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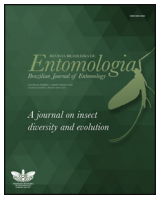

Species composition and prevalence of sharpshooters and spittlebugs potential vectors of *Xylella fastidiosa* in olive orchards of southeastern Brazil

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ABSTRACT

Xylem sap-feeding auchenorrhynchans, e.g. sharpshooters and spittlebugs (Hemiptera: Cicadellinae and Cercopoidea, respectively), are considered potential vectors of the xylem-limited bacterium *Xylella fastidiosa*, which is associated with olive leaf desiccation syndrome, a severe disease affecting olive orchards (*Olea europaea* L.) in the Mantiqueira mountain range region, southeastern Brazil. We evaluated, through faunal analysis, the composition and predominance of Cicadellinae and Cercopoidea species collected fortnightly over two years with yellow sticky cards in eight olive orchards distributed along an altitudinal gradient in the states of São Paulo and Minas Gerais. A high diversity of Cicadellinae (64 species) and Cercopoidea (10 species) was found in the orchards, with 20 of them considered predominant. *Clastoptera* sp. 1, *Macugonalia cavifrons*, and *Scopogonalia paula* were the most representative among the predominant species. We also found out that the trap position on the olive tree canopy at a height of 0.8 m above ground is more efficient than at 1.6 m for capturing the majority of Cicadellinae and Cercopoidea species associated with olive orchards.

Introduction

Xylella fastidiosa Wells et al., 1987 is a gram-negative phytopathogenic bacterium that colonizes the xylem vessels of plants, causing diseases in economically important fruit trees (Hopkins, 1989; Purcell and Saunders, 1999). This bacterium is transmitted by two groups of piercing-sucking insects that are exclusively xylem-sap feeders, the spittlebugs (Hemiptera: Cercopoidea) and the leafhoppers of the subfamily Cicadellinae (Hemiptera: Cicadellidae), commonly named sharpshooters (Redak et al., 2004; Cornara et al., 2019).

In Brazil, *X. fastidiosa* has been reported causing diseases in citrus (*Citrus sinensis* (L.) Osbeck), plum (*Prunus salicina* Lindl.), and coffee (*Coffea arabica* L.) (Carvalho and Souza, 1991; Chang et al., 1993; Paradella Filho et al., 1995; Carvalho et al., 2022). More recently, this bacterium was associated with a severe disease affecting olive groves (*Olea europaea* L.) from the Mantiqueira mountain range, in the southeastern region of the country (Coletta-Filho et al., 2016). In the last published update, the Mantiqueira mountain range had about 2,000 ha of olive plants (Oliveira and Henkes, 2021), with 83% of the orchards sampled by Safady et al. (2019) recorded as positive for *X. fastidiosa*. The bacterium causes severe symptoms in olive trees, such as completely desiccated branches, leaves showing different degrees of burn, which starts at the apical part of the leaf blade, partial defoliation, desiccated leaves that tend to stick to branches, and death of buds and branches (Coletta-Filho et al., 2016; Carvalho et al., 2022). This serious disease is currently known as "olive leaf desiccation syndrome" (OLDS) in Brazil or "olive quick decline syndrome" (OQDS) in Europe.

Considering the involvement of sharpshooters and spittlebugs in the dissemination of *X. fastidiosa*, along with the fact that in southeastern Brazil olive is mainly cultivated in mountainous regions, which differ in climate (cooler) and vegetation compared to areas where previous surveys of sharpshooter vectors in citrus, coffee, and plum orchards were carried out (Yamamoto and Gravena, 2000; Coelho et al., 2008; Giustolin et al., 2009; Miranda et al., 2009; Ringenberg et al., 2010), it is necessary to investigate the composition of potential vector species that make up the communities of Cicadellinae and Cercopoidea in olive orchards located at different elevations in the Mantiqueira mountain

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range and its surroundings. In addition, available data show that species compositions of Cicadellinae vary according to the geographic region (Saguez et al., 2014), even for the same crop (Miranda et al., 2009; Ringenberg et al., 2010).

