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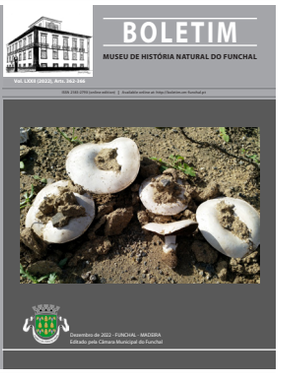

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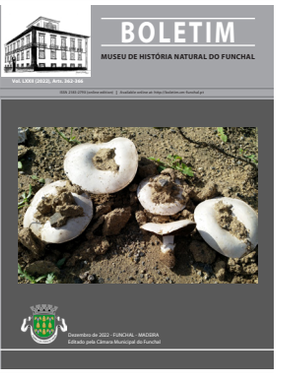

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Conservation actions in Polystichum drepanum (Sw.) C. Presl, a critically endangered fern from the island of Madeira

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With 1 figure

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ABSTRACT: *In vitro* culture techniques, using spores, were used to propagate the critically endangered fern *Polystichum drepanum*, in order to reinforce its known natural populations. In 1998 and 2010, a total of 194 plants of *P. drepanum* were reintroduced at Ribeira do Inferno, a historical habitat of this species and the source of the spores used in this research. In 2021, we observed that, only two of those plants had survived, without any indication of natural regeneration. Reintroduction failures and new reintroduction actions are discussed herein in order to promote the long-term conservation of this species.

Key words: *in vitro* propagation, critically endangered, fern, *Polystichum drepanum*, Madeira Island.

RESUMO: A técnica de cultura *in vitro* foi utilizada para propagar, através dos esporos, o feto, criticamente ameaçado de extinção, *Polystichum drepanum*, a fim de reforçar as suas populações naturais conhecidas. Em 1998 e 2010, um total de 194 plantas de *P. drepanum* foram reintroduzidas na Ribeira do Inferno, habitat histórico desta espécie e origem dos esporos utilizados neste trabalho. Em 2021 observamos que apenas duas dessas plantas sobreviveram, sem indícios de regeneração natural. Falhas na reintrodução e novas ações de reintrodução são discutidas a fim de promover a conservação desta espécie a longo prazo.

Palavras-chave: propagação *in vitro*, criticamente em perigo, feto, *Polystichum drepanum*, ilha da Madeira.

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INTRODUCTION

The word *Polystichum* is derived from the Greek word *polys*, which means many, and *stichos*, meaning line, in reference to the many rows of spores that the various species of *Polystichum* have (Jonhson & Smith, 1931). The genus *Polystichum* comprises between 160 and 200 species (Roux, 2005). In Macaronesia (for the purposes of this paper, considered as encompassing the archipelagos of Azores, Madeira, Selvagens, Canary Islands and Cape Verde), this genus is represented by five *taxa*: *Polystichum drepanum* (Sw.) C. Presl, *Polystichum falcinellum* (Sw.) C. Presl, *Polystichum* x *maderense* J. Y. Johnson, all endemic to the island of Madeira (Eriksson *et al*., 1979; Vieira, 1992; Hansen & Sunding, 1993; Press & Short, 1994; Jardim & Francisco, 2000; Jardim & Sequeira, 2008); *Polystichum setiferum* (Forssk.) T. Moore ex Woynar, with a more widespread distribution, occuring in Britain, Europe and North Africa (Roux, 2005) and which is native to the island of Madeira (Press & Short, 1994; Jardim & Sequeira, 2008), as well to the archipelago of the Azores (all islands; Silva *et al*., 2010) and the archipelago of the Canary Islands (El Hierro, La Palma, La Gomera, Tenerife and Gran Canaria, according to Acebes Ginovés *et al*., 2010); *Polystichum aculeatum* (L.) Roth, is native to the archipelago of the Canary Islands (La Palma, La Gomera and Tenerife, according to Acebes Ginovés *et al*., 2010). The archipelago of Cape Verde does not have any representative taxon from this genus (Sánchez-Pinto *et al*., 2005). There was another endemic *taxon*, formerly included under *Polystichum*, (*P. webbianum*) that now is treated as *Arachniodes webbiana* (A. Braun) Schelpe (Manton *et al*., 1987).

