the genitalia as an identifying character and the lack of phylogenetic analyses (Hamilton 1985; Young 1977). Consequently, species and subspecies have been grouped into complexes based on shared external morphological traits (Hamilton 1985). Established by Ball in 1901, the genus is characterized by reticulate tegminal venation and varying color patterns (green- or straw-coloured bodies and pale or greyish faces) (Ball 1927). In a phylogenetic context, Young (1977) identified three major lineages within the genus: *D. chypeata* Osborn and related species (Central and South America); *D. crassicornis* Van Duzee and related species (north temperate North America); and the remaining species (southeastern USA) (Dietrich 1994). Despite progress, species classification remains challenging, with molecular analyses providing valuable insights into species separation. The case for *D. robinsoni* underscores the importance of integrating morphological and molecular data for accurate species identification and classification.

Described by Hamilton in 1967, *D. robinsoni* is closely related to *Draeculacephala portola*, *D. minerva*, and *Draeculacephala producta*. *Draeculacephala robinsoni* is considered as one of the most common *Draeculacephala* species in southern Manitoba, Canada (Hamilton 1967). Dietrich (1994) considered *Draeculacephala zae* and *Draeculacephala sphagneticola* as junior synonyms of *D. robinsoni*, while rec-

Table 1. List of species of *Draeculacephala* spp. present and their distribution in the Americas.

Main/Related species	Common names	Synonym	Reported in
<i>D. robinsoni</i>		<i>D. zeae</i> <i>D. sphagneticola</i>	New Hampshire, Maine (Chandler & Hamilton 2017), Michigan, Washington, South Carolina, North Carolina, Georgia, Florida, Mississippi (Hamilton 1985) (United States); Québec, Nova Scotia, Alberta (Hamilton 1985), Manitoba, Ontario (Hamilton 1967), New Brunswick (Hamilton 1985), Saskatchewan (Hamilton 1967), British Columbia (Hamilton 1985) (Canada); Catalonia, Spain (Spain); and France (France) (Rösch et al. 2022)
<i>D. minerva</i>	Grass sharpshooter Green sharpshooter	<i>Acopsis minerva</i>	Northern California (California, Baja California) (Hamilton 1985), Southern Nevada (Nevada) (Metcalf 1965), Texas (Texas, Brownsville, Coahuila) (Hamilton 1985), Panama Canal Zone (Panama) (Metcalf 1965), Mexico (Jalisco, México, Aguascalientes, Oaxaca, Chiapas, Puebla, Veracruz) (Blanco-Rodríguez & Pinedo-Escatel 2022), Belize (Belize) (Young 1977), Guatemala (Guatemala) (Metcalf 1965), Honduras (Honduras), El Salvador (El Salvador), Costa Rica (Costa Rica), Nicaragua (Nicaragua) (Young 1977), and other locations (Arizona, Hawaii, Utah, Florida, Oregon, New Mexico, British Columbia, Mississippi, New York, Cuba) (Metcalf 1965)
<i>D. californica</i>			East of the USA (California), Hawaii (Hamilton 1985), and Mexico (Sonora) (Blanco-Rodríguez & Pinedo-Escatel 2022)
<i>D. crassicornis</i>		<i>D. bivoltina</i> <i>Carneocephala bivoltina</i> <i>D. borealis</i> <i>C. borealis</i>	Utah, Colorado, Nebraska (Hamilton 1985), Wyoming (Young 1977), Washington, Oregon, Idaho, California, Alaska, Montana (Hamilton 1985), South Dakota (McDaniel 1982), Missouri, Minnesota (Metcalf 1965) (United States); British Columbia, Alberta (Hamilton 1985), Manitoba (Hamilton 1972), Ontario, Québec, Yukon, Northwest Territories (Hamilton 1985) (Canada)
<i>D. noveboracensis</i>		<i>Aulacizes noveboracensis</i> <i>Diedrocephala noveboracensis</i>	Illinois, California (Metcalf 1965), Vermont (Ball 1901), Wisconsin, Washington (Metcalf 1965), Oregon (Young 1977), Massachusetts (Metcalf 1965), Rhode Island (Young 1977), Connecticut (Metcalf 1965), New York (Ball 1901), New Jersey, Minnesota (Metcalf 1965), Iowa (Ball 1901) North Dakota (Young 1977), South Dakota (Metcalf 1965), Nebraska (Ball 1901), Montana, Wyoming (Young 1977), Idaho (Ball 1901), Pennsylvania, Maine (Metcalf 1965), Indiana (Hamilton 1985), Colorado (Ball 1901), Alaska (McDaniel 1982), Missouri, Ohio, Utah (Metcalf 1965), Maryland (Ball 1901), New Hampshire, Michigan, Texas (Metcalf 1965) (United States); Québec (Hamilton 1985), British Columbia, Ontario (Ball 1901), Alberta (Hamilton 1985), Saskatchewan, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island (Hamilton 1985) (Canada)
<i>D. portola</i>			Delaware, Florida, North Carolina, South Carolina, Georgia, Virginia, Maryland (Dietrich 1994), South Dakota (McDaniel 1982), Hawaii (Liebhold et al. 2024), Louisiana, California, Illinois (USA) (Metcalf 1965).

ognizing *D. portola* and *Draeculacephala paludosa* as valid species. This classification was later supported by molecular analysis using the COI gene for barcoding (Chandler & Hamilton 2017). However, low genetic divergence and the lack of monophyletic branches suggest that all these taxa may represent a single species, possibly under the name *D. portola* (Rösch et al. 2022). Further discussions of the *D. producta* species group highlighted the need for closer examination of species boundaries using molecular data (Rösch et al. 2022). Consequently, *D. robinsoni* can be easily confused with *D. portola* because of the nearly identical male genitalia

(Dietrich 1994). *Draeculacephala robinsoni* individuals differs with *D. portola* on the coloration of the male abdominal sterna (entirely brown or with various amounts of yellow or completely yellow in some Florida populations), in having the clypellus angulate in profile and almost always have blue pigmentation on the pronotum and forewing veins (not observed in *D. portola*) (Hamilton 1985). Additionally, Hamilton (1985) identified key distinguishing features for *D. robinsoni*, including the anteroventral angle of aedeagus slightly cephalad of dorsal process, the usually black and convex face, and the shallow and nearly flat clypellus.

3 Biology and life cycle of the genus *Draeculacephala*

Sharpshooters are heterometabolous insects that develop through egg, five nymphal stages, and an adult winged stage (Bridges & Pass 1970). Despite being native to America, key biological and ecological aspects of *D. robinsoni*, as well as many other species within the genus, remain poorly understood, with little to no data available in the literature. Given the species' introduction into Europe, it is essential to investigate the biology and ecology of *D. robinsoni* to develop effective management strategies to mitigate its spread. Given that *D. minerva* is more thoroughly described in numerous studies and shares significant ecological and habitat similarities with *D. robinsoni*, this review will incorporate some of the main characteristics of *D. minerva*, and some relevant information of *Draeculacephala mollipes*, as a basis for comparison. However, it is important to note that misidentifications of species in previous studies should be considered. For example, Gibson's (1915) studies on *D. mollipes* likely referred to *D. minerva* (Purcell & Frazier 1985; Young & Davidson 1959).

For *D. mollipes*, oviposition takes place on any herbaceous plant, preferably on the stem and leaf axils, while others state that the eggs are deposited in the epidermis of grass leaves and stems (Delfin 1960). The oviposition process takes between 10 and 40 minutes, observed in the morning and late afternoon (Delfin 1960). Eggs hatch in one week, and the nymphal stage was completed in approximately 44 days. In greenhouse conditions, male adults were reported to live 5 weeks, and female adults 8 weeks (Bridges & Pass 1970).

For *D. minerva*, eggs hatch in 3 to 25 days depending on the season and temperature, with an average duration of 13 days, and a base developmental temperature of 13.5°C for the first generation of *D. minerva* eggs. The nymphal stage lasts between 20 and 50 days (Purcell & Frazier 1985). Upon reaching adulthood the female-to-male ratio is typically greater than one, with females living longer than males (average of 35 days for males and 56 days for females) (Purcell & Frazier 1985).

3.1 Population dynamics and dispersal

The number of generations and population structure of species within the *Draeculacephala* genus vary based on environmental conditions (Daane et al. 2011; Purcell & Frazier 1985). In Central California, *D. minerva* presents three discrete generations per year, with the first two generations being highly active and prone to dispersal, while the third generation, corresponding to the overwintering generation, shows reduced activity (Purcell & Frazier 1985). However, the simultaneous presence of adults, nymphs and eggs, makes it difficult to discriminate the different generations in the field (Delfin 1960; Purcell & Frazier 1985). Seasonally, population peaks of *D. minerva* occur in May, July, and September/October, with dispersal correlated to rainfall

events (Cabrera-La Rosa et al. 2008; Daane et al. 2011; Purcell & Frazier 1985). In California's Central and Coastal Valleys, three generations are observed, with eggs being laid in late February, followed by subsequent generations in early May and mid-July (Cabrera-La Rosa et al. 2008; Purcell & Frazier 1985; Winkler et al. 1949). The first nymphs appear in March, with coastal populations developing more slowly (Daane et al. 2011; Purcell & Frazier 1985). Peak nymph densities occur in April, June, and September, while adult peaks are in June, July, and August, with a less pronounced peak in October (Purcell & Frazier 1985). Similar trends were observed in almond orchards, although some studies report peaks in May and June (Daane et al. 2011; Purcell 1980; Sisterson et al. 2010).

