The ongoing dispersion of the Eucalyptus bronze bug (*Thaumastocoris peregrinus*) in Spain

Dayanna do Nascimento-Machado (do Nascimento-Machado, D)\textsuperscript{1,2}, Ervandil Corrêa-Costa (Corrêa-Costa, E)\textsuperscript{1,2}, Clérison Régis Perini (Régis Perini, C)\textsuperscript{2}, Gustavo Andrade-Ugalde (Andrade-Ugalde, G)\textsuperscript{2}, Mateus Alves-Saldanha (Alves-Saldanha, M)\textsuperscript{2}, João Vitor Leitão (Vitor Leitão, J)\textsuperscript{2}, Tiago Lovato-Colpo (Lovato-Colpo, T)\textsuperscript{2}, Jonas André Arnemman (André Arnemman, J)\textsuperscript{2} and Adolfo Cordero-Rivera (Cordero-Rivera, A)\textsuperscript{3}

\textsuperscript{1}Postgraduate Program in Forest Engineering, Federal University of Santa Maria, Roraima avenue, 1000, building 44, room 5255, 97105-900, Camobi, Santa Maria, RS, Brazil. \textsuperscript{2}Crop Protection Department, Federal University of Santa Maria, Roraima avenue, 1000, building 42, room 3223, 97105-900, Camobi, Santa Maria, RS, Brazil. \textsuperscript{3}Laboratory of Evolutionary and Conservation Ecology, Universidade de Vigo, E.E. Forestal, Campus Universitario 36005, Pontevedra, Galiza, Spain.

Abstract

**Aim of study:** *Thaumastocoris peregrinus* (Carpintero & Dellapé, 2006) is notable for its dispersion potential, and for its damage to a wide range of hosts of the genus *Eucalyptus*. The intense movement of people and cargo between continents contributes to the success of its geographical distribution on the globe and hinders the adoption of preventive measures. The celerity and precision in the identification of *T. peregrinus*, as well as its invasion and dispersion routes are fundamental for the implementation of measures to prevent new invasions.

**Area of Study:** Park of Retiro in the community of Madrid, Spain, where *T. peregrinus* is present.

**Material and methods:** We analyzed a fragment of COI mtDNA gene in *T. peregrinus* specimens, using samples collected at a public park in Madrid urban area, to study the possible pathways of incursion of this insect in Spain. The goal was achieved using molecular tools, with PCR amplification of partial mtDNA COI and sequencing the fragment, which is used as a barcode of life for identification at species level. Species identity was confirmed using the database in GenBank.

**Results:** The results confirms that the specimens found in Madrid are *T. peregrinus*, and all are from the same maternal lineage.

**Research highlights:** We present the first molecular information of *T. peregrinus* population present in Spain, and suggest and discuss possible routes of incursion of this pest.

**Additional keywords:** Invasive pest; DNA Barcoding; Invasion Routes; Forest Entomology.

**Authors’ contributions:** Conceived and designed the work: DNM, ECC, CRP, JAA, ACR. Performed the experiments and analyzed the data: DNM, ACR, CRP, JVL, MAS, GAU. Contributed materials/analysis tools: CRP, GAU, TLC. All authors assisted in writing and reviewed the article.

**Citation:** Nascimento-Machado, D.-do, Corrêa-Costa, E., Perini, C.-R., Andrade-Ugalde, G., Alves-Saldanha, M., Leitão, J.-V., Lovato-Colpo, T., Arnemman, J.-A., Cordero-Rivera, A. (2019). The ongoing dispersion of the Eucalyptus bronze bug (*Thaumastocoris peregrinus*) in Spain. Forest Systems, Volume 28, Issue 3, eSC03. https://doi.org/10.5424/fs/2019283-15353

**Received:** 24 Jun 2019. **Accepted:** 31 Oct 2019. **Copyright © 2019 INIA.** This is an open access article distributed under the terms of the Creative Commons Attribution 4.0 International (CC-by 4.0) License.

