New records of *Oecanthus* species (Orthoptera, Oecanthidae) in the Madeira archipelago

Hugo Miguel Silva[1], Laura Avivar-Lozano[2], Gonçalo Gomes[1], Howon Rhee[3], Thomas Dellinger[1,4], Dora Aguín-Pombo[1,4]

1 Universidade da Madeira, Funchal, Madeira, Portugal.
2 Laboratorio de Entomología, IFAPA, Centro "Las Torres", Ctra. Sevilla-Cazalla de la Sierra, 41200 Alcalá del Río, Seville, Spain.
3 Department of Biogeography, Trier University, Trier, Germany.
4 Centro de Investigação em Biodiversidade e Recursos Genéticos (CIBIO), Vairão, Portugal.

Corresponding author: Hugo Miguel Silva (hmvcsilva@ua.pt)

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Abstract

The Madeira and Porto Santo Islands have both witnessed substantial habitat loss since their initial colonization. Despite their small size and the degradation of their natural habitats, they harbor a rich diversity of terrestrial invertebrates, including a significant number of endemic species. While research on Orthoptera fauna has predominantly focused on the largest island of Madeira, the smaller island of Porto Santo has remained relatively understudied. Fieldwork on both islands has led to the discovery of *Oecanthus dulcisonans* Gorochov, 1993 in the Madeira archipelago (Porto Santo and Madeira) for the first time. This species was described based on specimens collected in Tenerife and the Arabian Peninsula. However, its distribution, which includes parts of Africa, Western Asia, and some localities in Southern Europe, remains poorly understood. *Oecanthus dulcisonans* is morphologically very similar to *Oecanthus pellucens* (Scopoli, 1763), the only species of this genus previously recorded for the island of Madeira. Due to this resemblance, doubts have arisen regarding which of these two species is present in Madeira. By examining new material of *O. pellucens*, we have confirmed the presence of this species on Madeira as well. These new findings highlight the fact that, for these species, the Madeira archipelago represents the western limit of their distributional ranges in the Palearctic region.

Keywords

Macaronesia, *Oecanthus dulcisonans*, *Oecanthus pellucens*, Porto Santo Island, tree-cricket

Introduction

Madeira is a biodiversity hotspot (Myers et al. 2000), particularly rich in insect species. Knowledge of the invertebrate fauna in Madeira is crucial for identifying rare or endemic species that may require special conservation attention. This information plays a vital role in conservation efforts, maintaining ecosystem stability, and preserving the unique natural heritage of the region.

Today, only around 20% of the native Laurel Forest area remains on Madeira Island. Natural habitats are primarily restricted to the north coast of Madeira, with a few areas confined to the south coast having been largely converted into urban and agricultural areas. In Porto Santo, the oldest island in this volcanic archipelago (14 million years old), only scattered remnants of its native vegetation survive, primarily on cliffs and mountaintops. Despite these habitat alterations, current environmental threats, and the small size of Porto Santo, both islands still harbor highly diverse terrestrial fauna. According to Borges et al. (2008), 69% of the arthropod taxa reported from Madeira Island are endemic species or subspecies. In Porto Santo, the arthropod fauna includes up to 20% of endemic species. Notably, its terrestrial mollusk fauna stands out as one of the world's richest in terms of the number of endemic species per square kilometer (Cameron et al. 1996).

A total of 38 publications have been dedicated to studying the Orthoptera of the Madeira archipelago. However, research efforts have been uneven among the five islands of the archipelago. Most publications (33) have focused on Madeira, the largest island, while the much smaller island of Porto Santo (43 km^2) has received limited attention (Gardner 1960, Chopard 1962, Lange 1990, Aguirre-Segura et al. 1995, Antunes et al. 2008). Both islands have undergone significant changes in their vegetation and have experienced a substantial loss of their natural habitats since their colonization in 1420 (Antunes et al. 2008).

Research on the Orthoptera fauna for the Madeira and Porto Santo Islands has reported 31 and 12 species, respectively. These include 13 and five from the Acridoidea, nine and two from Tettigonioidea, and nine and five from Grylloidea. Notably, while the papers on Madeira Island contain a few records of *Oecanthus pellucens* (Scopoli, 1763), there are no documented records of any species from this genus on Porto Santo. Given the size, age, and rich terrestrial fauna of this island, it is plausible that the Orthoptera fauna may be even more diverse than currently reported.