Migratory behaviour and dispersal abilities have profound implications for the spread of vector-borne diseases (Chapman et al. 2015; Fereres et al. 2017). Understanding patterns of vector movement is therefore critical for developing effective control strategies focused on vector management (Martini et al. 2015).

For species of the genus *Draeculacephala*, both nymphs and adults spend long periods immobile on the herbaceous host plants on which they feed. However, both can leap between neighbouring plants with ease due to the structure of their hind legs, which gives them great leaping ability (Purcell & Frazier 1985). Despite this mobility, *Draeculacephala* species exhibit limited dispersal capabilities, with no documented cases so far of mass movement, long-distance migration or large-scale dispersal. Instead, their movement is largely localized, peaking in the early evening (Cabrera-La Rosa et al. 2008; Purcell & Frazier 1985; Winkler et al. 1949).

Environmental factors can further constrain *Draeculacephala* dispersal. Among them, wind appears to play a key role, as it is the only factor previously identified as significantly influencing take-off activity. For example, flight was inhibited by high winds, but there was no mention of the wind speed that inhibited flight of other sharpshooters, such as *Homoladisca* spp. (Blackmer et al. 2004; Winkler et al. 1949). This suggests that, while these insects are capable of local movement, external conditions may impose additional variations on their dispersal range.

Flight activity in *Draeculacephala* spp. generally peaks about an hour after dark. For *D. minerva*, flight activity has been documented by Purcell & Frazier (1985) in the early evening, around 30 minutes before sunset until 1.5 hours after sunset in summer, under an average temperature of 21°C. The highest capture peak was found from 15 to 45 minutes after sunset. Peak flights of *D. minerva* occurred during March through early May in the regions where the studies were conducted (California) (Purcell & Frazier 1985). In this same study no sharpshooters were captured during the daylight period. In addition, females were found 5 to 6 times more likely to fly than males, resulting in higher captures of females.

Studies on the movement of *D. minerva* in North America have addressed two key issues, i.e the seasonal movement of the insect vector in and out of the crop (Cabrera-La Rosa et al. 2008; Daane et al. 2011; Krugner et al. 2012, 2014) and its dispersal from preferred habitats (e.g. alfalfa, grasses and pastures) to crops of economic importance such as vineyards and almond orchards (Sisterson et al. 2010, 2018). Some studies tracked *D. minerva* dispersal by combining sticky traps and direct collection by sweep net (Cabrera-La Rosa et al. 2008; Krugner et al. 2012). Ultraviolet (UV) light traps have been used on a more ad hoc basis to study the movement of *Draeculacephala* spp. Results obtained in preliminary studies do not provide evidence for the effectiveness of UV lights as reliable method for tracking *Draeculacephala* spp. dispersal.

Considering the distribution of these insects, in Europe, large populations of *D. robinsoni* were found across at least 11 different localities within a maximum distance of 86 km between them, showing a high dispersal potential under favourable environmental conditions (Rösch et al. 2022). Apart from this available information, little else is known about the flight capacity and movement of the species within the *Draeculacephala* genus or about the factors that influence their movement.

In light of these results, further research in different habitats is needed to compare and evaluate these sampling methods and identify the most appropriate one for studying leafhopper dispersal.

3.2 Current status of *Draeculacephala robinsoni* in Europe

Since its first detection in France and Spain in 2022, *D. robinsoni* has been the subject of very few studies. Currently, *D. robinsoni* distribution is restricted to northeastern Spain and southern France. More precisely, present distribution in Spain is restricted to the coastal region of Girona province and the border between Girona and Barcelona provinces. In France, *D. robinsoni* is present in the coastal region of Occitanie province reaching north up to Montpellier. This means that *D. robinsoni* has the potential to spread fast, as it has been detected 250 km north and 200 km south from its first detection site in 2021. In terms of population structure and dynamics, adults are usually found throughout the summer, from late May to late October in France and Spain (Reynaud 2023; Rösch et al. 2022). Densest populations are usually detected in periodically flooded grasslands, either naturally or artificially (Reynaud 2023; Rösch et al. 2022).

After its first detection in northeastern Spain (Girona province, Catalonia), systematic field surveys had been carried out since 2024 from January to early November in permanent pastures, cereal crops (oats and rice), alfalfa fields, apple orchards (canopy and ground cover), olive groves and vineyards (canopy and ground cover) and riverbanks in the region, considered suitable habitats for the establishment

of the species. Field surveys were also carried every three months in other non-infested regions including southern Catalonia, Valencia, La Rioja and Galicia (Spain) on environmental suitable conditions for the establishment of the insect. Surveys were made on permanent pastures, rice crops, ground covers of vineyards and olive groves, and grass mixtures in riverbanks. However, *D. robinsoni* was not found so far in any of the Spanish regions sampled except Catalonia.

The presence of rice in Girona province likely attracted *D. robinsoni* adults, causing them to migrate from their original oat fields and perennial grasses to the newly established rice crop where they reached high populations. We found evidence of insect movement between rice fields and nearby fields, suggesting migratory behaviour when rice is harvested, particularly when populations were at their highest peak. Additionally, some adults have been found on the ground vegetation -mainly grasses- of apple orchards, vineyards and olive groves.

3.3 Sampling techniques to monitor population dynamics of *Draeculacephala* spp.

A long list of sampling methods used for the study of population of leafhoppers, sharpshooters and other Cicadomorpha are described in the literature. The choice of methodology largely depends on the specific objectives of the study and the ecological system being sampled. The most commonly employed sampling techniques include sweep nets and/or yellow sticky traps. These are often complemented by additional methods, such as branch tapping (or beating) that is used on trees and shrubs (Bostanian et al. 2003; Cabrera-La Rosa et al. 2008; Holguin et al. 2010; Méndez-López et al. 2018; Purcell 1980; Sisterson et al. 2018). In addition, absolute methods, such as the D-VAC vacuuming of insects on an established vegetation surface for a specific period of time (Purcell & Frazier 1985; Quisenberry et al. 1979) are often used.

Sweep net sampling can cover a large area of habitat in a short period of time and allows easy standardization across samplers by establishing a fixed diameter of the sweep net, number of swings and a particular pattern of sampling (Naranjo 2008). On the other hand, sticky traps are a simple method for obtaining relative measurements of insect populations. In the case of *Draeculacephala* spp. monitoring, yellow sticky traps are mainly used to study abundance, population dynamics and insect movement. Some studies have used the two methodologies combined to survey the abundance and richness of *Draeculacephala* spp. and other leafhoppers (Cwikla 1987; Daane et al. 2011; Purcell 1980).

The efficiency and reliability of sweep net for collecting *D. minerva* and *Xyphon fulgida* (Nottingham) (Read Head Sharpshooter, RHSS) were compared with an absolute sampling method such as D-VAC vacuuming by Purcell & Frazier (1985). Results showed that while sweep net was more efficient in collecting adults, D-VAC sampling collected 7.4 times as many nymphs as sweeping. These differences may be because D-VAC sampling is more capable of

collecting small insects than sweep netting and, in addition, can reach areas close to the ground and the base of plants, where *D. minerva* and *X. fulgida* presumably prefer to feed.

So far, sweep net seems to be the most suitable method for sampling adult *Draeculacephala* spp. However, there is no clear evidence to support the use of yellow sticky traps as a method for measuring the abundance and species richness of *Draeculacephala* spp.

4 Ecology of the genus *Draeculacephala*

4.1 Habitat and host range

Sharpshooter species are typically polyphagous in favourable environments, feeding and reproducing on a wide variety of plant species across diverse climatic conditions, particularly in subtropical and temperate areas of the American continent (Froza et al. 2024; Rösch et al. 2022). *Draeculacephala* spp. are xylem feeders both as nymphs and adults, ingesting considerable amounts of xylem sap from the main transpiration stem. Some *Draeculacephala* species display the highest population densities on fast-growing grass species, depending on the availability of niches and habitats (Chandler & Hamilton 2017). *Cynodon dactylon* (L.) Pers. and *Echinochloa crus-galli* (L.) P. Beauv. were especially preferred as year-round food and breeding hosts for *D. minerva*. These *Draeculacephala* species can also be found often on sedges and grass mixtures (Cabrera-La Rosa et al. 2008; Hewitt et al. 1942; Purcell & Frazier 1985).

4.2 Host plants

The host plant species where specimens of *D. robinsoni* are usually found both in North America and in Europe (France and Spain) are mostly grasses and sedges (Reynaud 2023; Rösch et al. 2022) (Table 2).