The present study was designed to evaluate the faunal parameters of Cicadellinae and Cercopoidea species recorded from olive groves along an altitudinal gradient in the states of São Paulo and Minas Gerais, as a basis for identification of potential vectors of *X. fastidiosa* that prevail in the Mantiqueira mountain range region and its surroundings. The information presented here will be relevant for planning further ecological and transmission studies, as well as for the management of vectors associated with the dissemination of *X. fastidiosa* in olive groves, considering that the planting elevations of this crop are quite variable.

Material and methods

Experimental areas and sampling methods

Six representative orchards in the Mantiqueira mountain range and two outside this region were selected for the study of species composition of sharpshooters and spittlebugs (Table 1); the sites are located at different elevations in the states of São Paulo (SP) and Minas Gerais (MG), southeastern Brazil.

The insects were collected using yellow sticky cards (Isca®, Hot Melt model) with dimensions of 30 X 10 cm, hanged on peripheric branches on the north face of olive trees, at 0.8 m and 1.6 m above soil level, on nine trees in each orchard. The cards were replaced fortnightly from June 2015 to June 2017, except for the property located in the municipality of Pilar do Sul (SP), in which the survey was conducted from February 2017 to February 2019. After removal from the trees, the cards were individually packed in transparent plastic bags and transported to the Laboratory of Insect Vectors of Phytopathogens at the College of Agriculture Luiz de Queiroz, University of São Paulo, in Piracicaba (SP).

Sorting and identification of species

The sharpshooters and spittlebugs adhered to the yellow sticky cards were removed with a brush and mineral oil and subsequently placed in plastic microtubes containing 70% alcohol, labeled with the information of each collecting site and date. The counting and identification of individuals was made under a stereoscopic microscope (Motic SMZ-171), using dichotomic keys (e.g. Young, 1968, 1977; Dietrich, 2005; Hamilton, 2015). Male terminalia were also prepared, using the method described by Azevedo-Filho and Carvalho (2006), for the identification of genera and species.

Faunistic analysis

All sharpshooters and spittlebugs collected were submitted to faunal analysis using the ANAFAU program (Morais et al., 2003), which calculates the faunal indices of constancy, frequency, abundance, and dominance of the species, as described by Silveira Neto et al. (1976). From the data generated through the faunistic analysis, the predominant species (i.e., those categorized as dominant, constant, very frequent, and very abundant) were determined for each sampled orchard.

Installation height of yellow sticky cards and capture efficiency

Data on the number of collected individuals from those species of sharpshooters and spittlebugs that were identified as predominant were used for comparing the efficiency of capture at the two heights of installation of the yellow sticky cards on the tree canopy, 0.8 and 1.6 m above the ground. For statistical analysis, the Wilcoxon non-parametric test was applied, using the statistical program R (R Core Team, 2023).

Results

Collected insects per taxonomic group and orchard location

A total of 18,089 specimens of 74 species of sharpshooters and spittlebugs were collected in the six orchards, with the majority of individuals (82%) and species (64) belonging to the subfamily Cicadellinae (sharpshooters), which is currently subdivided into two tribes, Cicadellini and Proconiini, represented in this study by 49 (13,430 individuals) and 15 (1,404 individuals) species, respectively. The superfamily Cercopoidea (spittlebugs) was represented by the families Aphrophoridae (3 species, 15 individuals), Cercopidae (6 species, 487 individuals), and Clastopteridae (1 species, 2,753 individuals) (Table 2).

Table 1
Characteristics of eight olive groves selected for the sampling of sharpshooters and spittlebugs in the states of Minas Gerais (MG) and São Paulo (SP), southeastern Brazil (data from 2017).