**Competing interests:** The authors have declared that no competing interests exist.

**Correspondence** should be addressed to Dayanna do Nascimento-Machado: dayanasmac@gmail.com

**Funding agencies/Institutions**

| Funding agencies/Institutions | Project / Grant |
|------------------------------|----------------|
| Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Brazil | Scholarship to the first author in the Sandwich Doctorate Program Abroad - 88881.187250/2018-01 |
| Spanish Ministry of Science, Innovation and Universities | CGL-2018-096656-B-100, including FEDER funds. |

**Introduction**

The genus *Eucalyptus* is widely used in the world for fast-growing tree plantations, covering large areas, which are increasingly attacked by a diverse array of invasive pests, most of them obviously originary from Australia (Hurley et al., 2016). These insect pests produce significant reductions of the productivity of the plantations and widespread rapidly over many regions, as is the case of *Gonipterus scutellatus* complex, including *Gonipterus platensis* (Marelli, 1926) (Coleoptera: Curculionidae) and *Gonipterus pulverulentus* Lea, 1897 (Coleoptera: Curculionidae) (Mapondera et al., 2012); as well as species of Hymenoptera order *Leptocybe invasa* Fisher & LaSalle, 2004 (Hymenoptera: Eulophidae) (Zheng et
and species of Hemiptera order, comprising *Glycaspis brimblecombei* (Moore, 1964) (Hemiptera: Aphalaridae) (Karaca et al., 2017) and *Thaumastocoris peregrinus* (Carpintero & Dellapé, 2006) (Hemiptera: Thaumastocoridae).

*Thaumastocoris peregrinus* stands out for causing severe damage to more than 50 species of *Eucalyptus*, including hybrids (Saavedra et al., 2015b). Aspects such as its short life cycle and the high reproductive potential of females allow rapid population growth of the pest (Nadel et al., 2015; Soliman et al., 2012). When the infestation is severe, there is a significant reduction of leaves in the canopy and in some cases may lead to the death of the attacked trees, due to the feeding process being in chloroplasts and other cellular contents, leading to chlorosis (Santadino et al., 2017). Thus, there is a reduction of the photosynthetic area of the plant and consequently its growth (Jacobs & Neser, 2005). The expansion of occurrence of *T. peregrinus* includes several countries: South Africa (Jacobs & Neser, 2005), Argentina (Carpintero & Dellapé, 2006), Zimbabwe (Chilima, 2007), Brazil (Wilcken, 2008), Uruguay (Martínez & Bianchi, 2010), Chile (Mayorga et al., 2011), New Zealand (Sopow et al., 2012), Paraguay (Díaz et al., 2013), Italy (Laudonia & Sasso, 2012; Carapezza, 2014), Portugal (Garcia et al., 2013), Spain (Vivas et al., 2015), Reunion Island (Streito et al., 2016), Israel (Novoselsky & Freideberg, 2016), Mexico (Jiménez-Quiroz et al., 2016), United States of America (Hodel et al., 2016), Albania (Heyden, 2017) and Greece (Petrakis, 2018). In Spain, *T. peregrinus* had been recorded at Barbaño, province of Badajoz in 2014 (Vivas et al., 2015). The expansion of the species continues, and in this paper, we record it from the central area of Spain, at Madrid.

Based on the potential global distribution of the Bronze bug, European countries present localities with optimal climate conditions to its occurrence and dispersion (Saavedra et al., 2015a). However, there is no information about the genetic constitution of populations of *T. peregrinus* in Spain, even if this information is extremely important to know the diversity and possible routes of invasion, which are determined by the genetic signatures of the populations present on site. In this context, this work aims to report the expansion of *T. peregrinus* occurrence area in Spain and to characterize, using molecular analysis, the genetic structure and possible invasion routes of the population found in Madrid, Spain.