In Europe, *D. robinsoni* has been collected from various habitats, including dry riverbeds with ruderal vegetation, large permanent wetland sites, as well as periodically flooded pastures and meadows (Rösch et al. 2022). Based on observations of *D. robinsoni* in northeastern Spain (Girona province), primary suitable habitats are periodically flooded areas, either naturally during the rainy season or through flood irrigation in summer, with a preference for locations with a luxuriant but not dense growth of grasses. Nymphs and adults are commonly found in permanent pastures, including grass mixtures such as perennial ryegrass, alfalfa (*Medicago sativa* L.), and *Paspalum distichum* L., as well as in the ground herbaceous vegetation of apple orchards and olive groves. Interestingly, rice crops have also been identified as highly favourable hosts for *D. robinsoni*, as evidenced by the significantly high number of captures observed in these fields. This preference may be attributed to the fertilization of rice crops, which enhances their nutritional value. The improved nutritional availability likely supports the exponential growth of *D. robinsoni* populations within these fields.

Table 2. List of main *Draeculacephala robinsoni* host plants.

Host plant	Family
<i>Agrostis stolonifera</i> L. <i>Arundo donax</i> L. <i>Avena sterilis</i> L. <i>Bromus catharticus</i> Vahl. <i>C. dactylon</i> (L.) Pers. <i>Echinochloa</i> spp. <i>Elymus</i> spp. <i>Elymus virginicus</i> L. <i>Leersia</i> spp. <i>Muhlenbergia frondosa</i> (Poir.) Fernald <i>Paspalum distichum</i> L. <i>Phalaris</i> spp. <i>Polypogon maritimus</i> Willd. <i>Polypogon viridis</i> (Gouan) Breistr. <i>Saccharum</i> spp. <i>Zea</i> spp.	Poaceae
<i>Carex</i> spp. <i>Cyperus esculentus</i> L. <i>Cyperus eragrostis</i> Lam. <i>Scirpoides holoschoenus</i> (L.) Soják	Cyperaceae

Similarly, in America, both *D. robinsoni* and *D. minerva* exhibit their highest densities in fields with heavy irrigation or poor drainage, thriving on rapidly growing grasses, particularly perennial ryegrass for *D. robinsoni* and bermudagrass (*C. dactylon*) and watergrass (*Echinochloa crus-galli*, L.) for *D. minerva*. Earlier studies on *D. minerva* have documented these two species feeding on ground vegetation in almond orchards and vineyards (*D. minerva*, in America) (Daane et al. 2011) and in olive groves and apple orchards (*D. robinsoni*, in Spain). Notably, the highest number of *D. minerva* specimens were found in the ground vegetation of vineyards adjacent to pastures, which supported the largest insect populations (Daane et al. 2011). This preference for field margins is likely linked to better light availability in these areas compared to shaded zones, while still benefiting from accessible water from crop irrigation or nearby riverbanks (Daane et al. 2011).

Finally, it is important to note that, in contrast to the population dynamics of *D. minerva*, which exhibit relatively consistent population peaks, *D. robinsoni* shows considerable variability in the timing of these peaks. Specifically, population increases observed during the spring-summer period (May and June) differ significantly from those in late summer and autumn (October), the latter being linked to the establishment of a new rice crop in the region. This variation in population dynamics may reflect distinct environmental preferences or reproductive strategies between the two species. Furthermore, while rice crops are known to serve as a host for *D. minerva*, this species is primarily associated with a variety of grasses, while our data gathered in the field surveys in the Girona region suggest a different host preference for *D. robinsoni*. Specifically, *D. robinsoni* appears to prefer

entially inhabit rice crops, especially those that are irrigated and fertilized, when offered. Thus, rice crops could represent an important host plant that could influence the epidemiology of *Xf* diseases in Europe.

4.3 Feeding behaviour of *D. robinsoni*

The diet of sharpshooters consists exclusively of nutrient-poor xylem fluid from a wide variety of plant species (Krugner et al. 2019). These insects display an extremely high feeding rate on this nutritionally dilute and difficult to access food supply, which needs to be ingested by using a cibarium pump (suction apparatus) powered by large dilator muscles that have their origins in the bulging front region of the head (Andersen et al. 1989; Redak et al. 2004). Therefore, they have an inflated clypeus that encloses the strong musculature connected to the pumping diaphragm (cibarium), which enables these insects to overcome the xylem tension (Redak et al. 2004). Sharpshooters usually explore the surface of plants via labial dabbing until they find a suitable feeding site. Shortly after, a series of short and shallow stylet penetrations act as testing probes to assess the host characteristics and determine its suitability (Cornara et al. 2024; Krugner et al. 2019). If the plant is suitable, the insect will engage with long feeding bouts, lasting even hours. These species insert their stylets in an intracellular, nearly straight-line pathway into the plant as opposed to phloem feeders that generally insert their stylets intercellularly until they reach the phloem tissue. Stylet penetration can be rapid, taking from seconds to a few minutes to locate xylem vessels on suitable plants (Krugner et al. 2019). Certain species may allocate their nutritional resources either for immediate use to support current needs or storage for future use (Boggs 2009; Jervis et al. 2007).

During feeding, *D. robinsoni* can remain immobile on the same spot for hours or days. The preferred regions are the most tender areas of the stem and leaf nerves. However, if the insects detect any kind of disturbance in the environment, they hide under the stem or leaves, making them difficult to detect because of their greenish colour. The probability of the pathogen itself being acquired, retained and subsequently inoculated is directly determined by the probing, feeding and dispersal behaviour in response to plant cues by insects transmitting plant pathogens. Therefore, an insect vector's host preferences and feeding patterns directly affect both the insect's and the host plant's exposure to the pathogen (Jiménez et al. 2021; Markheiser et al. 2022; Rashed et al. 2011).

The Electrical Penetration Graph (EPG) is considered an essential tool in research on feeding behaviour and pathogen transmission by piercing-sucking insects. This tool has been used to analyse the probing and feeding behaviour of various sharpshooters and spittlebugs, but it has not yet been applied to any *Draeculacephala* species.

4.4 Vibrational communication

Substrate-borne vibrational signals are the primary means of communication in Auchenorrhyncha, mediating key behaviours such as mating (Virant-Doberlet et al. 2023). Typically, males and females engage in vibrational duets that facilitate mutual identification, localization (usually with the male searching for stationary females), and courtship. Other senses seem to have a minor role in accomplishing mating (Polajnar et al. 2015).

Among sharpshooters, the most comprehensive study on vibrational communication concerns the Glassy-Winged Sharpshooter (*Homalodisca vitripennis*), a Nearctic species, vector of *Xf* in California (Gordon & Krugner 2021; Nieri et al. 2017). Behavioural manipulation experiments on this species using playback signals have yielded promising results in mating disruption, both in laboratory and semi-field conditions (Gordon et al. 2017; Mazzoni et al. 2017).

Conversely, no biotremology studies have been conducted on *Draeculacephala* species, and their vibrational signals remain unknown. Detailed behavioural and biotremological studies will be essential to fully understand the ecological significance of these signals. Moreover, this knowledge could pave the way for innovative approaches to pest management, as already demonstrated in other Auchenorrhyncha species (Mazzoni et al. 2019; Polajnar et al. 2014).

4.5 Chemical communication

Historically, Auchenorrhyncha species, including *Draeculacephala* spp., were considered nearly anosmic due to the lack or scarcity of olfactory sensilla on their antennae. This assumption was largely based on early studies of their morphology. However, recent morpho-functional studies have challenged this view, revealing the presence of well-structured antennal lobes in the brains of both leafhopper and planthopper species, which are involved in processing chemical signals (Rossi Stacconi et al. 2014). The number of glomeruli in the antennal lobes varies depending on the species' feeding habits (i.e., degree of polyphagy). This suggests that, despite the earlier assumption, cicadellids can detect and respond to chemical cues in their environment, particularly in the process of host plant detection (Aráoz et al. 2019; Mazzoni et al. 2009; Rodrigues et al. 2022). In the context of the tri-trophic system, these chemical cues may help *Draeculacephala* spp. in locating suitable host-plant patches and may also influence the attraction of natural enemies, such as hymenopteran egg parasitoids, through cues emitted by plants following *Draeculacephala*'s feeding or oviposition activities (Boyd et al. 2018; Boyd & Hoodle 2007). Also, the egg masses laid by *Draeculacephala* females could be a source of kairomones exploited by parasitoids as short-range cue during host searching (Krugner et al. 2008). Further research is needed to deepen our understanding of the chemical communication mechanisms in *Draeculacephala* spp.

This knowledge could provide valuable insights into host-plant selection and natural enemy attraction, which can be leveraged in the development of IPM strategies, offering more sustainable and targeted approaches for controlling these species.

