TRAVAUX DU MUSÉUM NATIONAL D'HISTOIRE NATURELLE «GRIGORE ANTIPA»
THE JOURNAL OF "GRIGORE ANTIPA" NATIONAL MUSEUM OF NATURAL HISTORY

Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 65 (1): 25–36 (2022)
doi: 10.3897/travaux.65.e82873

FAUNISTIC NOTE

First records of the alien *Eucalyptus* psyllids *Blastopsylla occidentalis* (Hemiptera, Aphalaridae) from Cyprus and *Platyobria biemani* (Hemiptera, Aphalaridae) from Cyprus and continental Greece

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Received 3 March 2022 | Accepted 29 April 2022 | Published 30 June 2022

Citation: Demetriou J, Koutsoukos E, Davranoglou L-R, Roy HE, Spodek M, Martinou AF (2022) First records of the alien *Eucalyptus* psyllids *Blastopsylla occidentalis* (Hemiptera, Aphalaridae) from Cyprus and *Platyobria biemani* (Hemiptera, Aphalaridae) from Cyprus and continental Greece. Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 65(1): 25–36. https://doi.org/10.3897/travaux.64.e82873

Abstract

The psyllids *Platyobria biemani* Burckhardt, Queiroz & Malenovský, 2014 and *Blastopsylla occidentalis* Taylor, 1985 (Hemiptera: Psylloidea: Aphalaridae) originally native to Australia, have now spread to the Eastern Mediterranean as pests of *Eucalyptus* spp. In the present study, we provide the first records of these species from Cyprus and we expand the range of *P. biemani* within continental Greece. The specimens were collected from ornamental *Eucalyptus* trees in Paphos and Limassol districts. In addition, material surveys in Greece revealed the presence of *P. biemani* in Attica (Salamis Island and Nea Peramos). Given the number of sampled sites, both species should be classified as established pests responsible for small-scale, local infestations of *Eucalyptus* spp. The Australian *Glycaspis brimblecombei*

Moore, 1964, already known from Cyprus, is widespread on the island and its effects undermine the aesthetics of natural and urban landscapes. The socioeconomic impacts of alien *Eucalyptus* psyllids in Cyprus are discussed.

Keywords
alien insects, biological invasions, *Eucalyptus*, Mediterranean, non-native species, Sternorrhyncha, Psylloidea.

Introduction

Representatives of the genus *Eucalyptus* L'Hér. have been introduced across the globe outside their native range for the production of pulp and timber, as well as for the drying of marshes during anti-malarial campaigns (Cocquempot and Lindelöw 2010; Mifsud et al. 2010; Bayle 2019). While generally considered as ecological "deserts" (Brockerhoff et al. 2001), *Eucalyptus* spp. have been occasionally reported as beneficial to native biodiversity, especially in arid habitats (Herrmann et al. 2015). Nevertheless, even in such cases *Eucalyptus* plantations cannot substitute for natural habitats (Herrmann et al. 2015). Their extensive planting as ornamental and cultivars in urban, rural and natural habitats in the Mediterranean, has facilitated subsequent biological invasions of insects associated with *Eucalyptus*, such as the longhorn beetles *Phoracantha recurva* Newman, 1840 and *Phoracantha semipunctata* (Fabricius, 1775) (Cocquempot and Lindelöw 2010), alien hymenopteran leaf-gallers such as *Leptocybe invasa* Fisher & La Salle, 2004 and *Ophelimus maskelli* (Ashmead, 1900) (Dittrich-Schröder et al. 2020) as well as six alien Australian psyllids (Spodek et al. 2015). In particular, *Blastopsylla occidentalis* Taylor, 1985, *Ctenarytaina eucalypti* (Maskell, 1890), *Ctenarytaina peregrina* Hodkinson, 2007, *Ctenarytaina spatulata* Taylor, 1997, *Glycaspis brimblecombei* Moore, 1964 and *Platyobria biemani* Burckhardt, Queiroz & Malenovský, 2014.