During our various field trips aimed at studying the local Orthoptera in the archipelago, we collected many Orthoptera specimens from the Madeira and Porto Santo Islands. Among these specimens, we found for the first time in the archipelago *Oecanthus dulcisonans* Gorochov, 1993. Initially described from specimens collected in Tenerife and the Arabian Peninsula, the distribution of this species remains poorly understood. Recent records suggest that it may inhabit the same regions as *O. pellucens*, a morphologically very similar species often mistaken for it (Gorochov 1993, Gorochov and Llorente 2001). However, doubts have arisen regarding which of these two species occurs in Madeira, as records of *O. pellucens* from Madeira date back to before the description of *O. dulcisonans*. In this work, we provide the first recorded instance of *O. dulcisonans* in the Madeira archipelago and validate the presence of *O. pellucens*. The presence of both *O. dulcisonans* and *O. pellucens* on Madeira represents an extension of the known ranges for these species in the Palearctic region. This discovery holds significant implications for biogeographical research and enhances our understanding of the distributional patterns of these insects.

Materials and methods

The field trips to Madeira and Porto Santo were conducted during two separate periods: from June 14th to 19th, 2023, in Madeira and from October 22nd to 24th, 2022, in Porto Santo. Our primary method for locating crickets was by listening for their songs. In Madeira, we walked along paths through the vegetation between 22:00 and 00:00, while in Porto Santo, we traveled by car at a speed of 15 km/h between 20:00 and 23:00. Upon hearing an individual's song, we traced the source of the sound and captured the insect either by hand or with the use of a net. The coordinate data were collected using WGS84, with a precision of three meters.

Moreover, we recorded the calling song of *O. dulcisonans* in Porto Santo using a Xiaomi Redmi 9C NFC smartphone with 48 kHz sampling frequency and 16-bit resolution. As the original recording contained ambient noise due to the field recording conditions, we cut only the clearest part (5 seconds) of the song. Since we lacked audio recordings of *O. pellucens*, we compared the songs of *O. dulcisonans* with referenced data for *O. pellucens* from the Orthoptera Species Files Online (Cigliano et al. 2023). These reference recordings were made at a temperature comparable to the 23°C conditions for *O. dulcisonans*. For sound characterization, we generated all oscillograms using the "seewave" package in R (Sueur et al. 2008). Subsequent analysis of the sounds was conducted using Amadeus Pro software (HairerSoft 2023). Terminology used to describe the sounds follows that of Ragge and Reynolds (1998).

Finally, we examined two specimens of *O. pellucens* from Madeira Island that had previously been collected and were held in the University of Madeira Insect Collection (UMACI). Male and female specimens were identified according to Braud et al. (2015) using the shape of the metasternal plate, male epiphallus, and body measurements. The following measurements were taken under a stereomicroscope: body length from head to subgenital plate (BL), elytra length (EL), length of posterior hind wing protruding beyond the elytra (HW), length of the posterior femur (FL), and length of oviscape (OV).

All the material studied has been preserved as dry-pinned specimens and is deposited in the UMACI.

Results

During the present study, we found 21 specimens of *O. dulcisonans* and four specimens of *O. pellucens* on Madeira Island. We also found a nymph that, due to its presence at higher altitudes, could be *O. pellucens*. For Porto Santo Island, we collected one specimen of *O. dulcisonans* (Fig. 1).

Species accounts

Oecanthus dulcisonans Gorochov, 1993

Fig. 2A, B, D, G

Material examined.—PORTUGAL • 16♂, 1♀; Madeira Island, Machico, Caniçal, Ponta de São Lourenço; 32°44'37"N, 16°42'05"W; 76 m a.s.l.; 16.VI.2023; H. Silva, G. Gomes, T. Dellinger, H. Rhee leg.; on: *Hyparrhenia hirta*; UMACI • 3♂, 1♀; Madeira Island, Santa Cruz, Caniço, Reis Magos; 32°38'56"N, 16°49'23"W; 38 m a.s.l.; 19.VI.2023; H. Silva, G. Gomes, H. Rhee leg.; on: *Hyparrhenia hirta*; UMACI • 1♂; Porto Santo Island, Campo de Baixo; 33°2'53.39"N, 16°21'5.86"W; 16 m a.s.l.; 23.X.2022; H. Silva, D. Aguín-Pombo, L. Avivar-Lozano, M. Dias leg.; on: *Hyparrhenia hirta*; UMACI.