In the XIX century, Lowe (1851), under the specific name of *Aspidium drepanum* Sw, saw "abundant wild specimens" of this fern on the island of Madeira. Now, *P. drepanum* it is reportedly one of the rarest species worldwide (Christenhusz *et al*., 2017), having suffered at the hands of over-zealous collectors (Benl, 1971).

According to the IUCN Red List of Threatened Species and other authors, *Polystichum drepanum* is listed as Critically Endangered with 40-50 mature individuals (Jardim *et al*., 2006; Christenhusz *et al*., 2017; García Criado *et al*., 2017). This species is also listed in the top 100 Management Priority Species for the European archipelagoes of Azores, Madeira and the Canary Islands, taking into account both their protection priority and management feasibility (Jardim *et al*., 2008). According to Jardim & Sequeira (2008), *P. drepanum* is a protected and prioritary species under the Bern Convention and Habitats Directive (Annexes II and IV), restricted to the *Ocotea* laurel forest (*Laurissilva do Til*), an habitat within the protected area of Madeira Natural Park and the European Commission legislation, through the Natura 2000 network, under the designation of "Laurissilva da Madeira". *P. drepanum* has an extremely fragmented distribution in the valleys and slopes of the north coast of the island of Madeira, where it is confined to ravines in shady, wet places under laurel forest.

MATERIAL AND METHODS

1. *In vitro* propagation – Madeira Botanical Garden (MBG) propagated this species by sowing spores using i*n vitro* techniques adapted from Chá-Chá *et al*. (2005).

1. 1. Spores – Fronds with ripe sporangia were collected from live plants of MBG (Fig. 1A), and preserved in paper bags, at room temperature, until sterilization. After a few days in the bag, the sporangia opened and spores are dispersed inside it.

1. 2. Sterile conditions – Petri dishes and goblets were sterilized for 4 h at 160 °C. Culture medium, water, eppendorfs, and micropippete tips were sterilized at 120 °C (1 atm.) for 20 min. All sowing of the spores, on the culture medium, were made at sterile conditions in a laminar horizontal flow hood.

1. 3. Spores disinfection – Spores were surface disinfected for 5 min. in 5% commercial sodium hypochlorite solution in a sterilized eppendorf, then washed 3 times in sterile, distilled water (disinfection solution and water were separated from spores by centrifugation at 13,000 rpm).

1. 4. Spores transfer to medium – Disinfected spores were resuspended in sterile distilled water; 100 µl of this solution, containing spores, were transferred to 13.5x3 cm glass flasks with 10 ml of culture medium, using a micropipette.

1. 5. Spores culture – Spores were sown in MS medium (Murashige & Skoog, 1962) supplemented with sucrose at 20 g/l. The pH was adjusted to 5.5, before adding 6.0 g/l of agar. Culture medium was prepared from stock solution MS major salts (10x), MS minor salts (100x), MS vitamins (500x). Spores were kept in culture chambers, equipped with temperature and light control, at 20 °C ± 1 °C, under a 16 h/day photoperiod.

1. 6. Sporophyte induction – After spores had developed into prothallus [gametophyte stage], sterilized water was added to the glass flasks to promote fertilization and sporophyte growth.

1. 7. Acclimatization – *In vitro* sporophyte plants were washed in water to remove the agar, transferred to pots containing a substrate consisting on peat and perlite (50/50 mix) and transferred to a green house at room temperature.

2. Reintroduction – After growth of sporophyte, plants in the green house with 3-year growth were reintroduced into natural habitat, with each individual fern planted in isolation.

RESULTS

In 1998, the MBG, the former Madeira Natural Park (now, IFCN - *Instituto das Florestas e Conservação da Natureza, IP-RAM*) and the Conservatoire Botanique National de Brest (CBNB) drew up an integrated conservation programme for *P. drepanum* which included *in situ* and *ex situ* actions, namely population reintroduction, monitoring of new populations, *in vitro* propagation, and live population maintenance in MBG.