Eucalyptus trees were first introduced to the island of Cyprus during the 1880s and were planted for afforestation of vast areas (Ciesla 2004; Harris 2007). Although some concerns about their suitability were voiced (Harris 2007), the general enthusiasm for them and continuous tree planting resulted in the establishment of numerous *Eucalyptus* species on the island (Harris 2007; Pescott et al. 2018). To this day, *Eucalyptus* spp. are extensively planted as ornamentals in a diverse range of urban, semi-urban, rural, agricultural and natural habitats, including protected areas. Following their hosts, numerous wood-feeding, gall-inducing, sap-sucking, predacious and parasitic species have been introduced and detected in Cyprus (Demetriou 2021; Demetriou et al. 2021; Demetriou et al. 2022). To date, the only *Eucalyptus* psyllid, detected in Cyprus is *G. brimblecombei* (Karaca et al. 2017; Demetriou 2021). *Glycaspis brimblecombei* is a rapid colonizer, negatively affecting the fitness of *Eucalyptus* trees and the aesthetics of the urban landscape (Bella and Rapisarda 2013; Demetriou 2021).

Blastopsylla occidentalis is a species of psyllid widespread in the Mediterranean, reported from Italy (EPPO 2006), Turkey (Aytar 2007), Spain (Pérez-Otero et al. 2011), Portugal (Pérez-Otero et al. 2011), Israel (Spodek et al. 2015), and Malta (Mifsud 2020). On the contrary, records of *P. biemani* seem to be restricted to the Eastern Mediterranean. In particular, *P. biemani* was first described outside its native range by Burckhardt et al. (2014) from Lesvos Island (Greece), later it was detected in Israel (Burckhardt and Spodek 2015) and more recently in Turkey (Çıkarana and Avcı 2019) although it has yet to be found in its native range. Due to the serious impacts of other alien *Eucalyptus* psyllids such as *C. eucalypti*, further investigation on the distribution, biology and management of *P. biemani* was advised (Burckhardt et al. 2014; Burckhardt and Spodek 2015), in order to prevent further spread and development "into a serious new eucalypt pest".

Materials and Methods

Study area, specimen collection and identification

Weekly structured surveys using a beating sheet were undertaken at two sites in Limassol and four sites at the Akrotiri UK Sovereign Base Area from February to June 2021 (JD). These surveys were supplemented by occasional field surveys in Nicosia and Paphos districts during December 2020 to June 2021 as well as throughout collection of infested *Eucalyptus* leaves in sealed polyethylene bags from the 26th March to 4th April 2022 in Limassol city (Table 1). In Greece, *Eucalyptus* spp. trees were sampled weekly by hand from March to April and November 2021 in the Attica administrative region (EK) (Table 1). Specimens were examined under a stereomicroscope and identified as *B. occidentalis*, *G. brimblecombei* and *P. biemani* using the identification key of Spodek et al. (2015) (Table 1). Specimens are deposited in the Museum of Zoology (National and Kapodistrian University of Athens, Greece) (ZMUA), the Life Collections of the Oxford University Museum of Natural History (OUMNH), the Department of Ecology and Systematics, National and Kapodistrian University of Athens (NKUA) and the entomological collection of Joint Services Health Unit, Akrotiri, Cyprus (JSHU).

Maps

The distribution map was created using QGIS free and open source Geographic Information System (https://qgis.org/en/site/).

Table 1. Metadata of surveyed localities.