Measurements.—MADEIRA ISLAND – ♂: BL=14.44 ± 0.55 mm (n=19); EL=14.18 ± 0.68 mm (n=19); HW=2.59 ± 0.32 mm (n=19); FL=7.98 ± 0.50 mm (n=19); ♀: BL=14.08 ± 0.39 mm (n=2); EL=14.10 ± 0.55 mm (n=2); FL=7.85 ± 0.63 mm (n=2); OV=5.48 ± 0.32 mm (n=2). PORTO SANTO ISLAND – ♂: BL=17.34 mm (n=1); EL=13.28 mm (n=1); HW=2.00 mm (n=1); FL=7.03 mm (n=1).

Sounds.—The song of the species consists of continuous long echemes without gap, as has been already mentioned (Gorochov 1993, Cordeo et al. 2009) as a conspecific song trait (Fig. 3C).

Notes.—*Oecanthus dulcisonans* is primarily distinguished from *O. pellucens* by the shape of the metasternal plate. In the specimens of *O. dulcisonans*, this plate is longer and thinner than the metasternal plate of *O. pellucens* (Fig. 2A, D–F). In terms of size, the specimen from Porto Santo measured 17.34 mm in body length, slightly exceeding the 14.00–17.00 mm reported for this species in other works (Gorochov 1993, Cordero et al. 2009, Braud et al. 2015, Reitmeier 2018). However, specimens from Madeira, both male and female, fall within the size range. In contrast, some measurements differ from previous publications. For example, the mean length of the hind femur was 7.98±0.50 mm for males from Madeira and 7.03 mm for the male from Porto Santo, deviating from the 8.70–10.00 mm range reported in other studies (Gorochov 1993, Cordero et al. 2009). Additionally, the mean length of the protruding wing was 2.59±0.32 mm for specimens from Madeira and 2.00 mm for those from Porto Santo, which is less than the 3.00–4.00 mm reported in other studies (Braud et al. 2015, Reitmeier 2018) (Table 1). Notably, the mean length of the oviscape in females exceeded the value reported by Braud et al. (2015). The specimen from Porto Santo was discovered stridulating on a stem within a one-meter-high patch of spontaneous herbaceous vegetation, predominantly characterized by *Hyparrhenia hirta* E. Fourn. This habitat was located between buildings (Fig. 4A). Several individuals were also heard during the night along the southwest coast of Porto Santo in the vicinity of Praia do Zimbralinho, Cabeço da Ponta, and Campo de Baixo (Fig. 1). Similarly, specimens from Madeira

were observed stridulating on stems in patches dominated by *H. hirta*, on Ponta de São Lourenço and Reis Magos, with the presence of plant species such as *Euphorbia piscatoria* Aiton, *Echium nervosum* Dryand., and the invasive *Opuntia tuna* (L.) Mill. on Reis Magos (Fig. 4B). Several individuals were also heard at night in Garajau and Porto Novo.