CBNB have propagated *P. drepanum* by spores, since 1979 from one adult specimen taken from Ribeira do Inferno on the north coast of the island of Madeira (the exact location is kept confidential due to plant security reasons) (Lesouëf, 1999) and in July 1998 sent a total of 120 plants propagated from this one specimen, to the island of Madeira. Seventy of them were reintroduced into the original locality (Ribeira do Inferno) and the rest were planted in the MBG and around the Forestry House at Encumeada (Lesouëf, 1999).

MBG propagated species growing at MBG using *in vitro* propagation by spores techniques described above in the materials and methods. It was found that spores started to germinate after 22 days in culture (Fig. 1B) and after two months, the prothallus [gametophyte stage] were evident in the glass flasks (Fig. 1C). After six months (Fig. 1D), water was added to the glass flasks, to promote sporophyte growth (Fig. 1E). In April 2010, MBG took 124 of their *in vitro* propagated plants and reintroduced them into Ribeira do Inferno.

In total therefore, 194 plants were reintroduced into Ribeira do Inferno between July 1998 and April 2010. In 2021, a survey of the areas where these two reintroductions had taken place recorded only two surviving reintroduced plants and noted that there was no indication of natural regeneration.

DISCUSSION

Conservation of threatened species combines both *ex situ* and *in situ* measures within an integrated conservation programme. Conservation *in situ* (*e.g*., natural area protection and management and threat abatement) must always be the preferred policy to protect species, however, in some cases human intervention and *ex situ* conservation (*e.g*., botanical gardens, seed or DNA banks, *in vitro* culture, reintroduction, etc.) is necessary to support long-term conservation.

P. drepanum is a tetraploid (n = 82) fern (Manton *et al*., 1987). Polyploid species are expected to self-fertilize (termed 'selfing') more often than diploids, because genome duplication initially mitigates the effects of genetic load. Because selfing enables a single individual to reproduce in a new location, this ability to self-fertilize may often be an important component of population establishment following long-distance dispersal (Flinn, 2006). The rarity of *P. drepanum*, however, despite being a polyploidy fern, implies it is not efficient at selfing or long-distance dispersal and colonization and conservation programmes should consider this.

Reintroduction is a technique to restore or establish plant populations to enable them to become self-sustaining in natural habitats (Akeroyd & Jackson, 1995). It is the intentional movement and release of an organism inside its indigenous range from which it has disappeared (IUCN/SSC, 2013). According to IUCN/SSC (2013), "Conservation translocations consist of (i) reinforcement and reintroduction within a species' indigenous range, and (ii) conservation introductions, comprising assisted colonisation and ecological replacement, outside indigenous range". IUCN/SSC (2013) goes on to note that "It is increasingly recognised that, while species conservation remains a priority for conserving biodiversity, reintroduction needs to be undertaken in the context of the conservation and restoration of habitats and ecosystem services".

In vitro methods of propagation can be used to help preserve endangered plants (Fay, 1992; Fernandes *et al*., 1999; Maryam *et al*., 2014), reintroducing the propagated specimens to reinforce known natural populations. The *in vitro* technique, described in this paper, has proved to be effective in obtaining plants from spores for *P. drepanum* but the survival rate of reintroduced plants has not been shown to be effective in reinforcing known natural populations.