Country	Site	Latitude (decimal)	Longitude (decimal)	Habitat	Alt. (m)	Date	Coll.	Collected specimens
Cyprus	Nicosia, Aglantzia, Athalassa National Forest Park	35,1250	33,3829	Urban area – park	150	23-Dec-2020	J. Demetriou and E. Koliarou	No psyllids found
Cyprus	Limassol, Marina (Molos)	34,6750	33,0475	Urban park	0	Feb to Jun 2021	J. Demetriou	*Blastopsylla occidentalis*; *Glycaspis brimblecombei*
Cyprus	Limassol, Port Area	34,6453	33,0008	*Eucalyptus* spp. windbreaker near crop	0	Feb to Jun 2021	J. Demetriou	*Glycaspis brimblecombei*
Cyprus	Akrotiri UK Sovereign Base Area, salt lake	34,6005	32,9730	Cultivated land by the salt-lake	5	Feb to Jun 2021	J. Demetriou	*Glycaspis brimblecombei*; *Platyobria biemani*
Cyprus	Akrotiri UK Sovereign Base Area, near forest nursery	34,6268	32,9515	*Acacia saligna* and *Eucalyptus* spp. forest	10	Feb to Jun 2021	J. Demetriou	No psyllids found
Cyprus	Akrotiri village, Timios Stavros Church	34,6024	32,9545	Urban area – park	10	Feb to Jun 2021	J. Demetriou	No psyllids found
Cyprus	Akrotiri marsh	34,6300	32,9300	Marshland bordered by cultivated land; *Eucalyptus* spp.	5	Feb to Jun 2021	J. Demetriou	*Glycaspis brimblecombei*
Cyprus	Paphos, Kouklia, Aphrodite's Rock	34,6669	32,6232	Coastal area	30	24-Jan-2021	J. Demetriou and E. Koliarou	No psyllids found
Cyprus	Paphos, Choletria	34,7651	32,6010	Park with *Eucalyptus* spp.	300	6-Feb-21	J. Demetriou and E. Koliarou	No psyllids found
Cyprus	Paphos, Nata	34,7756	32,5706	Near cultivated rural area by the side of the road	160	06-Feb-2021 + 11-Mar-2021	J. Demetriou and E. Koliarou	*Platyobria biemani*; *Glycaspis brimblecombei*
Cyprus	Paphos, International Airport Area	34,7270	32,4530	Coastal area	0	5-Jan-21	J. Demetriou	No psyllids found
Cyprus	Paphos, Geroskipou	34,7382	32,4366	Urban coastal area	0	18-Jan-21	J. Demetriou and E. Koliarou	No psyllids found
Cyprus	Paphos, Drouseia	34,9623	32,4090	Rural area	580	03-Jan-2021	J. Demetriou and E. Koliarou	No psyllids found
Cyprus	Paphos, Polis Chrysochous camping site	35,0400	32,4200	*Eucalyptus* spp. Forest	10	27-Mar-21	J. Demetriou and E. Koliarou	No psyllids found
Greece	Attica, Salamis, Ambelakia	37,9543	23,5314	*Eucalyptus* spp. Across the road	5	5-Mar-21	E. Koutsoukos	No psyllids found
Greece	Attica, Salamis, Agia Maura	37,9624	23,5030	*Eucalyptus* spp. Across the road	22	13-Mar-2021	E. Koutsoukos	No psyllids found
Greece	Attica, Salamis, Steno Faneromenis	37,9740	23,4370	*Eucalyptus* spp. Next to the sea, in semi urban area	2	15-Mar-2021	E. Koutsoukos	*Platyobria biemani*
Greece	Attica, Salamis, Selinia	37,9350	23,5330	Semi urban area	51	31-Mar-2021	E. Koutsoukos	No psyllids found
Greece	Attica, Salamis, Kaki Vigla	37,9116	23,4972	Rural area	45	27-Mar-2021	E. Koutsoukos	No psyllids found
Greece	Attica, Salamis, Ergatikes katoikies	37,9568	23,4672	Semi urban area	35	21-Apr-2021	E. Koutsoukos	No psyllids found
Greece	Attica, Nea Peramos	37,9996	23,4174	Urban park with *Eucalyptus* spp., *Casuarina* sp. and *Pinus* sp.	2	20-Nov-2021	E. Koutsoukos	*Platyobria biemani*

Results

Material examined

***Blastopsylla occidentalis* Taylor, 1985**

CYPRUS: Limassol, Marina (Molos) (34.6750°N, 33.0475°E), alt. 0 m, 1♀, 20.V.2021, collected from *Eucalyptus* sp. trees in urban park by using a beating sheet, coll. J. Demetriou (Fig. 1A) (JSHU); Limassol, Agia Zoni (34.6877°N, 33.0429°E), alt. 30 m, 15♀17♂, 02.IV.2022, reared from *Eucalyptus* sp. leaves collected in urban roadside, coll. E. Koutsoukos (ZMUA).