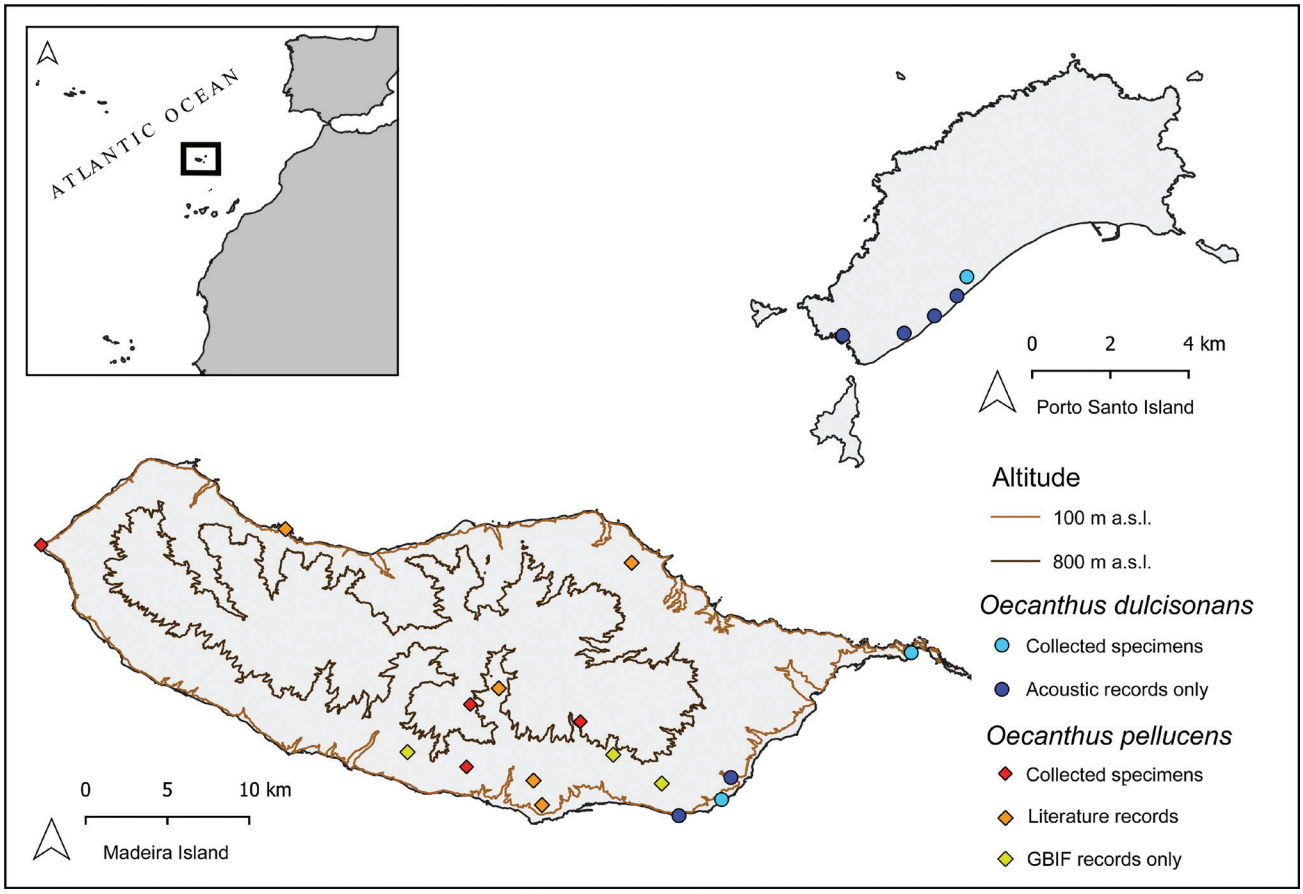

Fig. 1. Records of *Oecanthus* spp from Madeira and Porto Santo Islands. Data sources: authors' field sampling (collected specimens and acoustic records), literature (Chopard 1938, Lange 1990) and online databases (GBIF 2022).

Table 1. Morphometric data on *Oecanthus dulcisonans* and *Oecanthus pellucens*. Records from literature references and the specimens studied in this work. n = number of specimens studied, BL = body length, EL = elytra length, FL = posterior femur length, HW = length of posterior hind protruding below elytra, and OV = length of oviscape. All measurements are in millimeters.

Species	Locality	n	Sex	BL	EL	FL	HW	OV	Literature References
O. dulcisonans	Spain, Tunisia	6	♂♂	14.01±0.26	-	8.60±0.14	3.57±0.20	-	Cordero et al. 2009
	Spain	1	♀	-	-	-	-	-	
O. dulcisonans	-	-	-	14.00–17.00	-	-	3.50	-	Reitmeier 2018
O. dulcisonans	Spain, Saudi Arabia, Oman, Palestine, Cyprus	6	♂♂	15.00–17.00	14.00–16.00	8.70–10.00	-	-	Gorochov 1993
	Oman	1	♀	14.00	14.00	9.00	-	5.20	
O. dulcisonans	-	-	♂	15.00–17.00	13.00–16.00	-	3.00–4.00	-	Braud et al. 2015
		-	♀	14.00	14.00	-	-	5.20	
O. dulcisonans	Porto Santo Island	1	♂	17.34	13.28	7.03	2.00	-	This work
O. dulcisonans	Madeira Island	19	♂♂	14.44±0.55	14.18±0.68	7.98±0.50	2.59±0.32	-	This work
		2	♀♀	14.08±0.39	14.10±0.55	7.85±0.63	-	5.48±0.32	
O. pellucens	Spain	11	♂♂	10.80±0.14	-	7.60±0.17	0.42±0.10	6.00–7.50	Cordero et al. 2009
		7	♀♀	-	-	-	-	-	
O. pellucens	-	-	-	10.00–14.00	-	-	1.00	-	Reitmeier 2018
O. pellucens	-	-	♂	10.00–13.00	9.00–11.00	-	1.00	-	Braud et al. 2015
		-	♀	11.00–14.00	9.00–11.00	-	-	6.00–7.50	
O. pellucens	Madeira Island	4	♂♂	12.98±0.11	10.93±0.37	7.93±0.57	1.23±0.37	-	This work