5 *Draeculacephala* as vectors of *Xylella fastidiosa*

5.1 Vector intensity regarding *Xf* transmission

There is currently no information available about *Xf* transmission by *D. robinsoni*, therefore in this section we will mainly refer to transmission studies carried out in California with other species belonging to the same genus as *D. minerva* (GSS). We can assume that, being a xylem-sap feeder, *D. robinsoni* is a competent vector of *Xf* (Almeida et al. 2005). However, the epidemiological importance of an insect vector species for the bacterium spread depends on vector intensity, namely the product of vector activity (abundance of the vectors that land on the receptor plants) and vector propensity, which is vector transmission efficiency under field conditions (Irwin & Ruesink 1986; Purcell et al. 1999). Vector intensity, thus vector contribution to the spread *Xf* within a given agroecosystem, is the outcome of the interaction of several variables, as vector ecology, population dynamics, host range, host finding and acceptance behaviours, along with anthropogenic factors as agricultural inputs.

The GSS, and more generally, the *Draeculacephala minerva*-mediated transmission of *Xf* to economically relevant crops such as alfalfa, grapevine and almond has been reported to be generally associated with the proximity of the cultivated orchard to pastures and seminatural habitats serving as source of either the bacterium or insect vectors.

Freitag & Frazier (1954) reported GSS and *X. fulgida* highest abundance among several habitats monitored in San Joaquin Valley (California) in alfalfa fields. Particularly, GSS displayed a preference for weedy alfalfa fields in moist habitats, while RHSS was mostly encountered in drier habitats on sparse low-growing grasses and weeds. Infective sharpshooters were collected throughout the year, with infectivity peaks in March and November. According to the authors, alfalfa is not a preferred feeding and breeding site for GSS, that choose rather grasses growing in and around the alfalfa stand. Vector preference for grasses over alfalfa rather than the low bacterium transmission efficiency (see below) is deemed to be the factor underlying the relatively low prevalence of *Xf* in alfalfa fields (Sisterson et al. 2010).

The proximity to weedy alfalfa fields, or of seminatural areas dominated by Bermuda grass (*C. dactylon*), have been observed to be positively correlated with *Xf* prevalence in vineyards (Freitag & Frazier 1954; Cabrera-La Rosa et al. 2008; Daane et al. 2011). In vineyards, sharpshooters were observed to preferentially settle on the ground cover surrounding the orchard rather than on vegetation inside cul-

tivated fields, possibly because plants outside the orchard receive more sunlight and obtain more water from irrigation, which makes the presence of GSS inside vineyards occasional (Daane et al. 2011). This is consistent with seminal studies on the distribution of PD in vineyards (Hewitt et al. 1946; Purcell 1974): infected plants are indeed typically found along the vineyard borders, with GSS likely acquiring the bacterium from wild vegetation then inoculating “external” grapes. *Xf*-positive GSS and the RHSS individuals were indeed collected from wild riparian plants along the Napa River and near springs on Spring Mountain (California, US), including *Fragaria californica* (Chamisso & Schlechtendal wild strawberry), *Montia linearis* ((Douglas) Greene miner’s lettuce), *Rubus procerus* (P. J. Müller ex Boulay Himalaya blackberry), and *Vinca minor* L. (periwinkle). Sampled insects successfully transmitted the bacterium to recipient grapevines (Raju et al. 1983).

A similar pattern of movement of sharpshooters from pastures or seminatural habitats to cultivated orchards was observed for almond plots. For example, *D. minerva* was most frequently collected along almond orchards margins, with three generations per year reaching peak densities during summer, coinciding with peaks in bacterial populations in infected trees (Daane et al. 2011). GSS adults were reported to move into almond orchards throughout the growing season, with peak dispersal in late spring/early summer and fall (Cabrera-La Rosa et al. 2008). Sharpshooters collected from infected almond plants transmitted *Xf* recipient periwinkle plants, with the highest transmission rate observed in mid-season (July) (Cabrera-La Rosa et al. 2008).

The transmission efficiency by members of the *Draeculacephala* genus, as well as for all the vectors of *Xf*, varies depending on the vector-plant-bacterium relationship, besides anthropogenic factors as agronomic practices that might influence vector-plant interaction and bacterium transmission. The first study on transmission by *Draeculacephala* spp. was performed by Hewitt et al. (1946) using *D. minerva*. GSS individuals exhibited transmission rates of 67% from alfalfa (source) to grape (recipient) and of 51% from grape to alfalfa (Hewitt et al. 1946). Freitag (1951) observed that GSS and RHSS were able to efficiently inoculate *Xf* to healthy grapevines after acquiring the pathogen from 75 species belonging to 23 families, including species from the *Poaceae* and *Fabaceae* families, as well as some ornamental plants such as Johnson grass, Bermuda grass, ryegrass, and periwinkle (Freitag 1951). Mircetich et al. (1976) were the first to confirm the ability of GSS to cross-transmit *Xf* between almond plants and grapevines, although less efficiently than *Graphocephala atropunctata* (Blue-Green Sharpshooter BGSS) and *Philaenus spumarius* (Purcell 1980). Hewitt et al. (1946) and Severin (1949) provided insights into the latent period in pathogen transmission by GSS and RHSS. Hewitt et al. (1946) observed that the latent period for the pathogen, if it existed, was shorter than 4 days. In contrast, Severin (1949) concluded a latent period of 7 to 24h for GSS, and of 2 to 7h

for RHSS, was needed for successful transmission. As shown by Daugherty & Almeida (2009), transmission efficiency of *Xf* is positively correlated with the number of infective insects given access to a recipient plant. For instance, GSS showed transmission rates of 56.7% from grapevine to grapevine, and 87.7% from alfalfa to alfalfa when groups of insects were used (Hewitt et al. 1946). In contrast, naturally infective GSS individuals collected from various habitats in infected areas exhibited an average transmission rate to alfalfa and grapevine of ca. 13% when single insects were used for the IAP (Inoculation Access Period). Similarly, transmission rate of *Xf* by the RHSS to grapevine was estimated to be 59.4% (Hewitt et al. 1946), while single-insect trials resulted in lower transmission rates (15%). RHSS males were reported as more efficient (27%) than females (1%) at transmitting the bacterium to grapevine (Severin 1949). Apart from the number of insects, *Xf* transmission efficiency strongly depends on the vector between- and within-host preference coupled with bacterium distribution in the infected host. A preference for a certain host plant increases the vector activity, thus the frequency of behaviours conducive to *Xf* acquisition and inoculation (Almeida et al. 2005). Regarding the within-host preference, Daugherty et al. (2010) observed a preference of GSS for the basal portion of alfalfa plants, in contrast with a preference of the apical portion displayed by *G. atropunctata*, the latter being a less efficient vector of *Xf* to alfalfa compared to GSS. Given the bacterial load in the basal portion of alfalfa plant is higher than at the apex, the GSS preference for the plant basal part increases the probability for the vector to acquire *Xf*.

The vector-plant-bacterium interaction can further be influenced by anthropogenic factors such as agronomic practices. While theoretically, xylem-sap feeders should exhibit a strong preference for well-watered and fertilized plants (Marucci et al. 2005), an excessive nitrogen supply could alter the xylem sap homeostasis and affect plant suitability for the vector, thus curbing vector activity (Rossi et al. 1996).

5.2 *Draeculacephala robinsoni* as a potential vector of *Xf* in Europe

The Mediterranean Basin is characterized by humid cool winters and hot dry summers, with an irregular pattern in rainfall giving rise to limited water access, and by shallow soils with limited availability of nutrients and steep slopes (Debolini et al. 2018). These conditions lead to high vulnerability of agroecosystems to climate change, with future projections warning about possible climate-related severe crop losses (Semenov et al. 2014). Pests and the by-products associated with pests' management add another element of complexity to the system, contributing to potentially push foundational pillars of the Mediterranean agriculture as olive, grapevine, almond, and citrus, will make farming even harder in the future.

The large majority (ca. 95%) of the world's olive trees are cultivated in the Mediterranean Basin. Within Europe, Spain accounts for 50.2% of the total olive production, followed

by Italy (25%) and Portugal (12.7%) (EUROSTAT 2023). Spain is the largest producer of olive oil in the world (44% of the total production) and in the EU (50% of the total) (European Commission 2023). The cultivation of grapevines for wine production in Spain has a long history, dating back to 1,200 BC (Resco et al. 2016). In Spain, 945,061 hectares (ha) are devoted to grapevine, with a production of 28.3 million hl in 2023, i.e. the third global production after France and Italy (Organización Internacional de la Viña y el vino (OIV) 2023). Almond is one of the most profitable crops and currently occupies the first place in the world within the nut market both internationally and nationally, with Spain as the second producer of almonds worldwide after USA.

