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First report of *Scaphoideus titanus* for Madeira Island

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This is the first report of *Scaphoideus titanus*, the main vector of flavescence dorée, for Madeira (Portugal) and also for Macaronesia. This new record currently represents its southernmost occurrence in Europe. This leafhopper is present in most of the primary wine production regions in the north of Madeira island. There were no symptoms of flavescence dorée disease during the monitoring period from 2010 to 2017. The ability of *S. titanus* to survive in regions with a subtropical climate suggests that it may also live in the most meridional areas of the Mediterranean region where, until now, it has been absent.

The presence of *Scaphoideus titanus* in Madeira

Scaphoideus titanus (Hemiptera: Cicadellidae) is the vector of flavescence dorée, a key grapevine phytoplasma disease in Europe causing annual losses of tens of millions of euros (Steffek *et al*., 2007; Dermastia *et al*., 2017). Until now, the southernmost limit of the distribution of *S. titanus* in Europe was mainland Portugal. In this country, the first specimens were collected on *Vitis vinifera* in the northern region (Vila Real and Arcos de Valdevez) in 1998 (Quartau *et al*., 2001). The flavescence dorée pathogen was identified in 2003 from samples from the same region. Since then, both the vector and the disease have spread from Northern Portugal to the wine-producing regions of Central Portugal (de Sousa *et al*., 2011, 2013). After its discovery, in accordance with the national Ordinance N° 165/2013 (MARDF, 2013), regular monitoring also began in the Madeira archipelago. This study reports *S. titanus* for the first time on the island of Madeira and the Macaronesian archipelagos (Madeira, Azores, Canary Islands and Cape Verde). Due to the unique volcanic soil, the wine produced in these islands is of high quality. Although the grapevine production area is small, each archipelago has its own wine with a Protected Designation of Origin (PDO).

Monitoring activities to detect *S. titanus* were carried out in the archipelago of Madeira, in Madeira and the Porto Santo islands, from 2010 to 2017 (Fig. 1). Madeira is a grapevine-growing region known for producing high-quality wines that date back to the end of the 15th century. The leading brand, 'Madeira,' a world-famous wine since the 16th century, and 'Madeirense' are exported to about 30 countries, and currently provide one of the main revenues of the island (IVBAM, 2020). The Madeira archipelago of volcanic origin is in the Atlantic Ocean, about 600 km from Morocco and 800 km from the south of the Iberian Peninsula, the nearest continental points. Madeira (741 km^2, highest altitude 1862 m) and Porto Santo (42 km^2, highest altitude 517 m) are the only inhabited islands in the archipelago (Aguín-Pombo & Pinheiro de Carvalho, 2009; Fig. 1).

The island of Madeira is very steep, crossed by a mountain chain from east to west that divides it into two zones (north and south) with two types of ocean-influenced climates: temperate and subtropical, respectively. The 71 vineyards studied in Madeira represent the main grapevine production regions of these two zones. In Porto Santo, an arid and dry island with little vegetation, the cultivation of grapevine is limited. On this island, samples were taken from only one location. The number of plots, sites and samples in Madeira Island varied from year to year. Yellow chromotropic sticky traps were used for monitoring. The traps were placed in the grapevine canopy and replaced with new ones approximately every 2 weeks. On the island of Madeira, monitoring began in 2010 on 26 January and continued that year until 22 November. From 2011 to 2017, monitoring started from May or June and lasted until October or December. In most places, the sampling period took place over 1 or 2 years, but in five experimental vineyards, it extended to 7 or 8 years. In Porto Santo, monitoring was carried out in 2016 and 2017. The authors studied 4696 samples/traps (4654 from Madeira and 42 from Porto Santo).

The results showed that there were no symptoms of flavescence dorée in the last 10 years (2010–17 until 2019, Adelaide Fernandes, *pers. comm.*). Therefore, it can be assumed that the archipelago is free of the disease. *S. titanus* was found only on the island of Madeira in

The data that support the findings of this study are available from the corresponding author upon request.