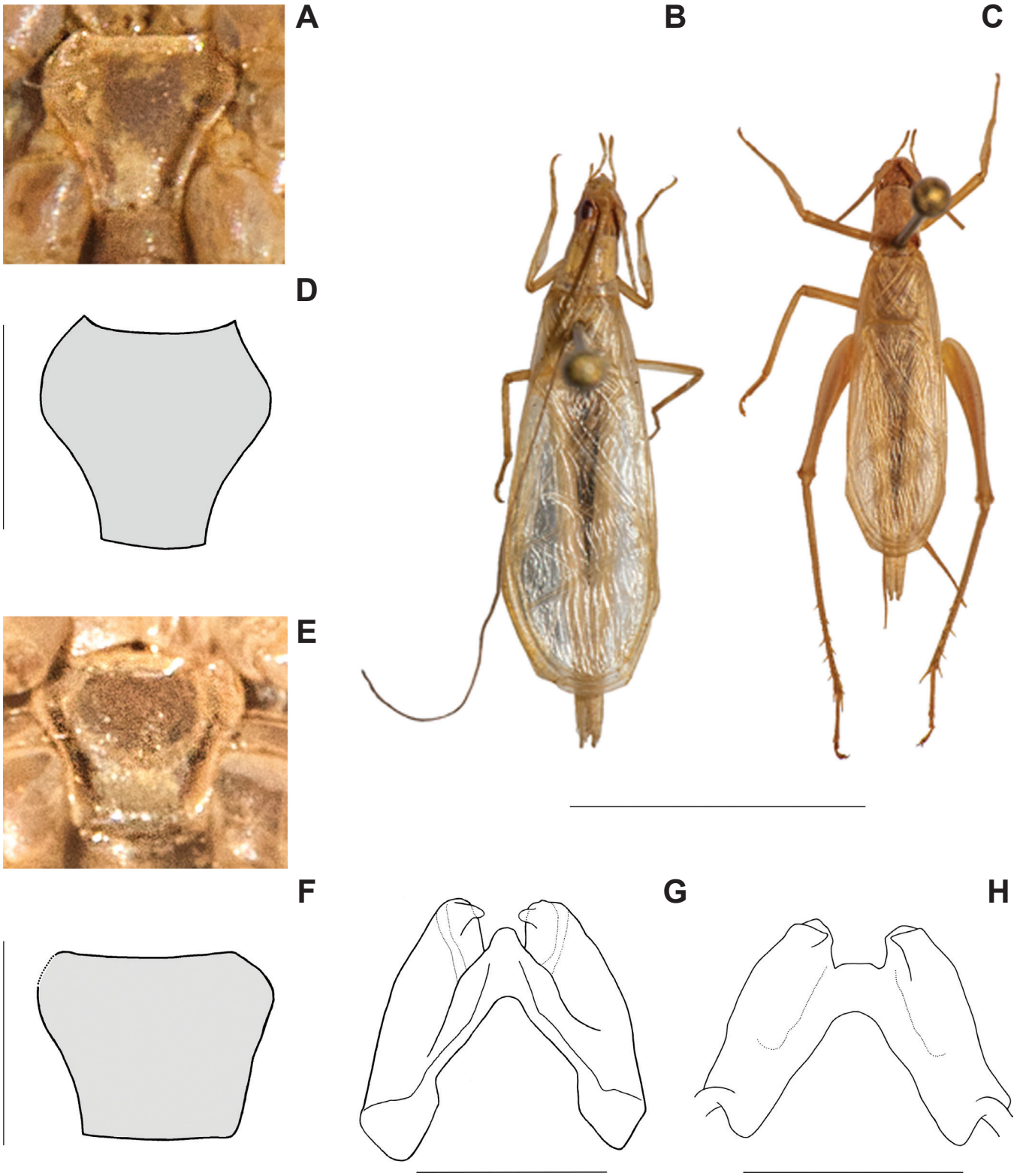

Fig. 2. *Oecanthus dulcisonans* (**A, B, D, G**) and *Oecanthus pellucens* (**C, E, F, H**) from Madeira archipelago. Metasternal plate (the dots represent parts of the structure that were not visible to draw) (**A, D, E, F**), body in dorsal view (**B, C**), and epiphallus in dorsal view (**G, H**). Photos: Thomas Dellinger. Scale bars: 1 mm (**A, D, E, F**); 10 mm (**B, C**); 0.5 mm (**G, H**).