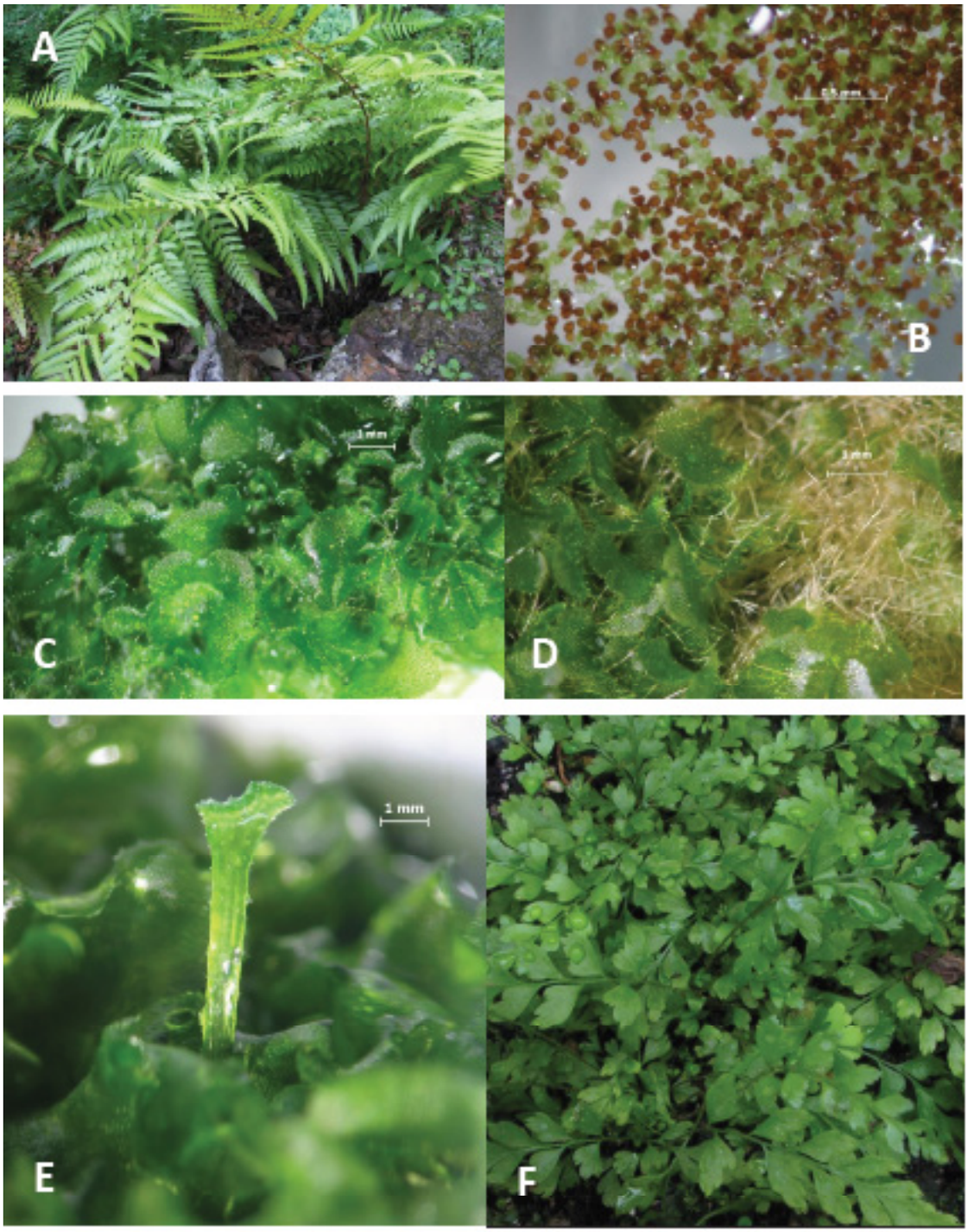

Fig. 1 – *In vitro* germination of spores and acclimatization of *P. drepanum*: **A** – Spore source plant at MBG; **B** – Spores germination; **C**, **D** – Prothallus (gametophyte stage); **E** – Beginning of sporophyte; **F** – Plant acclimatization in green house (photos taken by the first author and published in Gouveia *et al*. (2010).

The process of plant reintroduction combines the art and science of horticulture, ecology, and evolution (Maschinski & Albrecht, 2017). Reintroduction of native species has become increasingly important in conservation worldwide, however, many projects illustrate that various plant species seem to be particularly difficult to reintroduce and are considered as a relatively high-risk, high-cost activity (Godefroid *et al*., 2011). Although early efforts to reintroduce plants into the wild often suffered from failure (Falk *et al*., 1996), practitioners have since refined the practice of reintroduction and shared their experiences of success and failure for the sake of improving future practice (Maschinski & Haskins, 2012).

A number of factors can be considered to improve plant reintroductions, namely: propagule material type (*e.g*. spore, sporophyte, etc.); number of individuals reintroduced, provenance of material introduced, and demographic status of source population, introduction method and management of out-planting sites (Godefroid *et al*., 2011). In determining sites for plant reintroductions, the focus must be placed on defining the former distribution borders and historical habitat of species (Gorbunov *et al*., 2008), but should satisfy the same conditions (Akeroyd & Jackson, 1995; Gorbunov *et al*., 2008; IUCN/SSC, 2013; Soorae, 2013).