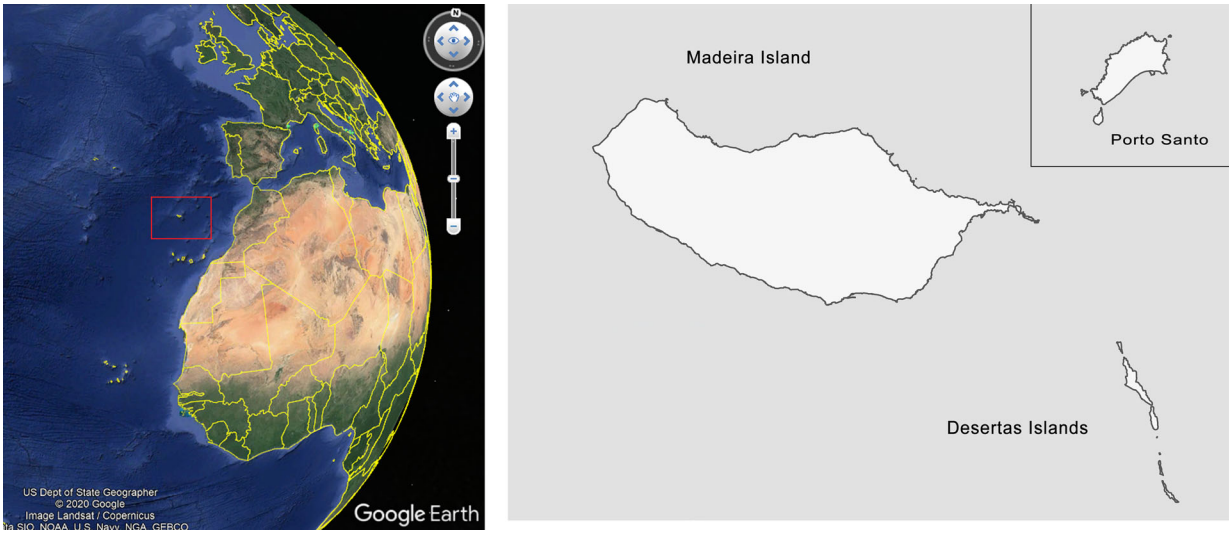

Fig. 1 Map of the Madeira Archipelago. [Colour figure can be viewed at wileyonlinelibrary.com]

vineyards at altitudes of 71–408 m. The vector was present in 36% of the 72 vineyards monitored throughout the archipelago from 2010 to 2017. The first specimens (nine individuals) were found in 2010 on 30 July. At present, *S. titanus* is common in the main wine-producing areas in the north of Madeira island. The large number of sites with *S. titanus* suggests that was established before 2010. Due to the isolation of the archipelago from the mainland, trade of *Vitis* planting material with eggs is the only possible pathway of arrival. Human trade is the most common route for invasive species in Madeira (Aguin-Pombo *et al*., 2010a,b) and the means of diffusion of *S. titanus* in Europe (Bertin *et al*., 2007). Vector entry after 2010 is less likely because *Vitis* plants can only be imported if they have a phytosanitary certificate.

Leafhopper samples were collected in all the monitoring years (Fig. 2). In the laboratory, the leafhoppers of each trap were counted. Since there are no other leafhopper species similar to *Scaphoideus* in Madeira (Aguin-Pombo & Freitas, 2008), the specimens were easily identified. Also, some males were removed from the traps with a drop of limonene and their genital structures studied. As in Europe, in Madeira *S. titanus* occurs on *Vitis*, is univoltine and hibernates in the egg stage (Chuche & Thiéry, 2014). Knowledge of Madeira leafhoppers and planthoppers is still incomplete (Aguin-Pombo & Freitas, 2008). Therefore, the occurrence of other important vectors of grapevine diseases, such as *Hyalesthes obsoletus* (Kehrli *et al*., 2010) or *Osbornellus auronitens* (Trivellone *et al*., 2017), cannot be completely excluded (Trivellone *et al*., 2016). Future studies should focus on the distribution and biology of *S. titanus*, as well as on the leafhopper and planthopper fauna associated with vineyards (Table 1). This information is necessary to understand the epidemiology of flavescence dorée disease and to choose the best pest management procedures, in addition to knowing if vectors of other diseases are present (Lessio *et al*., 2011; Bostanian *et al*., 2012).