**Materials and Methods**

**Specimens sampling**

Bronze bug specimens were sampled around Spain from November 2018 to April 2019, in Galiza region, including Vigo, Pontevedra, Santiago de Compostela and Baiona, and also in Barcelona and in Madrid. Galiza region have optimal climate conditions to a potential distribution of *T. peregrinus* in Europe as reported by Saavedra et al. (2015a), but we could not find any specimens in this area. Specimens of *T. peregrinus* were found in a city park “Parque de El Retiro” at Madrid, Spain (40°25′07.8″N - 3°41′13.2″W) (Fig. 1a) (40°24′54.4″N - 3°40′52.98″W) on April 12, 2019. We examined three *Eucalyptus globulus* and two *Eucalyptus camaldulensis* trees. However, only *E. camaldulensis* presented a moderate infestation of bronze-bug, since there were symptoms of tanning.
on leaves, many egg masses (Fig. 1b) and presence of nymphs and adults (Fig. 1c). *Eucalyptus* trees had a phytosanitary status of infestation by other insects, including *G. brimblecombei*. The weather during the day of sampling was between 5-19°C and had a clear sky (www.accurweather.com). We believe that the population of *T. peregrinus* sampled was in the beginning of infestation period, because we found many eggs and not many nymphs and adults on leaves.

Sampling procedure was performed on lower leaves of these trees collecting randomly the branches with bronze bug infestation. Insects were removed from leaves using a paint-brush and placed them in a plastic container (20 ml) with 96% alcohol, totalizing 10 specimens from each tree.

Samples collected in April were sent to the Laboratory of Forest Entomology - UFSM, Santa Maria, RS, Brazil, where the morphological characterization of the specimens was performed according to the morphological characters described by Carpintero & Dellapé (2006). The gDNA extraction and molecular characterization of the specimens was performed in the Laboratory of Integrated Pest Management (LabMIP-UFSM).

In August 5 of the same year with temperature around 35°C the trees were rechecked for infestation of bronze-bug and adults were found abundant, but eggs and nymphs were rare. Specimens from August were not sampled and not genetically analyzed, because the high probability of these insects to be family related.

DNA extraction, amplification and sequencing

Five insects were selected randomly from the specimens collected from each tree, for the extraction of gDNA. We used the DNeasy Blood and Tissue Kit (Qiagen, Hilden, Germany) to gDNA extraction of individual insects, according to the manufacturer's protocol. First of all, each adult was exposed to dry air in a paper towel in order to allow the ethanol evaporation. Then, we used 180 µL of buffer ATL and 20 µL of proteinase K to macerate the entire insect body in a 1.5 ml tube and left incubating at 56°C for 20 hours. Afterwards, gDNA was purified in a silica-based matrix and eluted in 35 µL of buffer AE. gDNA concentration was assessed using a NanoDrop™ 1000 (Thermo Scientific, Wilmington, DE, USA).

Samples with a gDNA concentration over 5ng/µL were used to amplify a fragment of the mitochondrial COI gene (468 bp) by polymerase chain reaction (PCR). The primers Tp2390F (5’ACCCGAGCATCTTATTAC-TTC) and Tp2937R (5’ATTGTGGCTCGTTTGGATA) (Nadel et al., 2010) were used. The PCR reaction included: 1.25 µL of JumpStart™ 10X reaction buffer; 7.0 µL of ultra-pure water; 0.625 µL de dNTP mixture (10 nM of each); 1.0 µL of each primer (10 pM), 0.220 µL of JumpStart™ DNA Polymerase (2.5 U/µL) (Sigma-Aldrich, St. Louis, MO, USA), and 1 µL of gDNA (05-100 ng/ µL).

The PCR reaction was performed following Nadel et al. (2010) protocol: initial denaturation at 98°C for 30 s, followed by 30 cycles at 95°C for 30 s, 48°C for 30 s, and 72°C for 1.5 min, and a final extension at 72°C for 10 min. The amplified products of mtDNA (COI fragment) were resolved on 1.0% agarose electrophoresis gel, pre-stained with Nancy-520 DNA gel stain (Sigma-Aldrich) and visualized with a gel documentation system. PCR products that were successfully amplified were sequenced by ACTGene genomics service provider (Alvorada, RS, BR), using an AB 3500 Genetic Analyzer.