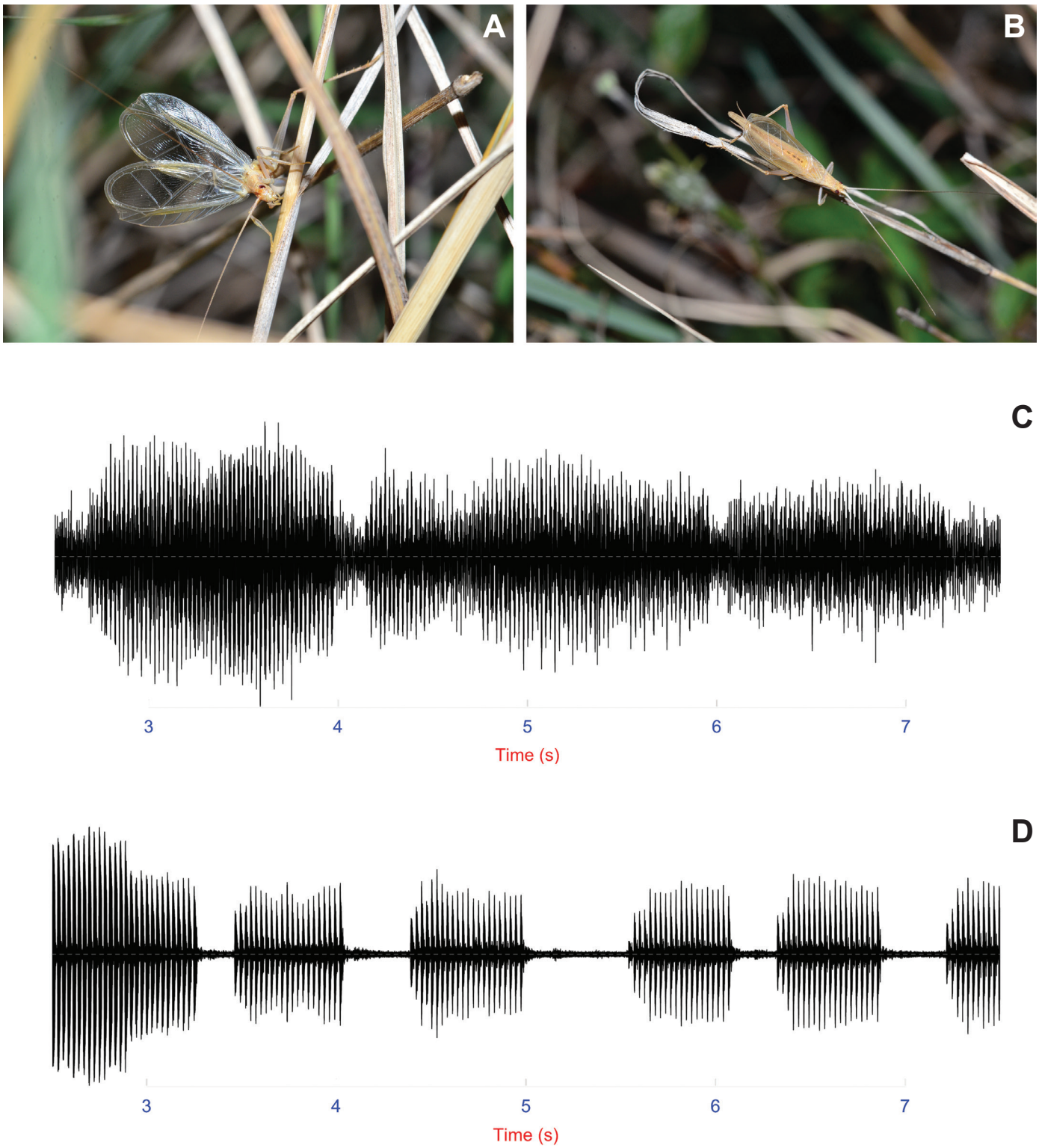

Fig. 3. Photos of *Oecanthus dulcisonans* stridulating (**A**) and standing (**B**) on *Hyparrhenia hirta* E. Fourn at Ponta de São Lourenço, Machico, Madeira Island on June 17, 2023. Photos: Howon Rhee. Oscillograms of songs of *O. dulcisonans* recorded at 23 °C in Porto Santo Island (**C**) and *Oecanthus pellucens* recorded at 22.5 °C in a laboratory with an individual from Spain by Klaus-Gerhard Heller (**D**), from the Orthoptera Species Files Online (Cigliano et al. 2023).