Conclusion

The new record shows that *S. titanus* can overwinter and develop large populations in areas with mild climate. Future studies in Madeira should focus on the biology of the vector in these new environmental conditions. This information is necessary to determine its potential range and, consequently, re-evaluate the present pest risk analysis.

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Premier signalement de *Scaphoideus titanus* sur l'île de Madère

Il s'agit du premier signalement de *Scaphoideus titanus*, le principal vecteur de la flavescence dorée, à Madère (Portugal) et en Macaronésie. Ce nouveau signalement correspond actuellement à sa présence la plus méridionale en Europe. Cet insecte vecteur est présent dans la plupart des principales communes viticoles de l'île de Madère. Aucun symptôme de la maladie de la flavescence dorée n'a été observé au cours de la période de surveillance de 2010 à 2017. La capacité de *S. titanus* à survivre dans des régions au climat subtropical suggère qu'il pourrait

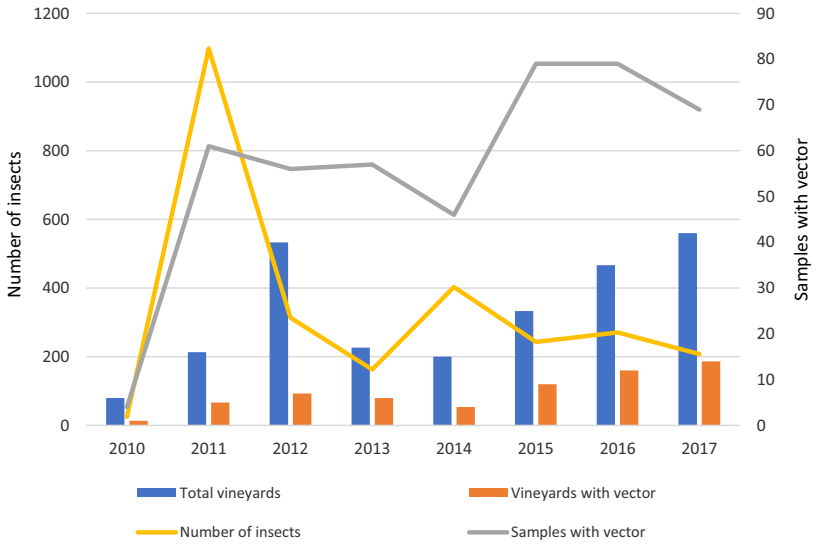

Fig. 2 Yearly recorded numbers of insects caught in yellow sticky traps, of samples and vineyards with *S. titanus*, and total number of vineyards studied from 2010 to 2017. [Colour figure can be viewed at wileyonlinelibrary.com]

Table 1. Urgent recommendations for future monitoring of *S. titanus* in Madeira

Goal	Future work
Distribution range	Sampling vineyards at higher altitudes
Host plants	Monitoring the nearby vegetation annually
Number of vectors	Sampling of potential leafhopper vectors on vineyards and nearby wild plants
Number of generations	Regular monitoring of adults and immatures
Timing of eclosion	Study vineyards representative of different altitudes

également vivre dans les zones les plus méridionales de la région méditerranéenne, où, à ce jour, il est absent.

Первое сообщение о *Scaphoideus titanus* на острове Мадейра

Это первое сообщение о *Scaphoideus titanus*, основном переносчике flavescence dorée, для Мадейры (Португалия), а также для Макаронезии. Это новое обнаружение в настоящее время является самым южным из зарегестрированых в Европе. Это насекомое-переносчик присутствует в большинстве основных винодельческих районов острова Мадейра. В период мониторинга с 2010 по 2017 год симптомов заболевания flavescence dorée не наблюдалось. Способность *S. titanus* выживать в регионах с субтропическим климатом позволяет предположить, что он может также жить в наиболее меридиональных зонах Средиземноморского региона, где на данный момент он отсутствует.

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