***Platyobria biemani* Burckhardt, Queiroz & Malenovský, 2014**

CYPRUS: Paphos, Nata (34.7756°N, 32.5706°E), alt. 160 m, 2♂, 06.ii.2021 and 11.iii.2021, collected from *Eucalyptus* near a cultivated rural area by the side of the road by using a beating sheet. The *Eucalyptus* spp. trees were observed bearing lerps resembling those of *G. brimblecombei* especially on young, reddish leaves, as well as galls of *L. invasa* (Demetriou et al. 2022), coll. J. Demetriou and E. Koliarou (OUMNH); Limassol, Agia Zoni (34.6877°N, 33.0429°E), alt. 30 m, 1♀, 02.IV.2022, reared from *Eucalyptus* sp. leaves collected in urban roadside, coll. E. Koutsoukos (ZMUA); **AKROTIRI UK SOVEREIGN BASE AREA:** Salt-lake (34.6005°N, 32.9730°E), alt. 5 m, 1♀, 12.VI.2021, collected from *Eucalyptus* spp. trees in windbreaker near crop by using a beating sheet, coll. J. Demetriou (Fig. 1B) (JSHU).

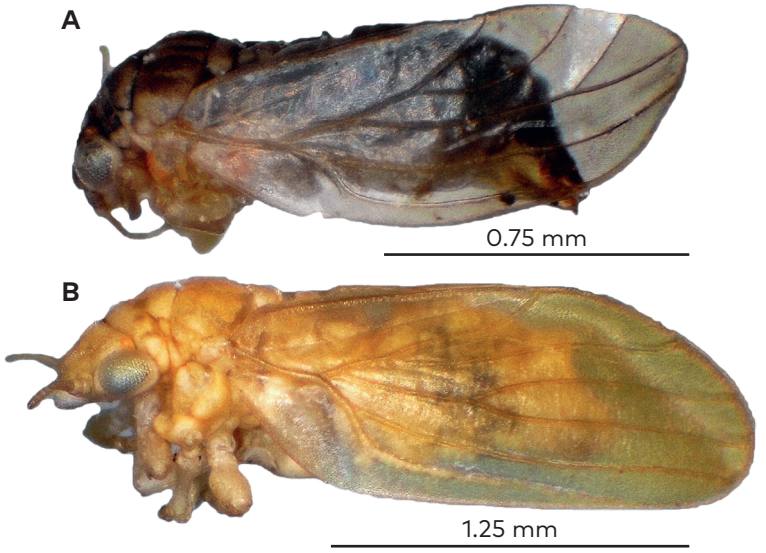

Figure 1. A ♀ *Blastopsylla occidentalis* Taylor, 1985 collected from Limassol, lateral view; **B** ♀ *Platyobria biemani* Burckhardt, Queiroz & Malenovský, 2014 collected from Akrotiri UK Sovereign Base Area, lateral view.

GREECE: Attica administrative region, Salamis Island, Steno Faneromenis (37.974°N, 23.437°E), alt. 2 m, 1♂, 15.iii.2021, collected by hand from an *Eucalyptus* sp. tree, coll. E. Koutsoukos (ZMUA); Attica administrative region, Nea Peramos (37.9996°N, 23.4174°E), alt. 2 m, 5♂2♀, 20.Xi.2021, collected from an *Eucalyptus* sp. tree by hand, coll. E. Koutsoukos (ZMUA).

***Glycaspis brimblecombei* Moore, 1964**

CYPRUS: Limassol, Marina (Molos) (34.6750°N, 33.0475°E), alt. 0 m, one individual, 31.III.2021, collected from *Eucalyptus* spp. trees in urban park by using a beat-sheet, coll. J. Demetriou.; one individual, 7.IV.2021; two individuals, 15.IV.2021; four individuals, 29.IV.2021; five individuals, 7.V.2021; six individuals, 20.V.2021; six individuals, 27.V.2021; 11 individuals, 3.VI.2021, five individuals, 12.VI.2021 (NKUA); Limassol, Port (34.6453°N, 33.0008°E), alt. 0 m, three individuals, 10.III.2021, collected from *Eucalyptus* spp. trees in windbreaker near crop by using a beat-sheet, coll. J. Demetriou; one individual, 24.III.2021, six individuals, 31.III.2021; one individual, 29.IV.2021; two individuals, 20.V.2021; one individual, 3.VI.2021; two individuals, 12.VI.2021 (NKUA); Paphos, Nata (34.7756°N, 32.5706°E), alt. 160 m, 06.ii.2021 and 11.iii.2021, observed on *Eucalyptus* near a cultivated rural area by the side of the road., obs. J. Demetriou and E. Koliarou; **AKROTIRI UK SOVEREIGN BASE AREA:** Akrotiri marsh (34.6300°N, 32.9300°E), alt. 5 m, III.2021, light infestation observed on *Eucalyptus* spp. bordering marshland, obs. J. Demetriou; Salt-lake (34.6005°N, 32.9730°E), alt. 5 m, II–VI.2021, large scale infestations observed on *Eucalyptus* spp. trees in windbreaker near crop, J. Demetriou (NKUA).