***Oecanthus pellucens* (Scopoli, 1763)**
Fig. 2C, E, F, H

Gryllus pellucens Scopoli, 1763: page 139
Oecanthus pellucens: Uvarov 1937: 2 [Rabaçal]; Chopard 1938: 221 [habitat]; Gardner 1960: 196 [Funchal, Santana]; Fernandes 1972: 307 [listed]; Lange 1990: 118 [Funchal, Câmara de Lobos] (records not confirmed).

Material examined.—PORTUGAL • 1♂; Madeira Island, Câmara de Lobos, Boca da Corrida; 32°42'40"N, 16°59'11"W; 1202 m a.s.l.; 25.XI.2020; G. Oliveria, T. Santos leg.; UMACI • 1♂; Madeira Island, Câmara de Lobos, Garachico; 32°40'12"N, 16°59'19"W; 439 m a.s.l.; 28.X.2018; R. Marques leg.; on: *Vitis vinifera*; UMACI • 2♂; Madeira Island, Calheta, Ponta do Pargo; 32°48'49"N, 17°15'41"W; 317 m a.s.l.; 14.VI.2023; H. Silva, H. Rhee leg.; on: *Hyparrhenia hirta* E. Fourn; UMACI • 1 Nymph; Madeira Island, Funchal, Parque Ecológico do Funchal; 32°42'25.0"N, 16°55'05.7"W; 1200 m a.s.l.; 01.VIII.2023; H. Silva, L. Soraya leg.; on: *Rumex maderensis* Lowe; UMACI.

Measurements.—MADEIRA ISLAND - ♂: BL=12.98 ± 0.11 mm (n=2); EL=10.93 ± 0.37 mm (n=4); HW=1.23 ± 0.37 mm (n=4); FL=7.93 ± 0.57 mm (n=4).

Sounds.—Regular gaps occur between each echeme in songs, which is also shown in Cordeo et al. (2009). The echeme repetition rate (the number of echeme per second) is approximately 1.0/s (Fig. 3D), which resembles the 1.0–1.5/s between 20°C and 25°C reported by Ragge and Reynolds (1998).

Notes.—The mean elytra length measurements of the males, averaging 10.93±0.37 mm, align with the reported range of 9.00–11.00 mm provided by Braud et al. (2015). Additionally, the mean length of the protruding part of the inner wings, a key feature for distinguishing this species from *O. dulcisonans*, measured 1.23±0.37 mm, surpassing the one millimeter reported by Reitmeier (2018) and Braud et al. (2015). Similarly, the mean length of the posterior femur, measuring 7.93±0.57 mm, exceeded the values reported by Cordero et al. (2009). The specimens from Ponta do Pargo were discovered stridulating on a stem within a one-meter-high patch of *Hyparrhenia hirta* E. Fourn. near a lighthouse. We also captured a nymph amid the endemic *Rumex maderensis* Lowe, where some adults of the species were also heard. Previous records of *O. pellucens* report this species from five of the ten municipalities of Madeira Island: Ribeira Brava (GBIF 2022), Funchal (Chopard 1938, GBIF 2022), Porto Moniz (GBIF 2022), Santana (Chopard 1938), and Câmara de Lobos (Lange 1990). These records are scattered across several institutions abroad, and most of them predate the description of *O. dulcisonans* in 1993. Others consist of online photographic records in which the main distinguishing character between the two species, the metasternal plate, is not visible. Since validating these records is challenging, the specimens documented in this paper represent the only valid first-hand data for this species on the Madeira archipelago. No specimens of *O. pellucens* were found on Porto Santo Island.

Discussion

Madeira now has a new *Oecanthus* species, further contributing to its overall biodiversity. This discovery holds significant value for conservation efforts and the identification of ecologically significant areas. The new records presented in this work expand the list of Orthoptera species in the Madeira archipelago to 29. Specifically, in Madeira, there are 27 species belonging to 21 different genera, while in Porto Santo, there are 13 species from 10 different genera. These records also confirm that the Madeira archipelago and the Canary Islands represent the westernmost limit of the Palearctic distributions for *O. dulcisonans* and *O. pellucens*. The presence of both species on Madeira signifies that the range extension for these species within the Palearctic region is larger than previously thought. This finding has implications for biogeographical research and enhances our understanding of the distributional patterns of these insects.