Considering possible shortcomings in the two reintroductions of *P. drepanum* in 1998 and 2010, it could help to define what could be improved for outcomes that are more successful. Godefroid *et al*. (2011) suggests that reproductive failure and genetic decline in reintroduced populations is likely to accelerate in subsequent generations. The fact that all specimens reintroduced at Ribeira do Inferno in 1998 and 2010 originated from one single founding individual, may be considered sub-optimal and it is recommended that future reintroductions ensure the specimens are propagated from different natural origins.

Future reintroductions should also consider establishing populations with greater than 50 plants, with relatively high planting densities (Maschinski & Haskins, 2012). Additionally, since this species has a global population that is fragmented and isolated, with less than 50 individuals in total, a review or study its genetic information to inform future reintroductions, may help improve the process (Maschinski & Albrecht, 2017).

Overall it is noted that reintroduction as a means of restoring or increasing the viability of plant populations is not an easy exercise. The whole procedure may take many years, is time consuming and is expensive (Akeroyd & Jackson, 1995). Setting clearly defined success criteria, ensuring sufficient monitoring over the years and having adequate documentation, may all help improve the design of future reintroductions (Godefroid *et al*., 2011). This paper helps document reintroductions of *P. drepanum* and make some observations and recommendations. It is hoped that this might facilitate improved success of future reintroductions of this species.

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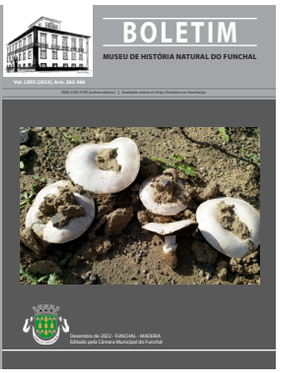

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Unveiling the provenance of cultivated *Taxus baccata* L.(Taxaceae) on the island of Madeira

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With 1 figure and 2 tables

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ABSTRACT: *Taxus baccata* L. (yew) is native to the island of Madeira and wild plants have been shown to belong to a relict lineage, that only exists in Macaronesia. In Madeira, this species has been used as an ornamental plant since at least the 19th century. But, scarcity of native plants, mostly due to over exploitation since the 15th century, which pushed the species to the fringe of extinction, led to the introduction in Madeira of yew plants from Europe. Currently, there are several yew plants in gardens and parks in Madeira, but there are many doubts as to their origin and the possibility of their use in programs for the conservation of the Macaronesian lineage of *T. baccata*. This work aims to clarify the provenance of these yew specimens, through the sequence analysis of the chloroplast *trnS-trnQ* intergenic spacer. All the wild yew plants analysed belong to the Macaronesian haplotype group, whereas all cultivated yew plants in the dataset are consistent with the Euro-Mediterranean lineage and indicative that all these plants are from Continental provenance.

Key words: *Taxus baccata*, relict lineage, cultivated, provenance.

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RESUMO: *Taxus baccata* L. (teixo) é uma espécie nativa da Madeira, pertencendo as plantas selvagens a uma linhagem relíquia, que apenas existe na Macaronésia. Na Madeira, esta espécie é utilizada como planta ornamental pelo menos desde o século XIX. Desde então, a escassez de plantas nativas, principalmente devido à sua sobre-exploração desde o século XV e que levou a espécie à beira da extinção, determinou a introdução na Madeira de plantas de teixo provenientes da Europa. Presentemente existem várias plantas de teixo em jardins e parques ao longo da Madeira, mas existem muitas dúvidas sobre a sua origem e a possibilidade da sua utilização em programas de conservação da linhagem Macaronésica de *T. baccata*. Este trabalho visa clarificar a proveniência desses exemplares de teixo, através da análise de sequências do espaçador intergénico *trnS-trnQ* do ADN cloroplastidial. Os resultados mostram que todas as plantas de teixo selvagens analisadas são do haplótipo Macaronésico, enquanto que todas as plantas de teixo cultivadas são consistentes com a linhagem Euro-Mediterrânica, indicativo de que serão todas de proveniência Continental.