Data analysis

The data from sequencing output were trimmed, edited and analyzed for each individual COI sequence, using the software Pregap and Gap4 within the Staden package (Staden & Bonfield, 2000). CLC Sequence Viewer (Version 7.8.1 - QIAGEN Aarhus A/S) was used to cut the ends, retrieve and align sequences of 468 bp long, based on a sequence model from GenBank (FJ623760). In addition, a pBlast analysis (amino acid homology confirmation) with *T. peregrinus* partial mtDNA COI genes on NCBI (National Center for Biotechnology Information, USA database) was performed. The sequence of *T. peregrinus* from Madrid was deposited in GenBank under accession number MN401749.

Results

From the morphological and molecular characterization of the adult insects found in the Parque de El Retiro of Madrid, we confirm that all the sequenced specimens belong to the species *Thaumastocoris peregrinus* (Carpintero & Dellapé, 2006). All the specimens belong to the haplotype A, described by Nadel et al. (2010).

Discussion

The expansion of the area of *T. peregrinus* in Spain was already expected, since the intense traffic of people and goods (Hurley et al., 2016) and because the climatic suitable conditions predicted by CLIMEX, that reports between a low and moderate potential distribution of...
this pest on Madrid region (Saavedra et al., 2015a). Presently this species has been widely distributed in some countries, e.g. as Brazil (Wilcken et al., 2010) and Portugal (Garcia et al., 2013).

Currently, it is known that only four strains of *T. peregrinus* of the eight haplotypes found by Nadel et al. (2010) and the 44 haplotypes found by Lo et al. (2019) in Australia, are scattered in different countries, two in South Africa (D and G haplotypes), one in South America (samples from Argentina, Brazil, Uruguay) (haplotype A - FJ623760) (Nadel et al., 2010) and one in Italy (IT haplotype - KF437485), not yet found in the center of origin of the pest (Nugnes et al., 2014).

The *T. peregrinus* population found in Madrid belongs to haplotype A, and there is no genetic diversity among the insects collected. Generally, in their area of natural occurrence, the species possess greater genetic diversity in relation to populations introduced in new environments (Puillandre et al., 2008).

When analyzing the first occurrence records of *T. peregrinus* in Europe, we verified that Italy (2011) (Laudonia & Sasso, 2012) and Portugal (2012) (Garcia et al., 2013) reported the presence of the insect before its detection in Spain. Therefore, we can suggest some hypothesis of introduction of *T. peregrinus* in Spain (Fig. 2), based on the genetic information of the population of Madrid. The most likely route of introduction may have been through the border with Portugal by natural dispersion (flight, hitchhiking in birds), transit of people and plant material or unintentionally by the importation of Eucalyptus timber from Latin America.

According to Garcia et al. (2013), most of the introductions of invasive alien species are mainly due to human activity, and *T. peregrinus* was probably introduced in Portugal through the importation of eucalypt logs from a Latin American country. In fact, the populations of *T. peregrinus* from Brazil, Argentina and Uruguay belong to the same haplotype found in Spain (Nadel et al., 2010). Thus, it is suggested that the haplotype present in Portugal is also haplotype A. Alternatively, it could have been introduced from Italy, however, the analysis of mtDNA from specimens of the population found in Italy have revealed the presence of a distinct haplotype, IT (Nugnes et al., 2014).

An introduction from Israel would be improbable because the first record of *T. peregrinus* was dated one month earlier than in Spain (Novoselsky & Freideberg, 2016). Finally, a direct introduction from Australia would also be very unlikely. The possible routes of introduction in Spain, can be confirmed when DNA analysis of populations of Portugal became available, in order to determine which lineage(s) of *T. peregrinus* are in the country. In addition, specimens from the region of Badajoz, Spain, could confirm the presence of the same haplotype, due to the proximity to the border of Portugal, where the pest is widespread (Garcia et al., 2013). We believe that an update of the genetic diversity of this species should be carried out in South America, Italy and South Africa, to find out if new introductory events with new haplotypes have occurred, thus increasing diversity in these places.