Discussion

Specimens of *B. occidentalis* (Fig. 1A) and *P. biemani* (Fig. 1B) from Paphos and Limassol represent the first records of these alien species from Cyprus (Fig. 2). In addition, surveys in Attica (Greece) revealed the presence of *P. biemani* in the Saronic Gulf, representing an expansion of its previously known range in Greece (Burckhardt et al. 2014) (Fig. 3). *Glycaspis brimblecombei* was collected from five sites in Cyprus, including the Akrotiri marsh (RAMSAR wetland) and Akrotiri salt-lake protected areas (Fig. 2). These results contribute to our understanding of the distributional range of *P. biemani* in the Eastern Mediterranean (Fig. 3). Records from Israel (Burckhardt and Spodek 2015), Cyprus and Greece highlight the need for investigating the possible presence of *P. biemani* in neighbouring European (e.g. Albania, Bulgaria, and Italy), Asian (e.g. Lebanon and Syria) and North African countries (e.g. Egypt). The same applies to *B. occidentalis*, which has already spread across the Mediterranean but has yet to be found in the Balkans.

Regarding the impact of *B. occidentalis* and *P. biemani*, no negative effects on *Eucalyptus* spp. or socioeconomic parameters were observed. Infested trees were mostly affected by other alien *Eucalyptus* pests such as *G. brimblecombei*, *L. invasa*

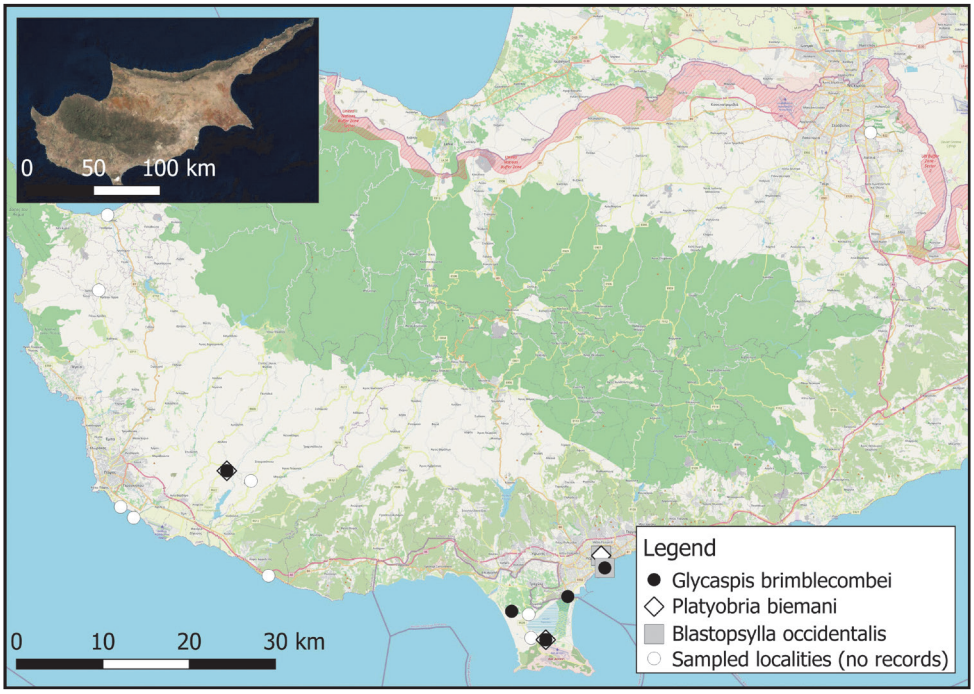

Figure 2. Sampling sites in Cyprus from December 2020 to June 2021 and 26th March to 4th April 2022. *Platyobria biemani* Burckhardt, Queiroz & Malenovský, 2014 (white diamonds) and *Blastopsylla occidentalis* Taylor, 1985 (grey rectangle) represent new records for the island.