Location (City/State, Farm name)	Geographic coordinates	Elevation (m)	Olive cultivar	Orchard age (years)	Surrounding vegetation	Ground vegetation
Wenceslau Braz/MG, Macieira	22°36'57.686"S 45°24'28.208"W	1780	Maria da Fé	10	Altitude fields, pine woods and mixed ombrophilous forest	Grasses and herbaceous plants
São Bento do Sapucaí/SP, São José	22°38'44.13"S 45°40'40.653"W	1512	Arbequina	11	Mixed ombrophilous forest, Araucaria forest, temperate fruits (peach, plum, apple)	Grasses and herbaceous plants
Maria da Fé/MG, EPAMIG ("Lago" site)	22°19'16.458"S 45°22'21.401"W	1329	Koroneiki	9	Araucaria forest, pasture, cultivated plants (corn)	Grasses and herbaceous plants
Maria da Fé/MG, EPAMIG ("Suíça" site)	22°19'14.303"S 45°22'6.335"W	1318	Arbequina	9	Araucaria forest, pasture, cultivated plants (corn)	Grasses and herbaceous plants
Maria da Fé/MG, EPAMIG ("Atemoia" site)	22°18'53.846"S 45°22'38.700"W	1310	Grappolo	9	Araucaria forest, pasture, temperate fruit trees (atemoya, peach, plum)	Grasses and herbaceous plants
Consolação/MG, Jequitibá	22°35'22. 508"S 45°55'11.437"W	1166	Arbequina	5	Araucaria forest, pasture, mixed ombrophilous forest	Grasses and herbaceous plants
Cabreúva/SP, Tanguá	23°16'27.193"S 47°9'7.557"W	883	Arbequina	7	Eucalyptus, pasture and pine trees	Grasses
Pilar do Sul/SP, David	23°46'3.137"S 47°39'3.561"W	700	Arbosana, Arbequina, Maria da Fé, Grappolo, Koroneiki, Ascolano	5	Tropical fruit trees (banana, citrus)	Grasses

The relative quantities (expressed in percentages) of specimens captured from each taxonomic group were variable among the sampled orchards, with clear predominance of sharpshooters (71.88-98.23%) (Table 2). The highest numbers of Cicadellinae individuals were trapped in the olive orchards located in the municipalities of São Bento do Sapucaí/SP (4,158 specimens) and Maria da Fé/MG (1,718-3,101 specimens) (Table 2). These orchards were located at elevations ranging from 1,300 to 1,500 m and showed a higher species diversity of herbaceous plants covering the rows between the olive trees, and of trees and shrubs around the orchards. The family Clastopteridae stands out as an important group of spittlebugs, which was more frequent in localities of the Mantiqueira mountain range, where it represented 6.53 to 26.15% of the total catches (Table 2). In Cabreúva/SP, located at a lower elevation (883 m), the spittlebugs of the Cercopidae family were more frequent (19.51%).

Faunistic analysis and determination of predominant species

Faunistic analysis recognized 19 species of Cicadellinae and only one species of Clastopteridae as predominant in one or more orchards (Table 3, supplementary material). Orchards from different regions

Table 2
Number and percentage (%, within parentheses) of individuals of the taxonomic groups containing possible vectors of *Xylella fastidiosa*, which were trapped by yellow sticky cards in eight olive orchards distributed over an altitudinal gradient in the states of São Paulo and Minas Gerais, southeastern Brazil.