*Thaumastocoris peregrinus* is considered a prolific species, however, insects can go unnoticed until their abundance becomes critical. In Israel, it has been reported that these insects cause irritation and eruptions on the skin of some people who visited parks, possibly due to the direct contact of the specimens with the skin (Novoselsky & Freideberg, 2016). In this sense, the population of *T. peregrinus* found in a park in

Figure 2. Possible routes of introduction of *T. peregrinus* in Spain.
Dispersion of the Eucalyptus bronze bug in Spain

Madrid, where the movement and the presence of people is intense, should be monitored. After detection, if preventive measures are not taken to control invasive species, their complete eradication will be more unlikely due to increasing population growth (Harvey & Mazzotti, 2014). It is important to highlight that eucalypt plantations in Spain comprise an area of approximately 500,000 ha (IFN; 2011; Santolamazza-Carbone et al., 2019).

There are no effective strategies for controlling T. peregrinus. Using pesticides, however, there was a significant reduction in populations in trees treated with imidacloprid in Australia (Noack et al., 2009). The results indicated that lambda-cyhalothrin + thiametoxam (1.2 + 25.8 g / ha) showed 100% control of insects after 24 hours of exposure (Machado et al., 2016). On the other hand, biological control is being widely diffused in several states (Wilcken et al., 2007). The species C. noackae was introduced in Brazil in 2012 and released in several states (Wilcken et al., 2015), because the introduction and successful establishment of natural enemies is important to regulate pest populations (Gerard et al., 2011; Thompson & Reddy, 2016). In addition, the species Chrysoperla externa (Hagen, 1861) (Neuroptera: Chrysopidae), was found preying nymphs of T. peregrinus (Wilcken et al., 2010) and Atopezolus opsimus (Elkins, 1954) (Hemiptera: Reduviidae) (Dias et al., 2014), adult insects of T. peregrinus.

Furthermore, there are studies with entomopathogenic fungi such as Beauveria bassiana Vuill and Isaria sp. (Lorenzetti et al., 2017). In addition, tests are in progress with isolates from the genera Beauveria, Fusarium, Isaria, Lecanicillium, Paecilomyces, Pochonia, Purpureocillium and Simplicillium (Corallo et al., 2019) and Metarhizium anisopliae (Metsch.) (Soliman et al., 2019), which demonstrated potential for control of T. peregrinus.

Biosecurity measures should be intensified globally in order to hamper the rapid spread of invasive pests and possible damage to plantations. In this sense, we report the expansion of T. peregrinus in Spain and confirm that the population found in Madrid belongs to haplotype A. This is the same maternal lineage found in South America, being one of the probable routes of introduction of this haplotype in Spain.

Acknowledgements

Thanks are given to Mariana Ferneda Dossin and Daniela Rodrigues for the support during the collection of the specimens of T. peregrinus in April.

References

Carapezza A, 2014. The arrival of one more eucalyptus pest in Sicily: Thaumastocoris peregrinus Carpentiero & Dellapé, 2006 (Hemiptera Heteroptera Thaumastocoridae). Naturalista Sicil. XXXVIII, 127-129.

Carpintero DL, Dellapé PM, 2006. A new species of Thaumastocoris Kirkaldy from Argentina (Heteroptera: Thaumastocoridae: Thaumastocoridae). Zootaxa 1228: 61-68. https://doi.org/10.11646/zootaxa.1228.1.4

Chilima CZ, 2007. New Eucalyptus Pest Recorded from Zimbabwe. Forest Invasive Species Network for Africa (FAO). http://www.fao.org/forestry/fisna/26061/en/