and *O. maskelli* (Demetriou and Koutsoukos pers. observations). No records of species interactions, parasitoids or insects feeding out of honeydew were investigated in Greece and Cyprus although, natural enemies of *B. occidentalis* reported from Cameroon include ladybug predators and a parasitoid identified as *Psyllaephagus* sp. (Soufo and Tamesse 2015). Three of our sampling sites in Cyprus hosted *P. biemani* and just two *B. occidentalis* (Fig. 2). It is therefore likely that these species constitute minor pests of *Eucalyptus* spp. (Burckhardt et al. 2014; Burckhardt and Spodek 2015; Spodek et al. 2015), with infested trees being subjected to small-scale, local infestations. Nevertheless, further studies are needed in order to fully assess the impacts of these alien psyllids on *Eucalyptus* trees of Cyprus, as well as the presence of any native or accidentally introduced parasitoids and predators. In addition, the distribution, introduction pathways and spread of the species need to be closely monitored by implementing standardised collecting methods and molecular markers to better understand the invasion history of alien *Eucalyptus* psyllids (Burckhardt et al. 2014; Burckhardt and Spodek 2015; Spodek et al. 2015).

In contrast, *G. brimblecombei* has been found to cause negative socioeconomic impacts in Cyprus, mostly by undermining the aesthetics of nature and that of the urban landscape (Kueffer and Kull 2017; Demetriou 2021; Dept. of Forestry,

unpublished data). Since its initial detection on the island in 2015, the species has become widespread (Karaca et al. 2017; Demetriou 2021; Demetriou et al. 2022; Dept. of Forestry, unpublished data). On June 2019, the Department of Forestry issued an online statement informing the public about large-scale infestations caused by the psyllid throughout Cyprus (http://www.moa.gov.cy/moa/fd/fd.nsf/All/FE295879274AC330C2258435001B5E4E?OpenDocument). The Department also stated that specimens were mostly found on *Eucalyptus* trees in riverbeds, causing discolouration and shedding of their foliage. Due to the large amounts of honeydew excreted by the psyllid, the Department urged the public to avoid sitting under or near affected trees, while stating that the problem is expected to gradually begin to subside after August 2019. This notion already postulated back in 2015 was supported by the additional presence of the species' obligate parasitoid *Psyllaephagus bliteus* Riek, 1962 which was expected to gradually bring a "balance in the ecosystems where *Eucalyptus* trees grow", lowering populations of *G. brimblecombei* (http://www2.parliament.cy/parliamentgr/008_3g/23_06_010_05_024.htm). The Department's online statement was extensively covered by the media, spreading awareness about the species' presence and impacts. Despite reassurances, two years after the statement, follow-up material sampling in Limassol mentioned that *G. brimblecombei* was observed to negatively affect the