Oecanthus species are often closely associated with specific vegetation types and microhabitats (Labadessa and Todisco 2016). Such information is relevant for land management and conservation planning, especially in the context of habitat preservation and restoration. In Madeira and Porto Santo, these species are commonly found in areas characterized by tall herbaceous vegetation dominated by *Hyparrhenia hirta* E. Fourn. However, in the Canary Islands and Mallorca, the two species have been reported in different habitats and altitudinal ranges (Arechavaleta et al. 2010, Reitmeier 2018). *O. dulcisonans* tend to inhabit lower altitudes in herbaceous habitats, whereas *O. pellucens* is often encountered at higher altitudes in areas with tall trees and shrubs (Labadessa and Todisco 2016). The records from Madeira and Porto Santo further

Fig. 4. Habitats of *Oecanthus dulcisonans* in Madeira and Porto Santo: **A.** Campo de Baixo, Porto Santo Island. Photo: Tomé Freitas; **B.** Reis Magos, Caniço, Madeira Island. Photo: Hugo Silva.

confirm this pattern, with *O. dulcisonans* being prevalent at lower altitudes and *O. pellucens* at higher altitudes (Labadessa and Todisco 2016). To gain a comprehensive understanding of these species' distribution and potential interactions, additional research in the Macaronesian Islands would be necessary to determine if both species occur in sympatry or exhibit habitat segregation.

Oecanthus pellucens is abundant and widespread, spanning from southern and central Europe to northern Africa and central and western Asia (Fedor and Majzlan 2001). The Madeira archipelago has many xerothermic habitats characterized by dry, tall vegetation, which are well suited for the feeding and breeding of *Oecanthus* species (Brizio and Buzzetti 2014). However, available records from Madeira and other Macaronesian archipelagos suggest that these species may be relatively rare in this region. Since its first record in 1938, only 17 specimens of *O. pellucens* have been collected in Madeira. Similarly, in the Canary Islands, despite being found on multiple islands such as Tenerife, Gran Canaria, La Gomera, La Palma, and El Hierro, there have been relatively few reported specimens (Krauss 1892, Burr 1911, Willemse 1936, Chopard 1942, Chopard 1954, Gangwere et al. 1972, Bland et al. 1996, Gangwere et al. 1998). Furthermore, there was a recorded presence of this species from the Faial and Pico islands in the Azores by Massa in 1999, but subsequent reports have been absent (PBA 2023).

Acoustic monitoring and recording of individuals can serve as valuable methods for studying the distribution and population density of these tree crickets (e.g., continuous echemes for *O. dulcisonans* and non-continuous echemes for *O. pelluscens*). During our field trips to Madeira, we collected only two specimens of *O. pellucens* on the island's western point. In contrast, we collected 21 specimens of *O. dulcisonans* from two different locations, suggesting that the species might be more abundant in certain areas. Additionally, we heard its distinctive stridulations in various places at lower altitudes along the island's south coast. Similarly, during our field trip to Porto Santo, we observed several individuals of *O. dulcisonans* engaged in stridulating near Praia do Zimbralinho, Cabeço da Ponta, and Campo de Baixo, suggesting a potentially widespread distribution throughout the island.

Further studies are needed to assess the potential risks confronting *Oecanthus* species in the Madeira archipelago. In Madeira, the natural vegetation depletion of the south coast, particularly at lower altitudes, has drastically reduced suitable coastal habitats for the species. Additionally, habitat fragmentation at higher altitudes presents significant challenges. It is essential to confirm the presence of the species on the north side of the island to assess the potential risks they encounter in Madeira. In Porto Santo, erosion and nutrient runoff have been impoverishing the soil since the 15th century (Cameron et al. 2006, Antunes et al. 2008). In the last decade, the intensive construction of tourist infrastructure has further diminished coastal areas with suitable vegetation.

Enhancing our knowledge of the orthopteran fauna in the Madeira archipelago, particularly of Porto Santo Island, remains a priority. Comprehensive research is urgently required to better understand the species inhabiting these increasingly fragile and reduced habitats. Only with a solid understanding of the local fauna can we formulate effective conservation strategies. Similarly, an in-depth investigation of the orthopteran fauna of Madeira Island is essential. Analyzing their ecology and morphological variations will aid in finding externally recognizable characters to facilitate the identification of these variable species and provide valuable insights into their preferred habitats. Furthermore, considering the size variations noted in specimens from the Madeira archipelago, conducting genetic comparisons with specimens from the remainder of Europe can provide additional insights into the populations of Orthoptera in Madeira. Moreover, the discovery of *Oecanthus* crickets in Madeira offers a unique opportunity to engage the public and students in the importance of biodiversity and conservation. These findings can be used for educational outreach programs to raise awareness about the island's unique insect fauna.

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