Spittlebugs are the main epidemiologically relevant vectors of *Xf* in all the European outbreaks reported so far. Few sharpshooter species in the Palearctic region (e.g., *Graphocephala fennahi* and the green leafhopper *C. viridis*) are vectors of *Xf*, and their contribution is limited and generally restricted to humid areas. Their contribution to bacterial spread in Europe is deemed to be limited (Krugner et al. 2019; Markheiser et al. 2022; Bodino et al. 2022). However, the introduction of new xylem-feeding species in Europe might change the current epidemiological scenario. The detection of *D. robinsoni* in 2021 at South-Western France and North Eastern Spain marked the first appearance of the genus *Draeculacephala* in the Palearctic region. In the EU, *D. minerva* and *Draeculacephala* sp. are listed as A1 quarantine pests, as 'Cicadomorpha known to be vectors of *Xylella fastidiosa*' (EFSA Panel on Plant Health (PLH) et al. 2019).

Xylella fastidiosa has already been detected in the regions where *D. robinsoni* is currently present. This "encounter" between *Xf* and *D. robinsoni* might change the bacterial epidemiology scenario in Europe, likely leading to foster the spread of this bacterial disease, as we know that sharpshooters are effective vectors of *Xf*. Members of the genus *Draeculacephala* are mostly associated with weeds and grasses that are commonly grown as cover crops and are very common in Mediterranean regions (e.g. *Lolium* spp. or *Brachypodium* sp.). *Draeculacephala robinsoni* can reach high population densities in the areas in northeastern Spain (Girona province) where grapevine or other *Xf*-susceptible crops are grown. Therefore, the sharpshooter could build up large populations in cover crops or hedgerows and then transiently move to crops, contributing to *Xf* primary and/or secondary spread. Transmission of *Xf* is a fast process not lasting more than few minutes (Cornara et al. 2024) and even transient populations of *D. robinsoni* could efficiently transmit the bacterium, as observed for *D. minerva* in Californian almond orchards.

The current lack of knowledge on the sharpshooter biology, ecology, ethology and *Xf* transmission represents a major limitation to either envisioning the potential outcome of the sharpshooter introduction on *Xf* epidemiology or devising a sustainable control strategy interfering with *D. robinsoni*-mediated transmission. The lack of knowledge

on spittlebugs and spittlebugs-mediated *Xf* transmission biology has been, since 2013, one of the main factors hampering the deployment of an effective *Xf* containment strategy. The possible change of the established epidemiological paradigm driven by the introduction of a new competent *Xf* vector in European ecosystems can have profound and far-reaching consequences, which has since spread to other regions and where it has become the primary vector of *Xf*. The inadvertent introduction of *D. robinsoni* in the EU highlights the critical importance of proactive long-term monitoring and produce knowledge on competent *Xf*-vectors to mitigate their impact on ecosystems and economies.

6 Future prospects

Insect-vector plant diseases have become a major threat to European agriculture. The two plant diseases declared by the EU Commission as priority pests among a list of 20 key organisms are *Xf* and *Candidatus liberibacter* spp. Both are transmitted by sap-sucking insects that belong to the order Hemiptera. Among these, sharpshooters are the main vectors of *Xf* in the Americas, while spittlebugs are the main vectors in Europe. The introduction of sharpshooter species belonging to the genus *Draeculacephala*, which are known as effective *Xf* vectors, add a potential new actor to the *Xf* epidemiological scenario. Pro-active research on the sharpshooter-plant-bacterium interaction is of paramount importance to: i) understand whether *D. robinsoni* might play a relevant role in *Xf* spread in European agro-ecosystems; ii) devise a sustainable vector-management strategy.

At the present time *D. robinsoni* distribution is limited to specific areas in the Girona province in Spain and South-Western France. The sharpshooter is mainly associated with grasses and pastures where high population densities can be reached in the summer and fall. Thus, intensive field surveys across Europe are urgently required to determine the geographical distribution of *D. robinsoni*. Field surveys should be conducted in natural habitats where the sharpshooter thrives such as humid areas being periodically flooded, naturally in the rainy season and by irrigation in summer, and close to orchards cultivated with species susceptible to *Xf*. It is very important to note that *D. robinsoni* was recently detected in Occitanie (France) where *Xf* is currently present (Martin Strugarek, Plant Health Service, Occitanie, France, personal communication). This new encounter might change the bacterial epidemiology scenario in Europe increasing the risk of *Xf* spread. This makes the need to understand the real extension of vector distribution even more urgent. Vineyards, olives and almonds are probably the most threatened crops in Europe due to the introduction of *D. robinsoni*.

Insect biology, population dynamics, ecology and host range, behaviours and cues underlying the host plant finding and acceptance, and *Xf* transmission efficiency, are all fundamental aspects that should be investigated to understand

which crop(s) could be exposed to *D. robinsoni*-mediated transmission of *Xf* and the possible pattern of spread of the bacterium, along with timely devise sustainable management strategies.

Acknowledgements: Authors would like to acknowledge an EFSA procurement action on research into the biology and transmission capacity of *Xf* by the sharpshooter *D. robinsoni*, under Grant Agreement No. GP/EFSA/PLANTS/2023/06 (BIODROB).

References

- Almeida, R. P., Blua, M. J., Lopes, J. R., & Purcell, A. H. (2005). Vector transmission of *Xylella fastidiosa*: Applying fundamental knowledge to generate disease management strategies. *Annals of the Entomological Society of America*, 98(6), 775–786. [https://doi.org/10.1603/0013-8746\(2005\)098\[0775:VTOXFA\]2.0.CO;2](https://doi.org/10.1603/0013-8746(2005)098[0775:VTOXFA]2.0.CO;2)
- Almendra-Paxtian, L., García-Martínez, O., Robles-Hernández, V. E., & Sánchez-Peña, S. R. (2021). Cicadomorpha in a vineyard at Parras, Coahuila, Mexico, and vectors of diseases. *The Southwestern Entomologist*, 46(1), 147–152. <https://doi.org/10.3958/059.046.0114>
- Andersen, P. C., Brodbeck, B. V., & Mizell, R. F., III. (1989). Metabolism of amino acids, organic acids and sugars extracted from the xylem fluid of four host plants by adult *Homalodisca coagulata*. *Entomologia Experimentalis et Applicata*, 50(2), 149–159. <https://doi.org/10.1111/j.1570-7458.1989.tb02384.x>
- Aráoz, M. C., Jacobi, V. G., Fernandez, P. C., Albarracín, E. L., Virla, E. G., Hill, J. G., & Catalan, C. A. N. (2019). Volatiles mediate host-selection in the corn hoppers *Dalbulus maidis* (Hemiptera: Cicadellidae) and *Peregrinus maidis* (Hemiptera: Delphacidae). *Bulletin of Entomological Research*, 109(5), 633–642. <https://doi.org/10.1017/S000748531900004X>
- Ball, E. D. (1901). A review of the Tettigoniidae of North America North Mexico. *Proceedings of the Iowa Academy of Science*, 8, 35–75.
- Ball, E. D. (1927). The genus *Draeculacephala* and its allies in North America (Rhynchotha Homoptera). *The Florida Entomologist*, 11(3), 33–40. <https://doi.org/10.2307/3493016>
- Blackmer, J. L., Hagler, J. R., Simmons, G. S., & Cañas, L. A. (2004). Comparative dispersal of *Homalodisca coagulata* and *Homalodisca liturata* (Homoptera: Cicadellidae). *Environmental Entomology*, 33(1), 88–99. <https://doi.org/10.1603/0046-225X-33.1.88>
- Blanco-Rodríguez, E., & Pinedo-Escatel, J. A. (2022). Review of the New World genus *Draeculacephala* Ball (Hemiptera: Cicadellidae: Cicadellinae) from Mexico, with description of a new species. *Zootaxa*, 5174(4), 381–394. <https://doi.org/10.11646/zootaxa.5174.4.4>
- Bodino, N., Cavalieri, V., Saponari, M., Dongiovanni, C., Altamura, G., & Bosco, D. (2022). Transmission of *Xylella fastidiosa* subsp. pauca ST53 by the sharpshooter *Cicadella viridis* from different source plants and artificial diets. *Journal of Economic Entomology*, 115(6), 1852–1858. <https://doi.org/10.1093/jee/toac172>
- Boggs, C. L. (2009). Understanding insect life histories and senescence through a resource allocation lens. *Functional Ecology*, 23(1), 27–37. <https://doi.org/10.1111/j.1365-2435.2009.01527.x>