Taxa	Orchard location[1]								
	WB	SB	MF - Lg	MF - Sç	MF - At	CS	CB	PS	Total
Cercopoidea	**113 (11.21)**	**1020 (19.70)**	**1213 (28.12)**	**381 (17.04)**	**302 (14.95)**	**102 (8.19)**	**95 (21.06)**	**29 (1.77)**	**3255 (18.0)**
Aphrophoridae	0 (0)	5 (0.10)	0 (0)	7 (0.31)	0 (0)	0 (0)	3 (0.67)	0 (0)	**15 (0.08)**
Cercopidae	6 (0.60)	36 (0.70)	85 (1.97)	79 (3.53)	170 (8.42)	6 (0.48)	88 (19.51)	17 (1.04)	**487 (2.70)**
Clastopteridae	107 (10.61)	979 (18.91)	1128 (26.15)	295(13.51)	132 (6.53)	96 (7.70)	4 (0.89)	12 (0.73)	**2753 (15.22)**
Cicadellinae	**895 (88.79)**	**4158 (80.30)**	**3101 (71.88)**	**1853 (82.96)**	**1718 (85.05)**	**1144 (91.81)**	**356 (78.94)**	**1609 (98.23)**	**14834 (82.0)**
Cicadellini	892 (88.49)	3988 (77.02)	2940 (68.15)	1698 (76.03)	1611 (79.75)	951 (76.32)	333 (73.84)	1017 (62.09)	**13430 (74.24)**
Proconiini	3 (0.30)	170 (3.28)	161 (3.73)	155 (6.93)	107 (5.30)	193 (15.49)	23 (5.10)	592 (36.14)	**1404 (7.76)**
Total	**1008**	**5178**	**4314**	**2234**	**2020**	**1246**	**451**	**1638**	**18089**

[1]Municipalities in the states of Minas Gerais (MG) and São Paulo (SP): WB: Wenceslau Braz/MG; SB: São Bento do Sapucaí/SP; MF: Maria da Fé/MG; CS: Consolação/MG; CB: Cabreúva/SP; PS: Pilar do Sul/SP. In MF, sampling was carried out in three distinct sites designated as "Lago" (MF-Lg), "Suíça" (MF-Sç), and "Atemoia" (MF-At). The trapping period was from June 2015 to June 2017, except for Pilar do Sul/SP where trapping was carried out from February 2017 to February 2019.

Table 3
Predominant (PD) sharpshooter and spittlebug species trapped by yellow sticky cards in olive orchards over an altitudinal gradient in southeastern Brazil.

Superfamily/Family	Orchard location (elevation - m)[1]							
Species	WB (1,780)	SB (1,512)	MF-Lg (1,329)	MF-Sç (1,318)	MF-At (1,310)	CS (1,166)	CB (883)	PS (770)
Cercopoidea/Clastopteridae								
Clastoptera sp. 1	**PD**[2]	**PD**	**PD**	**PD**	**PD**	**PD**	NDcFY[3]	DcFY
Membracoidea/Cicadellidae								
Cicadellinae, Cicadellini								
Amblyscartidia pardaliota	NDrPFZ	**PD**	DcFW	DcFW	DdPFY	DcFW	-[4]	-
Amblyscartidia sp. 1	-	**PD**	NDdPFZ	DcFY	DrPFZ	NDrPFZ	-	-
Bucephalogonia xanthophis	DcFY	**PD**	DcFW	DcFW	**PD**	DcFW	NDcFY	**PD**
Diedrocephala bimaculata	DcFW	**PD**	DcFW	DaMFW	DcFW	DcFW	NDdPFZ	NDdPFZ
Dilobopterus costalimai	-	-	-	NDrPFZ	-	DcFY	**PD**	**PD**
Dilobopterus dispar	-	NDrPFZ	DdPFW	**PD**	DcFW	NDrPFZ	DcFZ	-
Erythrogonia hertha	NDrPFZ	NDrPFZ	DcFW	DcFY	DcFW	**PD**	NDcPFY	-
Erythrogonia phoenicea	NDdPFZ	DcFW	**PD**	**PD**	**PD**	**PD**	-	NDdPFZ
Erythrogonia sinvali	-	-	DcFW	**PD**	**PD**	-	-	-
Hanshumba mariae	**PD**	NDrPFZ	-	-	-	-	-	-
Macugonalia cavifrons	**PD**	**PD**	**PD**	**PD**	**PD**	**PD**	**PD**	**PD**
Macugonalia leucomelas	-	DcFW	DcFW	DcFW	**PD**	DdPFZ	DcFY	DcFW
Paratubana luteomaculata	**PD**	**PD**	-	-	-	-	-	-
Scopogonalia paula	**PD**	**PD**	**PD**	**PD**	**PD**	**PD**	DcFW	**PD**
Scoposcartula tobiasi	**PD**	NDrPFZ	-	NDrPFZ	NDrPFZ	-	-	
Sibovia sagata	DcFY	**PD**	DcFW	DcFW	DcFW	DcFW	NDdPFY	DcFY
Subrasaca bimaculata	**PD**	**PD**	NDrPFZ	NDrPFZ	NDrPFZ	NDrPFZ	-	-
Cicadellinae, Proconiini								
Acrogonia citrina	-	NDdPFY	DdPFZ	DcFW	DdPFY	DcFW	NDdPFZ	**PD**
Oncometopia facialis	-	DcFW	**PD**	**PD**	**PD**	**PD**	**PD**	**PD**