Corollo B, Simeto S, Martinez G, Gómez D, Abreo E, Altier N, Lupo S, 2019. Entomopathogenic fungi naturally infecting the eucalypt bronze bug, Thaumastocoris peregrinus (Heteroptera: Thaumastocoridae), in Uruguay. J Appl Entomol 143(5): 542-555. https://doi.org/10.1111/jen.12624

Dias TKR, Wilcken CF, Soliman EE, Barbosa LR, Serrão JE, Zanuncio JC, 2014. Predation of Thaumastocoris peregrinus (Hemiptera: Thaumastocoridae) by Atopezolus opsimus (Hemiptera: Reduviidae) in Brazil. Invertebrate Surviv J 11: 224-227.

Díaz EAB, Coronel RS, Godziewski D, 2013. Consideraciones sobre dos nuevas plagas del eucalipto em Paraguay, El pílilo de la concha o escudo Glycaspis brimblecombei (Hemiptera: psyllidae) y La chinche marrón Thaumastocoris peregrinus (Hemiptera: thau-mastocoridae). Bol Mus Nac Hist Nat Parag 17: 72-75.

García A, Figueiredo E, Valente C, Monserrat VJ, Branco M, 2013. First record of Thaumastocoris peregrinus in Portugal and of the Neotropical predator Hemerobius bolivari in Europe. B Insectol 66: 251-256.

Gerard PJ, Wilson DJ, Eden TM, 2011. Field release, establishment and initial dispersal of Irish Microctonus aethiopoides in Sitona lepidus populations in northern New Zealand pastures. BioControl 56: 861-870. https://doi.org/10.1007/s10526-011-9367-5

Harvey RG, Mazzotti FJ, 2014. The Invasion Curve: A Tool for Understanding Invasive Species Management in South Florida. IFAS Publication Number WEC347 University of Florida, Gainesville, FL. https://edis.ifas.ufl.edu/pdffiles/UW/UW39200.pdf

Heyden TVD, 2017. The first record of Thaumastocoris peregrinus Carpentiero & Dellapé, 2006 (Hemiptera: Heteroptera: Thaumastocoridae) for Albania. Rev Gadiriana Entomol VIII:133-135.

Hodel DR, Arakelian G, Obara LM, 2016. The Bronze Bug Another New Threat to Eucalypts in California. Palm Arbor 5:1-11.

Hurley BP, Garnas J, Wingfield MJ, Branco M, Richardson DM, Slippers B, 2016. Increasing numbers and intercontinental spread of invasive insects on eucalypts.
Dispersion of the Eucalyptus bronze bug in Spain

Biol Invasions 18:921-933. https://doi.org/10.1007/s10530-016-1081-x

IFN, 2011. Cuarto Inventario Forestal Nacional. Ministerio de Medio Ambiente, y Medio Rural y Marino. Madrid, Spain. https://www.mapa.gob.es/es/develop-terrestrial/temas/política-forestal/inventario-cartografía/inventario-forestal-nacional/default.aspx

Jacob DH, Nese S, 2005. Thaumastocoris australicus. Kirkaldy (Heteroptera: Thaumastocoridae): a new insect arrival in South Africa, damaging to Eucalyptus trees. S Afr J Sci 101: 233-236.

Jiménez-Quiroz E, Vanegas-Rico JM, Morales-Martínez O, Lameli-Flores JR, Rodriguez-Leyva E, 2016. First Record of the Bronze Bug, Thaumastocoris peregrinus Carpintero & Dellapé 2006 (Hemiptera: Thaumastocoridae), in Mexico. J Agric Urban Entomol 32: 35-40. https://doi.org/10.3954/1523-5475-32.1.35

Karaca İ, Avci M, Güven O, 2017. Glycaspis brimblecombei Moore (Hemiptera: Aphalaridae), the New Exotic Pest of Eucalyptus in Northern Cyprus. J Agric Sci and Technol A 7:552-556. https://doi.org/10.17265/2161-6256/2017.08.005

Laudonia S, Sasso R, 2012. The bronze bug Thaumastocoris peregrinus: a new insect recorded in Italy, damaging to Eucalyptus trees. Bul Insect 65:89-93.