- Bostanian, N. J., Vincent, C., Goulet, H., Lesage, L., Lasnier, J., Bellemare, J., & Mauffette, Y. (2003). The arthropod fauna of Quebec vineyards with particular reference to phytophagous arthropods. *Journal of Economic Entomology*, *96*(4), 1221–1229. <https://doi.org/10.1093/jee/96.4.1221>
- Boyd, E. A., & Hoddle, M. S. (2007). Host specificity testing of *Gonatocerus* spp. egg-parasitoids used in a classical biological control program against *Homalodisca vitripennis*: A retrospective analysis for non-target impacts in southern California. *Biological Control*, *43*(1), 56–70. <https://doi.org/10.1016/j.biocontrol.2007.04.010>
- Boyd, E. A., Triapitsyn, S. V., & Hoddle, M. S. (2018). Parasitism of *Draeculacephala minerva* Ball, 1927 (Hemiptera: Cicadellidae) eggs by three species of Trichogrammatidae and Mymaridae (Hymenoptera) in California, USA. *The Pan-Pacific Entomologist*, *94*(3), 147–150. <https://doi.org/10.3956/2018-94.3.147>
- Bragard, C., Dehnen-Schmutz, K., Di Serio, F., Gonthier, P., Jacques, M.-A., Jaques Miret, J. A., ... MacLeod, A., & the EFSA Panel on Plant Health (PLH). (2019). Pest categorisation of *Spodoptera litura*. *EFSA Journal*, *17*(7), e05765. <https://doi.org/10.2903/j.efsa.2019.5765>
- Bridges, E. T., & Pass, B. C. (1970). Biology of *Draeculacephala mollipes* (Homoptera: Cicadellidae). *Annals of the Entomological Society of America*, *63*(3), 789–792. <https://doi.org/10.1093/aesa/63.3.789>
- Cabrera-La Rosa, J. C., Johnson, M. W., Civerolo, E. L., Chen, J., & Groves, R. L. (2008). Seasonal population dynamics of *Draeculacephala minerva* (Hemiptera: Cicadellidae) and transmission of *Xylella fastidiosa*. *Journal of Economic Entomology*, *101*(4), 1105–1113. <https://doi.org/10.1093/jee/101.4.1105>
- Cavaliere, V., Fasanelli, E., Gibin, D., Gutierrez Linares, A., La Notte, P., Pasinato, L., & Delbianco, A., & the European Food Safety Authority (EFSA). (2024). Update of the *Xylella* spp. Host plant database – Systematic literature search up to 31 December 2023. *EFSA Journal*, *22*(7). <https://doi.org/10.2903/j.efsa.2024.8898>
- Chandler, D. S., & Hamilton, K. A. (2017). Biodiversity and ecology of the leafhoppers (Hemiptera: Cicadellidae) of New Hampshire. *Transactions of the American Entomological Society*, *143*(4), 773–971. <https://doi.org/10.3157/061.143.0408>
- Chapman, J. W., Reynolds, D. R., & Wilson, K. (2015). Long-range seasonal migration in insects: Mechanisms, evolutionary drivers and ecological consequences. *Ecology Letters*, *18*(3), 287–302. <https://doi.org/10.1111/ele.12407>
- Choueri, E., Abou Kubaa, R., Valentini, F., Yaseen, T., El Sakka, H., Gerges, S., ... El Moujabber, M. (2023). First report of *Xylella fastidiosa* on almond (*Prunus dulcis*) in Lebanon. *Journal of Plant Pathology*, *105*(3), 1157–1157. <https://doi.org/10.1007/s42161-023-01361-w>
- Cornara, D., Morente, M., Markheiser, A., Bodino, N., Tsai, C. W., Fereres, A., ... Lopes, J. R. S. (2019). An overview on the worldwide vectors of *Xylella fastidiosa*. *Entomologia Generalis*, *39*(3–4), 39. <https://doi.org/10.1127/entomologia/2019/0811>
- Cornara, D., Bojanini, I., Fereres, A., & Almeida, R. P. (2024). Definitive elucidation of the inoculation mechanism of *Xylella fastidiosa* by sharpshooter leafhoppers. *Entomologia Generalis*, *44*(1), 121–131. <https://doi.org/10.1127/entomologia/2023/2126>
- Cornara, D., Zaffaroni-Caorsi, V., Hamouche, Z., Avosani, S., Cavallo, G., Verrastro, V., ... Fereres, A. (2024). Host finding and probing behavior by *Philaenus spumarius* on olive varieties with a different degree of susceptibility to *Xylella fastidiosa*. *Journal of Pest Science*, *97*(4), 2101–2113. <https://doi.org/10.1007/s10340-024-01743-8>
- Cwikla, P. S. (1987). Annotated list of leafhoppers (Homoptera: Cicadellidae) from two Ohio fens with a description of a new Chlorotettix. *The Ohio Journal of Science*, *87*(4), 134–137.
- Daane, K. M., Wistrom, C. M., Shapland, E. B., & Sisterson, M. S. (2011). Seasonal abundance of *Draeculacephala minerva* and other *Xylella fastidiosa* vectors in California almond orchards and vineyards. *Journal of Economic Entomology*, *104*(2), 367–374. <https://doi.org/10.1603/EC10226>
- Daugherty, M. P., & Almeida, R. P. P. (2009). Estimating *Xylella fastidiosa* transmission parameters: Decoupling sharpshooter number and feeding period. *Entomologia Experimentalis et Applicata*, *132*(1), 84–92. <https://doi.org/10.1111/j.1570-7458.2009.00868.x>
- Daugherty, M. P., Lopes, J., & Almeida, R. P. (2010). Vector within-host feeding preference mediates transmission of a heterogeneously distributed pathogen. *Ecological Entomology*, *35*(3), 360–366. <https://doi.org/10.1111/j.1365-2311.2010.01189.x>
- Debolini, M., Marracini, E., Dubeuf, J. P., Geijzendorffer, I. R., Guerra, C., Simon, M., ... Napoléone, C. (2018). Land and farming system dynamics and their drivers in the Mediterranean Basin. *Land Use Policy*, *75*, 702–710. <https://doi.org/10.1016/j.landusepol.2017.07.010>
- Delfin, E. D. (1960). *The biology of Draeculacephala mollipes* (Say) (Homoptera: Cicadellidae). The Ohio State University.
- Dietrich, C. H. (1994). Systematics of the leafhopper genus *Draeculacephala* Ball (Homoptera: Cicadellidae). *Transactions of the American Entomological Society*, 87–112.
- European Food Safety Authority (EFSA), Delbianco, A., Gibin, D., Pasinato, L., & Morelli, M. (2022). Update of the *Xylella* spp. host plant database – systematic literature search up to 30 June 2021. *EFSA Journal*, *20*(1), e07039.
- EFSA Panel on Plant Health (PLH) (2015). Scientific opinion on the risks to plant health posed by *Xylella fastidiosa* in the EU territory, with the identification and evaluation of risk reduction options. *EFSA Journal*, *13*(1), 3989. <https://doi.org/10.2903/j.efsa.2015.3989>
- European and Mediterranean Plant Protection Organization (EPPO) (2015). *Xylella fastidiosa* detected in Coffea spp. Plants imported into Switzerland. *EPPO Reporting Service no. 10/2015*. Article 2015/181. <https://gd.eppo.int/reporting/article-5128>
- European and Mediterranean Plant Protection Organization (EPPO) (2016). First report of *Xylella fastidiosa* subsp. *Fastidiosa* on Nerium oleander in Germany. *EPPO Reporting Service no. 07/2016*. Num. Article 2016/133. <https://gd.eppo.int/reporting/article-5878>
- European and Mediterranean Plant Protection Organization (EPPO) (2019). First report of *Xylella fastidiosa* subsp. *Multiplex* in Portugal. *EPPO Reporting Service no. 01/2019*. Num. Article 2019/017. <https://gd.eppo.int/reporting/article-6447>
- European and Mediterranean Plant Protection Organization (EPPO) (2024). *Draeculacephala minerva*. EPPO datasheets on pests recommended for regulation. <https://gd.eppo.int>
- European Commission (2023). Olive oil | European Commission. Aceite de Oliva: Descripción General de La Producción y Comercialización En La Unión Europea. <https://ec.europa.eu/info/food-farming-fisheries/plants-and-plant-products/plant-products/olive-oil>
- EUROSTAT (2023). Agricultural production – Crops. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agricultural_production_-_crops