[1]Municipalities in the states of Minas Gerais (MG) and São Paulo (SP), Brazil. WB: Wenceslau Braz/MG; SB: São Bento do Sapucaí/SP; MF: Maria da Fé/MG; CS: Consolação/MG; CB: Cabreúva/SP; PS: Pilar do Sul/SP. In MF, sampling was carried out in three distinct sites designated as "Lago" (MF-Lg), "Suíça" (MF-Sç), and "Atemoia" (MF-At). The trapping period was from June 2015 to June 2017, except for Pilar do Sul/SP where trapping was carried out from February 2017 to February 2019. [2]Based on the faunal analysis carried out independently for each orchard, a species was considered predominant (PD) only when classified as dominant, very abundant, very frequent, and constant. [3]Faunistic indices of dominance (D: dominant; ND: not dominant), abundance (r: rare; d: disperse; c: common; ma: very abundant), frequency (PF: little frequent; F: frequent; MF: very frequent), and constancy (Z: accidental; Y: accessory; W: constant). [4]Not trapped.

and elevations differed in terms of predominant species. *Macugonalia cavifrons* (Stål, 1862) was predominant in all collection areas, whereas *Clastoptera* sp. 1 was predominant in orchards located above 1,100 m of elevation and *Scopogonalia paula* Young, 1977 was predominant in all areas, except Cabreúva. *Dilobopterus dispar* (Germar, 1821), *Erythrogonia sinvali* Froza, Quintas & Mejdalani, 2021, and *Macugonalia leucomelas* (Walker, 1851) were predominant only in Maria da Fé/MG. *Amblyscartidia pardaliota* Young, 1977, *Amblyscartidia* sp. 1, and *Sibovia sagata* (Signoret, 1854) were predominant only in São Bento do Sapucaí/SP. *Hanshumba mariae* Froza & Mejdalani, 2022 and *Scoposcartula tobiasi* Cavichioli & Mejdalani, 1996 were predominant only in Wenceslau Braz/MG. *Oncometopia facialis* (Signoret, 1854) was predominant in areas located below 1,300 m, whereas *Dilobopterus costalimai* Young, 1977 was predominant only in Cabreúva/SP and Pilar do Sul/SP, areas up to 880 m. *Erythrogonia hertha* Medler, 1963 and *Acrogonia citrina* Marucci & Cavichioli, 2002 were predominant only in the orchards of Consolação/MG and Pilar do Sul/SP, respectively. *Paratubana luteomaculata* (Signoret, 1853) and *Subrasaca bimaculata* Silva, Cavichioli & Mejdalani, 2013 were predominant in areas above 1,500 m, whereas *Erythrogonia phoenicea* (Signoret, 1853) was predominant in areas with an elevation in the range from 1,100 to 1,300 m. *Bucephalogonia xanthophis* (Berg, 1879) was predominant in São Bento do Sapucaí, Maria da Fé, and Pilar do Sul.

Efficiency of capture in relation to the trap height

To compare the capture efficiency of yellow sticky cards positioned at heights of 1.6 m (trap A) and 0.8 m (trap B) on the olive tree, we used the trapping data of the sharpshooter and spittlebug species classified as predominant by the faunistic analysis.