Palavras-chave: *Taxus baccata*, linhagem ancestral, cultivadas, proveniência.

INTRODUCTION

Taxus baccata L. (yew) is a dioecious tree, native to most of Europe, the Atlas Mountains in northern Africa and to the Caucasus Mountains in Asia minor (Benham *et al*., 2016). It is a relic tree species, with fossil records showing its existence during the upper Miocene(0 - 15 million years BP) (Hageneder, 2007), although closely related species have been dated back to the Jurassic period, around 140 million years BP (Hartzell, 1991).

Paleobotanical studies, focusing the Quaternary period (ca. 11.000 years BP), show that, at that time, *T. baccata* populations would have been more abundant and with a wider distribution in Europe than nowadays (Deforce & Bastiaens, 2007). During the late Holocene (from *ca*. 4000-3000 years BP), paleobotanical records indicate a general decline in fossil evidence of *T. baccata*, showing a notable retreat of the yew populations. This decline has been associated to several biological, environmental and anthropic factors, namely climate warming during the Late Holocene and, probably most importantly, exclusive competition with other tree species associated with anthropic activities, such as deforestation, selective felling, grazing and use of wood for tool production (Pérez-Díaz *et al*., 2013).

Presently, *T. baccata* is a declining or even a threatened species in several countries where it is native (Svenning & Magård, 1999; Catarino, 2007; Abella, 2009; Piovesan *et al*., 2009; Katsavou & Ganatsas, 2012; Tumpa *et al*., 2022). The species is rarely found in pure monospecific stands. Instead, it most frequently belongs to diverse forest communities, which, for hosting yew, have been designated as special protection areas by the European Community under the Habitats Directive (92/43/EEC): Mediterranean *Taxus baccata* woods – 9580; Apeninne beech forests with *Taxus* and *Ilex* – 9210; Atlantic acidophilous beech forests with *Ilex* and sometimes also *Taxus* in the shrub layer (*Quercion robori-petraeae* or *Ilici-Fagenin*) – 9120 (European Council, 1992; Benham *et al*., 2016).

T. baccata is also native to the archipelagos of Madeira and the Azores. These are part of Macaronesia, a region that includes five north Atlantic archipelagos (Azores, Madeira, Selvagens, Canaries and Cape Verde) and which is included in the Mediterranean basin biodiversity hotspot (Myers, 2000). This region hosts a high number of plant endemics (Jardim & Sequeira, 2008) and encompasses relict plant lineages and species representative of by-gone continental vegetation types, that occurred over Europe during the Tertiary and Quaternary, gone extinct due to sever climate change events during the Quaternary (Vargas, 2007; Fernandez-Palacios *et al*., 2011; Garcia-Verdugo *et al*., 2019).

Recent morphological, ecological, and molecular investigations on Madeiran and Azorean *T. baccata* indigenous plants (Schirone *et al*., 2010; Vessella *et al*., 2013) evidenced several differences from the continental (Eurasian and North African) co-specifics and showed that Madeiran and Azorean yew plants are in fact a relict lineage of the ancestral form of *T. baccata*. These studies point out the need for further studies to assess the evolutionary history and bio-ecology of this lineage and to define an appropriate taxonomic rank for Macaronesian yew lineage.

Unfortunately, in Madeira, as in the Azores, native *T. baccata* is in the fringe of extinction due to over exploitation for timber since the first human settlements in

the 15th century (see Vessella *et al.*, 2013 for a comprehensive account on the historical occurrence and use of wild *T. baccata* in Madeira). In the island of Madeira, although all wild specimens occur within the Natural Park and within two Natura 2000 Network SACs, *i.e.*, "Laurissilva" and "Maciço Montanhoso Oriental", wildfires during the past years have pushed the species even further towards extinction in the wild. Natural populations are currently restricted to a small number of isolated patches, most of them comprising one or few scattered individuals. Despite the rarity of the species, documented since the 19th century (Lowe, 1857, 1862; Taylor, 1882), no information on measures for its recovery is available. During the 20th century, the species was hardly used in forestry recovery programs in Madeira (Campos de Andrada, 1990), probably due to difficulties in propagating the species and the slow growth of the plants (Madeira Forestry Department records).