- Fereres, A., Irwin, M. E., & Kampmeier, G. E. (2017). Aphid movement: Process and consequences. *Aphids as Crops Pests*, 196–224.
- Frazier, N. W. (1965). Xylem viruses and their insect vectors. In *Proceedings of the international conference on virus and vectors on perennial hosts, with special reference to Vitis (Vol. 91, p. 99)*.
- Freitag, J. H. (1951). Host range of the Pierce's disease virus of grapes as determined by insect transmission. *Phytopathology*, 41(10), 920–934.
- Freitag, J. H., & Frazier, N. W. (1954). Natural Infectivity of Leafhopper Vectors of Pierce's Disease Virus of Grape in California. *Phytopathology*, 44, 7–11.
- Froza, J. A., Moura, P. H., Silva, L. F., Mejdalani, G., & Lopes, J. R. (2024). Species composition and prevalence of sharpshooters and spittlebugs potential vectors of *Xylella fastidiosa* in olive orchards of southeastern Brazil. *Revista Brasileira de Entomologia*, 68(3), e20240017. <https://doi.org/10.1590/1806-9665-rbent-2024-0017>
- Gibson, E. H. (1915). *The sharp-headed grain leafhopper (No. 254)*. US Department of Agriculture. <https://doi.org/10.5962/bhl.title.108633>
- Gordon, S. D., Sandoval, N., Mazzoni, V., & Krugner, R. (2017). Mating interference of glassy-winged sharpshooters, *Homalodisca vitripennis*. *Entomologia Experimentalis et Applicata*, 164(1), 27–34. <https://doi.org/10.1111/eea.12594>
- Gordon, S. D., & Krugner, R. (2021). Copulatory Signaling and Polygamy of Glassy-Winged Sharpshooters (Hemiptera: Cicadellidae). *Annals of the Entomological Society of America*, 114(4), 522–527. <https://doi.org/10.1093/aesa/saab019>
- Güldür, M., Çağlar, B. E. H. Ç. E. T., Castellano, M., Ünlü, L., Güran, S., Yılmaz, M., & Martelli, C. (2005). First report of almond leaf scorch in Turkey. *Journal of Plant Pathology*, 87(3).
- Guo, T., Wang, S., Pan, C., Sattar, A., Xing, C., Hao, H., & Zhang, C. (2024). Evidence of the involvement of *Xylella fastidiosa* in the occurrence of walnut leaf scorch in Xinjiang, China. *Plant Disease*, 108(12), 3648. <https://doi.org/10.1094/PDIS-07-23-1430-PDN>
- Hamilton, K. A. (1967). A new species of *Draeculacephala* (Homoptera: Cicadellidae) from Manitoba. *Canadian Entomologist*, 99(7), 767–769. <https://doi.org/10.4039/Ent99767-7>
- Hamilton, K. G. A. (1972). The Manitoban fauna of leafhoppers (Homoptera: Cicadellidae). Part II. The fauna of macro-leafhoppers. *Canadian Entomologist*, 104(8), 1137–1148. <https://doi.org/10.4039/Ent1041137-8>
- Hamilton, K. G. A. (1985). Review of *Draeculacephala* Ball (Homoptera, Auchenorrhyncha, Cicadellidae). *Entomologische Abhandlungen*, 49(1), 83–103.
- Hewitt, W. B., Frazier, N. W., Jacob, H. E., & Freitag, J. H. (1942). Pierce's disease of grapevines. California Agricultural Experiment Station, Circular, 353.
- Hewitt, W. B., Houston, B. R., Frazier, N. W., & Freitag, J. H. (1946). Leaf-hopper transmission of the virus causing Pierce's disease of Grape and dwarf of Alfalfa. *Phytopathology*, 36(2), 117–128.
- Holguin, C. M., Reay-Jones, F. P. F., Frederick, J. R., Adler, P. H., Chong, J. H., & Savereno, A. (2010). Insect diversity in switchgrass grown for biofuel in South Carolina. *Journal of Agricultural and Urban Entomology*, 27(1), 1–19. <https://doi.org/10.3954/1523-5475-27.1.1>
- Hopkins, D. L., & Purcell, A. H. (2002). *Xylella fastidiosa*: Cause of Pierce's Disease of Grapevine and Other Emergent Diseases. *Plant Disease*, 86(10), 1056–1066. <https://doi.org/10.1094/PDIS.2002.86.10.1056>
- Irwin, M. E., & Ruesink, W. G. (1986). Vector intensity: a product of propensity and activity. In D. George (Ed.), *Plant virus epidemics: monitoring, modelling and predicting outbreaks*.
- Jervis, M. A., Boggs, C. L., & Ferns, P. N. (2007). Egg maturation strategy and survival trade-offs in holometabolous insects: A comparative approach. *Biological Journal of the Linnean Society. Linnean Society of London*, 90(2), 293–302. <https://doi.org/10.1111/j.1095-8312.2007.00721.x>
- Jiménez, J., Moreno, A., & Fereres, A. (2021). Transmission of phloem-limited viruses to the host plants by their aphid vectors. *Progress in Botany*, 82, 357–382. https://doi.org/10.1007/124_2020_47
- Kottelenberg, D., Hemerik, L., Saponari, M., & Van Der Werf, W. (2021). Shape and rate of movement of the invasion front of *Xylella fastidiosa* spp. Pauca in Puglia. *Scientific Reports*, 11(1), 1061. <https://doi.org/10.1038/s41598-020-79279-x>
- Krugner, R., Johnson, M. W., Daane, K. M., & Morse, J. G. (2008). Olfactory responses of the egg parasitoid, *Gonatocerus ashmeadi* Girault (Hymenoptera: Mymaridae), to host plants infested by *Homalodisca vitripennis* (Germar)(Hemiptera: Cicadellidae). *Biological Control*, 47(1), 8–15. <https://doi.org/10.1016/j.biocontrol.2008.06.004>
- Krugner, R., Ledbetter, C. A., Chen, J., & Shrestha, A. N. I. L. (2012). Phenology of *Xylella fastidiosa* and its vector around California almond nurseries: An assessment of plant vulnerability to almond leaf scorch disease. *Plant Disease*, 96(10), 1488–1494. <https://doi.org/10.1094/PDIS-01-12-0017-RE>
- Krugner, R., Sisterson, M. S., Chen, J., Stenger, D. C., & Johnson, M. W. (2014). Evaluation of olive as a host of *Xylella fastidiosa* and associated sharpshooter vectors. *Plant Disease*, 98(9), 1186–1193. <https://doi.org/10.1094/PDIS-01-14-0014-RE>
- Krugner, R., Sisterson, M. S., Backus, E. A., Burbank, L. P., & Redak, R. A. (2019). Sharpshooters: A review of what moves *Xylella fastidiosa*. *Austral Entomology*, 58(2), 248–267. <https://doi.org/10.1111/aen.12397>
- Liebold, A. M., Turner, R. M., Bartlett, C. R., Bertelsmeier, C., Blake, R. E., Brockerhoff, E. G., ... Yamanaka, T. (2024). Why so many Hemiptera invasions? *Diversity & Distributions*, 30(12), e13911. <https://doi.org/10.1111/ddi.13911>
- Martini, X., Hoffmann, M., Coy, M. R., Stelinski, L. L., & Pelz-Stelinski, K. S. (2015). Infection of an insect vector with a bacterial plant pathogen increases its propensity for dispersal. *PLoS One*, 10(6), e0129373. <https://doi.org/10.1371/journal.pone.0129373>
- Marucci, R. C., Lopes, J. R. S., Vendramim, J. D., & Corrente, J. E. (2005). Influence of *Xylella fastidiosa* infection of citrus on host selection by leafhopper vectors. *Entomologia Experimentalis et Applicata*, 117(2), 95–103. <https://doi.org/10.1111/j.1570-7458.2005.00336.x>
- Markheiser, A., Santoiemma, G., Fereres, A., Kugler, S., Maixner, M., & Cornara, D. (2022). XylFeed – Analysing DC-EPG waveform variables for European spittlebugs and sharpshooters.
- Mazzoni, V., Gordon, S. D., Nieri, R., & Krugner, R. (2017). Design of a candidate vibrational signal for mating disruption against the glassy-winged sharpshooter, *Homalodisca vitripennis*. *Pest Management Science*, 73(11), 2328–2333. <https://doi.org/10.1002/ps.4619>
- Mazzoni, V., Ioriatti, C., Trona, F., Lucchi, A., De Cristofaro, A., & Anfora, G. (2009). Study on the role of olfaction in host plant