In the orchard of Wenceslau Braz, there were statistical differences in trapping data between trap heights for the sharpshooters *S. tobiasi* and *S. bimaculata* (Fig. 1A), which were more collected at the lower trap (0.8 m). In the orchard of São Bento do Sapucaí, we found statistical differences for the following species: *Clastoptera* sp. 1, *A. pardaliota*, *Diedrocephala bimaculata* (Gmelin, 1789), *P. luteomaculata*, *S. paula*, *S. sagata*, and *S. bimaculata*, which were all mostly captured at 0.8 m (Fig. 1B). Also in São Bento do Sapucaí, *M. cavifrons* had the highest capture events at 1.6 m (trap A). In the Maria da Fé area, close to a lake ("Lago" site), there were statistical differences for *E. phoenicea*, which was more captured at 1.6 m, and for *O. facilais*, which was more captured at 0.8 m (Fig. 1C). In the "Suiça" site of Maria da Fé, we found statistical differences for *E. phoenicea*, *E. sinvali*, *M. cavifrons*, *S. paula*, and *O. facialis*, which were more captured at 0.8 m, except for *O. facialis*, with more occurrences at 1.6 m (Fig. 1D). In the "Atemoia" site of Maria da Fé, there were statistical differences for *E. phoenicea*, *E. sinvali*, *M. leucomelas*, and *S. paula*, with their captures being higher at 0.8 m (Fig. 1E). In the orchard from Consolação, *E. hertha*, *E. phoenicea*, and *O. facialis* showed statistical differences, with the first two species more captured at 0.8 m and the third one at 1.6 m (Fig. 1F). In the Cabreúva orchard, there were no statistical differences for the studied species (Fig. 1G). Finally, in the Pilar do Sul orchard, we detected statistical differences for *A. citrina*, *B. xanthophis*, *D. costalimai*, and *O. facialis*, all of them more collected at 1.6 m (Fig. 1H).

Discussion

During two years of sampling in the eight olive orchards studied in the states of São Paulo and Minas Gerais, a large number of individuals and species from the groups considered vectors of *X. fastidiosa* (Cicadellinae and Cercopoidea) were trapped by yellow sticky cards, indicating that there is a high diversity of sharpshooters and spittlebugs in olive growing regions of southeastern Brazil, especially in the Mantiqueira mountain range. Sharpshooters (Cicadellinae) stood out as the most trapped group in all studied olive orchards, representing 82% of the individuals collected. Similar prevalence of sharpshooters was found in surveys using this capture method in other crops of economic importance, such as citrus and grapevine (Miranda et al., 2009; Ringenberg et al., 2010).

Sharpshooter and spittlebug species are usually polyphagous, feeding on a high number of plant species (Redak et al., 2004). The diversity of plant species in a given region is connected with the availability of niches and habitats for insects and is thus clearly related to the number of species and individuals of these animals (Altieri et al., 2003; Santoiemma et al., 2019; Carpio et al., 2020; Thanou et al., 2020). In the areas of the sampled orchards, there are high diversities of plant species, both in the ground vegetation of the orchards and in the surrounding vegetation, the latter with stretches of well-preserved native forest (Atlantic Forest). In addition, the studied olive orchards were relatively small (0.1 to 5 hectares per orchard) and, in most cases, close to the natural woody vegetation. Some orchards remained months without mowing, allowing ground vegetation to grow, possibly providing additional shelter and host plants for the insects.

Faunistic analysis was employed in this work because it is a suitable method for recognizing predominant species within a community. Predominant species should be targeted for more detailed ecological studies, especially those taxa of greater economic interest, such as sharpshooter and spittlebugs that are vectors of phytopathogens. Here, predominant species were recognized by means of the study of four ecological parameters, which allow the application of numerical analyses: dominance, abundance, frequency, and constancy. Of the 20 species here classified as predominant in at least one of the orchard locations, five have already been identified as vectors of *X. fastidiosa* in citrus: *A. citrina*, *B. xanthophis*, *D. costalimai*, *M. leucomelas*, and *O. facialis*; two in coffee: *D. costalimai* and *O. facialis*; and three in plum: *M. cavifrons*, *M. leucolemas*, and *S. sagata* (Carvalho et al., 2022).