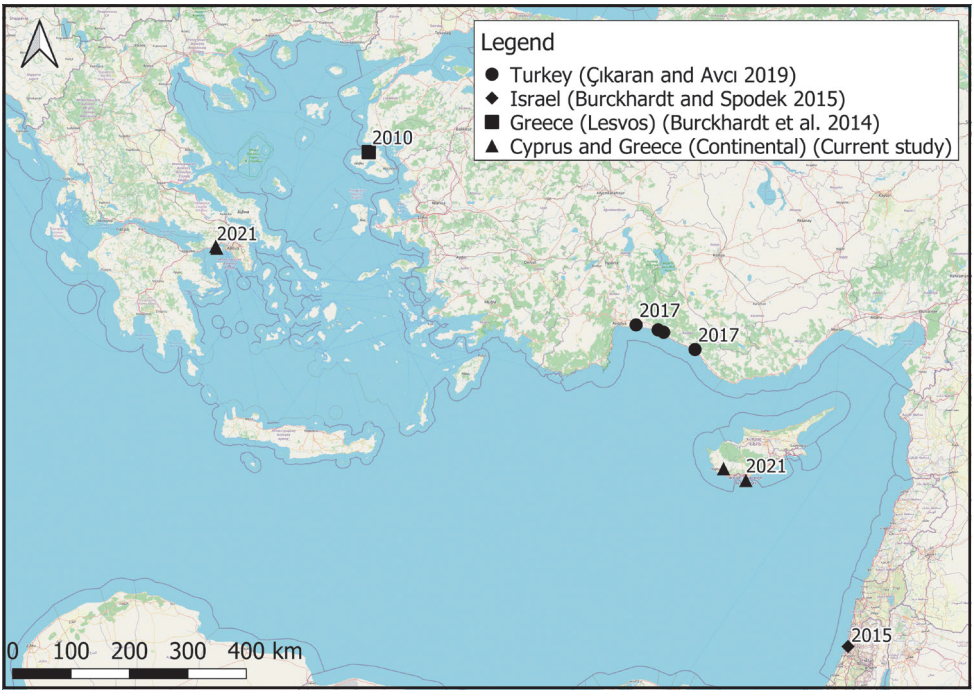

Figure 3. Known distribution of *Platyobria biemani* Burckhardt, Queiroz & Malenovský, 2014 in the Eastern Mediterranean. Sampling sites include Greece and Cyprus (current study) where the species was collected (black triangles). Year of first record (specimen collection year) displayed over points.

aesthetics of nature while its lerps filled low hanging branches surrounding public playgrounds and sidewalks (Demetriou 2021). Its sticky excretions regularly stained the author's equipment and clothing, especially during late spring and early summer months (Demetriou 2021). During surveys, infested leaves were collected in sealed polyethylene bags from which a few *P. bliteus* individuals emerged (Demetriou et al. 2022). Furthermore, during a visit to Athalassa National Forest Park in December 2021 the first author observed remnants of dried up, mouldy lerps presumably created by *G. brimblecombei*. Thus, the socioeconomic impacts of *G. brimblecombei* are seasonal and recurrent while *P. bliteus* seems unable to suppress the population explosions of its host (Demetriou et al. 2022), as already observed in other Mediterranean countries (Boavida et al. 2016).

Given the extensive distribution of *Eucalyptus* spp. in Cyprus, the large number of their associated alien insects should be closely monitored (Spodek et al. 2015; Mendel and Protasov 2019; Demetriou et al. 2022). Structured surveys could be supplemented by opportunistic citizen-science approaches i.e. throughout the provision of photographic material (Cianferoni et al. 2021), specimen collection, organizing BioBlitzes and interactive workshops for the early detection and monitoring of alien species (Groom et al. 2019; Meeus et al. 2021). In the case of *G. brimblecombei* which constructs conspicuous lerps, citizen scientists could also report observations of honeydew and their perceptions of it in order to gain a better understanding of the adverse socioeconomic impacts of the species as well as how these impacts change spatiotemporally. Citizen-science is subjected to multiple spatiotemporal biases, for example heavily influenced by infrastructure and population density (Isaac and Pocock 2015; Geldmann et al. 2016). Nevertheless, the majority of alien species inhabit man-made habitats (Lopez-Vaamonde et al. 2010). As such, public participation in scientific research can help in mapping the distribution and detecting new alien *Eucalyptus* associates, such as Australian psyllids of the genus *Ctenarytaina*, already reported in the Western Palearctic (Burckhardt 1998; Costanzi et al. 2003; Mansilla et al. 2004; Valente et al. 2004; Hodkinson 2007).

Acknowledgments

We are grateful to Prof Margarita Arianoutsou and Dr Canella Radea (National and Kapodistrian Univeristy of Athens, Greece) for overseeing the MSc Thesis during which many of the first author's field surveys took place. We also kindly thank Ms Evi Koliarou for her valuable field assistance in spotting and collecting infested plant material. We are also thankful to Dr David Ouvrard for his valuable comments and corrections to the manuscript during the review process. Finally, we are thankful to the State Scholarship Foundation of Cyprus (IKYK) and the UK Government through Darwin Plus (DPLUS124), for funding this project and the postgraduate studies of Jakovos Demetriou. Prof Helen E Roy was supported by the Natural Environment Research Council award number NE/R016429/1 as part of the UK-SCAPE programme

Delivering National Capability. Dr Leonidas-Romanos Davranoglou acknowledges his Leverhulme Trust Early Career Fellowship grant (ECF-2021-199). Mr Evangelos Koutsoukos acknowledges COST Action CA17122 – Alien CSI, supported by COST (European Cooperation in Science and Technology), www.cost.eu.

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