- detection of *Scaphoideus titanus* (Hemiptera: Cicadellidae) nymphs. *Journal of Economic Entomology*, 102(3), 974–980. <https://doi.org/10.1603/029.102.0316>
- Mazzoni, V., Nieri, R., Eriksson, A., Virant-Doberlet, M., Polajnar, J., Anfora, G., & Lucchi, A. (2019). Mating disruption by vibrational signals: state of the field and perspectives. *Biotremology: studying vibrational behavior*, 331–354.
- McDaniel, B. (1982). The leafhoppers of South Dakota and additional distribution records from 18 states and Canada. *Agricultural Experiment Station Technical Bulletins*, 62, 1–96.
- Mendez-Lopez, A., Cordova-Tellez, L., Sanchez-Vega, M., Salazar-Torres, J. C., & Garcia-Martinez, O. (2018). Diversity and abundance of leafhoppers in *Jatropha curcas* L., in Mazatepec, Morelos, Mexico.
- Metcalf, Z.P. (1965). General catalogue of the homoptera: fascicle VI: Cicadelloidea. Washington, D.C., USDA, II, 730.
- Mircetich, S. M., Lowe, S. K., Moller, W. J., & Nyland, G. (1976). Etiology of almond leaf scorch disease and transmission of the causal agent. *Phytopathology*, 66(1), 17–24. <https://doi.org/10.1094/Phyto-66-17>
- Naranjo, S. E. (2008). Samplig arthropods. *Encyclopedia of Entomology*, 3231–3246.
- Nieri, R., Mazzoni, V., Gordon, S. D., & Krugner, R. (2017). Mating behavior and vibrational mimicry in the glassy-winged sharpshooter, *Homalodisca vitripennis*. *Journal of Pest Science*, 90(3), 887–899. <https://doi.org/10.1007/s10340-017-0840-5>
- Olmo, D., Nieto, A., Adrover, F., Urbano, A., Beidas, O., Juan, A., ... Landa, B. B. (2017). First detection of *Xylella fastidiosa* infecting cherry (*Prunus avium*) and *Polygala myrtifolia* plants, in Mallorca Island, Spain. *Plant Disease*, 101(10), 1820. <https://doi.org/10.1094/PDIS-04-17-0590-PDN>
- Organización Internacional de la Viña y el vino (OIV) (2023). Estadística de los países. <https://www.oiv.int/es/what-we-do/country-report?oiv>
- Polajnar, J., Eriksson, A., Lucchi, A., Anfora, G., Virant-Doberlet, M., & Mazzoni, V. (2015). Manipulating behaviour with substrate-borne vibrations—potential for insect pest control. *Pest Management Science*, 71(1), 15–23. <https://doi.org/10.1002/ps.3848>
- Purcell, A. H. (1974). Spatial patterns of Pierce's disease in the Napa Valley. *American Journal of Enology and Viticulture*, 25(3), 162–167. <https://doi.org/10.5344/ajev.1974.25.3.162>
- Purcell, A. H. (1980). Almond leaf scorch: Leafhopper and spittlebug vectors. *Journal of Economic Entomology*, 73(6), 834–838. <https://doi.org/10.1093/jee/73.6.834>
- Purcell, A. H., & Frazier, N. W. (1985). Habitats and dispersal of the principal leafhopper vectors of Pierce's disease bacterium in the San Joaquin Valley.
- Purcell, A. H., Saunders, S. R., Henderson, M., Grebus, M. E., & Henry, M. J. (1999). Causal role of *Xylella fastidiosa* in oleander leaf scorch disease. *Phytopathology*, 89(1), 53–58. <https://doi.org/10.1094/PHYTO.1999.89.1.53>
- Quisenberry, S. S., Yonke, T. R., & Huggans, J. L. (1979). Leafhoppers associated with mixed tall fescue pastures in Missouri (Homoptera: Cicadellidae). *Journal of the Kansas Entomological Society*, 421–437.
- Raju, B. C., Goheen, A. C., & Frazier, N. W. (1983). Occurrence of Pierce's disease bacteria in plants and vectors in California. *Phytopathology*, 73(9), 1309–1313. <https://doi.org/10.1094/Phyto-73-1309>
- Rashed, A., Killiny, N., Kwan, J., & Almeida, R. P. P. (2011). Background matching behaviour and pathogen acquisition: Plant site preference does not predict the bacterial acquisition efficiency of vectors. *Arthropod-Plant Interactions*, 5(2), 97–106. <https://doi.org/10.1007/s11829-010-9118-z>
- Redak, R. A., Purcell, A. H., Lopes, J. R., Blua, M. J., Mizell Iii, R. F., & Andersen, P. C. (2004). The biology of xylem fluid-feeding insect vectors of *Xylella fastidiosa* and their relation to disease epidemiology. *Annual Review of Entomology*, 49(1), 243–270. <https://doi.org/10.1146/annurev.ento.49.061802.123403>
- Resco, P., Iglesias, A., Bardají, I., & Sotés, V. (2016). Exploring adaptation choices for grapevine regions in Spain. *Regional Environmental Change*, 16(4), 979–993. <https://doi.org/10.1007/s10113-015-0811-4>
- Reynaud, P. (2023). Cicadelle *Draeculacephala robinsoni* Hamilton, 1967. Fiche de reconnaissance. ANSES-LSV Unité d'entomologie et plantes invasives.
- Rodrigues, I., Benhadi-Marín, J., Rodrigues, N., Baptista, P., & Pereira, J. A. (2022). Olfactory responses to volatile organic compounds and movement parameters of *Philaenus spumarius* and *Cicadella viridis*. *Journal of Applied Entomology*, 146(5), 486–497. <https://doi.org/10.1111/jen.12992>
- Rösch, V., Marques, E., Miralles-Nez, A., Zahniser, J. N., & Wilson, M. R. (2022). *Draeculacephala robinsoni* Hamilton, 1967 (Hemiptera: Auchenorrhyncha: Cicadellidae), a newly introduced species and genus in Europe with comments on its identification. *Zootaxa*, 5116(3), 439–448. <https://doi.org/10.11646/zootaxa.5116.3.8>
- Rossi, A. M., Brodbeck, B. V., & Strong, D. R. (1996). Response of xylem-feeding leafhopper to host plant species and plant quality. *Journal of Chemical Ecology*, 22(4), 653–671. <https://doi.org/10.1007/BF02033576>
- Rossi Stacconi, M. V., Hansson, B. S., Rybak, J., & Romani, R. (2014). Comparative neuroanatomy of the antennal lobes of 2 homopteran species. *Chemical Senses*, 39(4), 283–294. <https://doi.org/10.1093/chemse/bjt114>
- Saponari, M., Boscia, D., Altamura, G., Loconsole, G., Zicca, S., D'Attoma, G., ... Martelli, G. P. (2017). Isolation and pathogenicity of *Xylella fastidiosa* associated to the olive quick decline syndrome in southern Italy. *Scientific Reports*, 7(1), 17723. <https://doi.org/10.1038/s41598-017-17957-z>
- Saponari, M., Giampetruzzi, A., Loconsole, G., Boscia, D., & Saldarelli, P. (2019). *Xylella fastidiosa* in Olive in Apulia: Where We Stand. *Phytopathology*, 109(2), 175–186. <https://doi.org/10.1094/PHYTO-08-18-0319-FI>
- Semenov, V. A., Shelekhova, E. A., Mokhov, I. I., Zuev, V. V., & Koltermann, K. P. (2014). Influence of the Atlantic Multidecadal Oscillation on settling anomalous climate regimes in Northern Eurasia based on model simulation. *Doklady Earth Sciences*, 459(2), 1619–1622. <https://doi.org/10.1134/S1028334X14120307>
- Severin, H. H. (1949). Transmission of the virus of Pierce's disease of grapevines by leafhoppers. <https://doi.org/10.3733/hilg.v19n06p190>
- Sisterson, M. S., Thammiraju, S. R., Lynn-Patterson, K., Groves, R. L., & Daane, K. M. (2010). Epidemiology of diseases caused by *Xylella fastidiosa* in California: Evaluation of alfalfa as a source of vectors and inocula. *Plant Disease*, 94(7), 827–834. <https://doi.org/10.1094/PDIS-94-7-0827>
- Sisterson, M. S., Dwyer, D. P., & Uchima, S. Y. (2018). Alfalfa and pastures: Sources of pests or generalist natural enemies? *Environmental Entomology*, 47(2), 271–281. <https://doi.org/10.1093/ee/nvy011>
- Sisterson, M. S., & Stenger, D. C. (2018). Effects of nymphal diet and adult feeding on allocation of resources to glassy-winged

- sharpshooter egg production. *Environmental Entomology*, 47(5), 1173–1183. <https://doi.org/10.1093/ee/nvy094>
- Su, C. C., Chang, C. J., Chang, C. M., Shih, H. T., Tzeng, K. C., Jan, F. J., ... Deng, W. L. (2013). Pierce's Disease of Grapevines in Taiwan: Isolation, Cultivation and Pathogenicity of *Xylella fastidiosa*. *Journal of Phytopathology*, 161(6), 389–396. <https://doi.org/10.1111/jph.12075>
- Virant-Doberlet, M., Stritih-Peljhan, N., Žunič-Kosi, A., & Polajnar, J. (2023). Functional diversity of vibrational signaling systems in insects. *Annual Review of Entomology*, 68(1), 191–210. <https://doi.org/10.1146/annurev-ento-120220-095459>
- Wilson, M. R., Turner, J. A., & McKamey, S. H. (2009). *Sharpshooter Leafhoppers (Hemiptera: Cicadellinae): An Illustrated Checklist. Part 1: Old World Cicadellini*. National Museum of Wales.
- Winkler, A. J., Hewitt, W. B., Frazier, N. W., & Freitag, J. H. (1949). Pierce's disease investigations. *Hilgardia*, 19(7), 207–264. <https://doi.org/10.3733/hilg.v19n07p207>
- Young, D. A., & Davidson, R. H. (1959). A review of leafhoppers of the genus *Draeculacephala*. Technical Bulletin No. 1198. Agricultural Research Service. United States Department of Agriculture.
- Young, D. A. (1977). Taxonomic study of the Cicadellinae (Homoptera: Cicadellidae). Part 2. New World Cicadellini and the genus *Cicadella*.
- Zecharia, N., Krasnov, H., Vanunu, M., Siri, A. C., Haberman, A., Dror, O., ... Bahar, O. (2022). *Xylella fastidiosa* Outbreak in Israel: Population Genetics, Host Range, and Temporal and Spatial Distribution Analysis. *Phytopathology*, 112(11), 2296–2309. <https://doi.org/10.1094/PHYTO-03-22-0105-R>

Manuscript received: April 14, 2025

Revisions requested: August 1, 2025

Revised version received: August 6, 2025

Manuscript accepted: August 16, 2025