In the orchards sampled in Maria da Fé, eight predominant species were found, five of them being quite common: *Clastoptera* sp. 1, *E. phoenicea*, *M. cavifrons*, *S. paula*, and *O. facialis*. *Clastoptera* sp. 1, *M. cavifrons*, and *S. paula* were prevalent in at least six orchards studied. Except for *M. cavifrons* and *O. facialis*, these species have not yet been reported as vectors of *X. fastidiosa*; they should be included in transmission studies focused on olives.

In most of the studied orchards, the statistical analyses revealed differences in capture efficiency of predominant sharpshooters and spittlebugs between traps positioned on the olive tree canopy at heights of 1.6 m and 0.8 m. For the majority of species in which a difference was detected, the greatest number of captures was obtained by traps positioned at the lower height. This result can be explained by the fact that these traps were located closer to the ground vegetation associated with the orchards, which provides shelter for many sharpshooter and spittlebug species, as already reported in other studies (Ringenberg et al., 2010; Antonatos et al., 2021; Dongiovanni et al., 2023). The information generated by traps installed at distinct heights on the tree canopy is certainly useful for establishing vector monitoring methods and management strategies.

Additional studies should be performed with the predominant sharpshooter and spittlebug species to assess their competence as vectors of *X. fastidiosa*. The population dynamics and abundance of these insects, presence of *X. fastidiosa* in field-collected individuals, host-plant associations and occurrence on olive trees and other plants (inoculum sources of *X. fastidiosa*), associated with disease spread, transmission efficiency and feeding behavior studies, are other ecological aspects that should be evaluated in order to better understand the role