Lin NQ, Huber JT, LA Sallej, 2007. The Australian genera of Laudonia S, Sasso R, 2012. The bronze bug Thaumastocoris peregrinus Carpintero & Dellapé (Hemiptera: Thaumastocoridae). Agrociencia XIV: 15-18.

Mayorga SI, Ruiz CG, Sandoval AC, Valenzuela JE, 2011. Detection of Thaumastocoris peregrinus (Hemiptera: Thaumastocoridae) associated to Eucalyptus spp. in Chile. (Deteccción de Thaumastocoris peregrinus (Hemiptera: Thaumastocoridae) asociado a Eucalyptus spp. en Chile. Bosque 32: 309-313. https://doi.org/10.4067/S0717-920-2011000300012

Nadel RL, Slippers B, Scholes MC, Lawson SA, Noack AE, Wileken CF, Bouvet JP, Wingfeld MJ, 2010. DNA barcoding reveals source and patterns of Thaumastocoris peregrinus invasions in South Africa and South America. Biol Invasions 12: 1067-1077. https://doi.org/10.1007/s10530-009-9524-2

Nadel RL, Wingfield MJ, Scholes MC, Garnas JR, Lawson SA, Slippers B, 2015. Population dynamics of Thaumastocoris peregrinus in Eucalyptus plantations of South Africa. J Insect Sci 88: 97-106. https://doi.org/10.1007/s10340-014-0558-6

Noack AE, Kaapro J, Bartimote-Aufflick K, Mansfield S, Roseh A, 2009. Efficacy of Imidacloprid in the control of Thaumastocoris peregrinus on Eucalyptus scoparia in Sydney, Australia. Arboric & Urban Forest 35(4): 192-196.

Novoselsky T, Freideberg A, 2016. First record of Thaumastocoris peregrinus (Hemiptera: Thaumastocoridae) in the Middle East, with biological notes on its relations with eucalyptus trees. Isr J Entomol 46: 43-55.

Nugnes F, Caprio E, di Prisco GS, Laudonia S, Sasso R, 2014. Thaumastocoris peregrinus Carpinero & Dellapé (Heteroptera, Thaumastocoridae): a new haplotype in Italy. In: XXIV Italian National Congress of Entomology, Orosei. https://www.researchgate.net/publication/264000885_Thaumastocoris_peregrinus_Carpinero_Dellape_Heteroptera_Thaumastocoridae_un_nuovo_apolito_in_italia

Petrakis PV, 2018. First record of the bug Thaumastocoris peregrinus in Greece. Entomol Hellenica 27:1-9. https://doi.org/10.12681/eh.18703

Puillandre N, Dupas S, Dangles O, Zeddam JL, CapdevielleDulac C, Barbin K, Torres Leguizamon M, Silvain JF, 2008. Genetic bottleneck in invasive species: the potato tuber moth adds to the list. Biol Invasions 10: 375-388. https://doi.org/10.1007/s10530-007-9132-y

Saavedra MC, Avila G A, Withers T M, Holwell G, 2015a. The potential global distribution of the Bronze bug Thaumastocoris peregrinus Carpinero and Dellapé (Hemiptera: Thaumastocoridae). Agric Forest Entomol 17:375-388. https://doi.org/10.1111/afe.12117

Saavedra M, C, Avila G A, Withers T M, Holwell G, 2015b. Susceptibility of four Eucalyptus host species for the development of Thaumastocoris peregrinus Carpinero and Dellapé (Hemiptera: Thaumastocoridae). Forest Ecol Manag 336: 210-216. https://doi.org/10.1016/j.foreco.2014.10.024
Santadino M, Brentassi ME, Fanello DD, Coviella C, 2017. First evidence of Thaumastocoris peregrinus (Heteroptera: Thaumastocoridae) feeding from mesophyll of eucalyptus leaves. Environ Entomol 46: 251-257. https://doi.org/10.1093/ee/nvw163