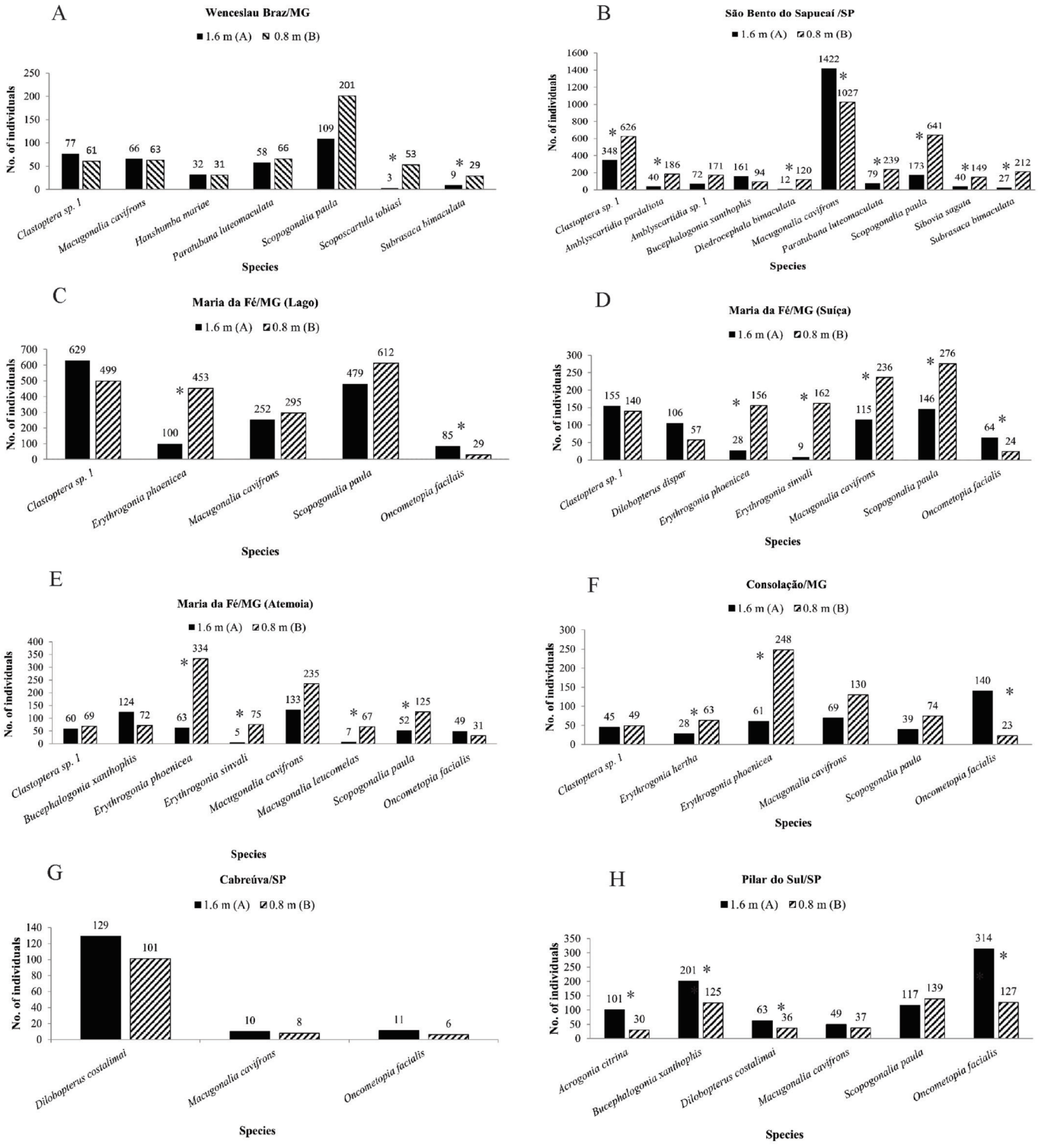

Figure 1 Comparison of the capture efficiency of predominant Cercopoidea and Cicadellinae species: yellow sticky traps positioned at heights of 1.6 m (A) and 0.8 m (B) from the ground on the canopy of olive trees in orchards of southeastern Brazil. The Wilcoxon (W) non-parametric test was employed. Asterisks (*) between the bars indicate a statistically significant difference ($p<0.1$) between the total number of individuals captured at heights A and B for the same species.

of these potential vectors in the epidemiology of olive leaf desiccation syndrome. Furthermore, other vector sampling methods should be employed to better estimate the abundance of species that may not be efficiently attracted to yellow sticky traps, which is known to be the case for some spittlebugs (Dongiovanni et al., 2023).

Conclusions

This was the first survey of sharpshooter and spittlebug species associated with olive orchards over an altitudinal gradient, with focus on the Mantiqueira mountain range region, in southeastern Brazil. It

was also the first work addressing possible vectors of *X. fastidiosa* in olive orchards in Brazil. We found a high diversity of sharpshooters and spittlebugs, with 20 out of 74 sampled species recognized as predominant through faunal analysis. Among the predominant species, *Clastoptera* sp. 1, *M. cavifrons*, and *S. paula* were the most representative and were recognized as predominant in most of the orchards studied. We also conclude that traps placed at a height of 0.8 m on the periphery of the olive tree canopy, closer to the ground vegetation, are more efficient in capturing sharpshooter and spittlebug species than those located closer to the top of the tree canopy. However, further studies using other collection methods are necessary and are currently underway.

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Conflicts of interest

The authors declare no conflicts of interest.

Author contribution statement

The study conception and design were idealized by JAF and JRSL. Data collection was performed by JAF, PHAM, LFOS, and JRSL. Material preparation and analysis were performed by JAF and GM. The first draft of the manuscript was written by JAF and all authors commented on previous versions. All authors read and approved the final version. This contribution is part of JAF M.Sc. dissertation.

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Supplementary material

The following online material is available for this article:

Faunistic analyses with complete tables.