Santolamazza-Carbone S, Pérez-Rodríguez A, García-fojo R, Cordero-Rivera A, 2019. Local augmentation efficiency of Anaphes nitens (Hymenoptera, Mymaridae), the egg parasitoid of Gonipterus platensis (Coleoptera, Curculionidae). J Appl Entomol 143: 574-583. https://doi.org/10.1111/jen.12626

Soliman EP, Castro BMC, Wilcken CF, Firmino AC, Dal Pogetto MHFA, Barbosa LR, Zanuncio JC, 2019. Susceptibility of Thaumastocoris peregrinus (Hemiptera: Thaumastocoridae), a Eucalyptus pest, to entomopathogenic fungi. Sci Agric 76(3): 255-260. https://doi.org/10.1590/1678-992x-2017-0043

Soliman EP, Wilcken CF, Pereira JM, Dias TKR, Zaché B, Dal Pogetto MHFA, Barbosa LR, 2012. Biology of Thaumastocoris peregrinus Carpintero & Dellapé (Hemiptera: Thaumastocoridae) in different eucalyptus species and hybrids. Phytoparasitica 40: 223-230. https://doi.org/10.1007/s12600-012-0226-4

Sopow S, George S, Ward N (2012). Bronze bug, Thaumastocoris peregrinus: a new Eucalyptus pest in New Zealand. Surveillance 39: 43-46.

Staden RBKF, Bonfield JK, 2000. The Staden package, 1998. Methods Mol Biol 132:115-130. https://doi.org/10.1385/1-59259-192-2:115

Streito JC, Matocq A, Legros V, Genson G, Pierre É, Pluot-Sigwalt D, 2016. Report of the invasive species Thaumastocoris peregrinus Carpintero & Dellapé, 2006, on Réunion Island (Hemiptera, Heteroptera, Thaumastocoridae). Bul Soc Entomol France 12: 65-72.

Thompson BM, Reddy GVP, 2016. Status of Sitodiplosis mosellana (Diptera: Cecidomyiidae) and its parasitoid, Macroglenes penetrans (Hymenoptera: Pteromalidae), in Montana. Crop Protec 84: 125-131. https://doi.org/10.1016/j.cropro.2016.03.009

Vivas L, Crespo J, Jacinto V, 2015. Primer registro de la especie invasora Thaumastocoris peregrinus Carpintero & Dellapé, 2006 en España y nuevos datos para Portugal (Hemiptera: Thaumastocoridae). BV News 4: 30-35.

Wilcken CF, 2008. Percevejo bronzeado do eucalipto (Thaumastocoris peregrinus) (Hemiptera: Thaumastocoridae): ameaça às florestas de eucalipto brasileiras. http://www.ipef.br/protecao/alerta-percevejo.pdf

Wilcken CF, Soliman EP, de Sá LAN², Barbosa LR, Dias TKR, Ferreira-Filho PJ, Oliveira RJR, 2010. Bronze bug Thaumastocoris peregrinus Carpintero and Dellapé (Hemiptera: Thaumastocoridae) on Eucalyptus in Brazil and its distribution. J Plant Prot Res 50(2): 210-205. https://doi.org/10.2478/v10045-010-0034-0

Wilcken, CF, Barbosa LR, Soliman EP, Lima ACV, de Sá LAN, Lawson S, 2015. Percevejo-bronzeado-do-eucalipto, Thaumastocoris peregrinus Carpintero & Dellapé. In: Vilela EF, Zucchi RA. Pragas introduzidas no Brasil: insetos e ácaros. Fealq, Piracicaba, pp 898-908.

Zheng XL, Li J, Yang ZD, Xian ZH, Wei JG, 2014. A review of invasive biology, prevalence and management of Leptocybe invasa Fisher & La Salle (Hymenoptera: Eulophidae: Tetrastichinae). Afr Entomol 22 (1): 68-79. https://doi.org/10.4001/003.022.0133