Despite *T. baccata* having experienced one of the sharpest declines of all European tree species (Benham *et al.*, 2016), for centuries it has been used as an ornamental tree in Europe. The evergreen foliage, red berries, high tolerance to shade and pruning, as well as superstitions and myths built around the species, are some factors that have contributed to this use (Thomas & Polwart, 2003; Catarino, 2007; Abella, 2009). In Madeira, it seems that yew has been used as an ornamental tree since at least the late 19th century (Taylor, 1882). During the 18th century and until the late 19th century, British merchants occupied a pivotal position in the strong growth of the Madeiran economy, as a result of the commodification of Madeiran products, such as wine, real estate and sugar. These wealthy families built or purchased manor houses (*Quintas*), estates of ample proportions which included lawns and beds of exotic plants marked by shade trees, such as oaks, stink-laurel or other less common species (Silva, 2013). Of the latter, yew would have likely fallen into preference, due to its extensive use in Britain as hedging, specimen trees and for topiary. The scarcity of plants of the Madeiran indigenous yew during the late 19th century (Lowe, 1857, 1862; Taylor, 1882; Menezes, 1894) may have led to the introduction in Madeira of yew plants from Europe. This import of plants would have continued during the 20th century, aided by the construction of well-appointed gardens mostly for hotels (Franco *et al.*, 2010) and facilitated by the development of commercial plant nurseries in Madeira. The presence of distinct lineages of yew (Euro-Mediterranean and Macaronesian) in Madeira has been showed by Vessella *et al.* (2013). According to these authors, although plants from Madeiran provenance show peculiar leaf size and morpho-anatomical characters, distinguishing them from Continental provenance ones, based on morphological characters, is still complex.

Presently, several plants of *T. baccata* can still be found in several manor house (*Quintas*) gardens, public gardens (Quintal, 2007), roadsides and even in forest parks in Madeira. Their location, in reference to the native plants' location and habitat, suggests that they were most likely introduced by man, but there are many doubts regarding the provenance of these cultivated plants, whether they are native or introduced. In almost all cases, no historical records on the provenance of the plants exists.

The scarcity of known Madeiran *T. baccata* plants and its high risk of extinction calls for urgent conservation measures. The lack of wild plants and seed availability may lead to collecting yew plant material for propagation where it is easily available, such as gardens and forest parks. Given the difficulties to distinguish between plants of the Macaronesian and Euro-Mediterranean lineages, it is of utmost importance that the origin of the cultivated plants is determined, and thus avoid crossbreeding and assuring the conservation of the Macaronesian lineage. This study aims clarifying the provenance of the cultivated yew specimens in Madeira and contribute to the conservation of the Macaronesian lineage of *T. baccata*.

MATERIAL AND METHODS

Cultivated *T. baccata* plants' lineage was assessed through DNA sequence analysis of the chloroplast *trnS–trnQ* intergenic spacer, located in the large single-copy region of the plastid genome, between trnS and trnQ coding regions. This marker was used for the first time by Hao *et al.* (2008), who found it able to discriminate among 14 Old World and New World *Taxus* species. The primers used in this study were designed and used by Schirone *et al.* (2010) to detect the persistence of an ancient Macaronesian yew lineage in the Azores, and further used by Vessella *et al.* (2013) to detect that same lineage in Madeira.

For this study, leaf samples from all *T. baccata* plants in private and public gardens in Madeira (Fig. 1 and Table 1), as well as of wild plants from most known populations, were collected, dried in silica gel and stored at -5 ºC prior to DNA extraction. Herbarium voucher specimens were produced and deposited in the MADJ herbarium (herbarium acronym according to Thiers, 2022). Leaves were homogenized using TissueLyser II from QIAGEN. Total genomic DNA extracts were obtained by using GeneJET

Plant Genomic DNA Purification Mini Kit following the manufacturer's instructions. Amplification using plastid *trnS–trnQ* DNA marker followed the procedure described by Schirone *et al*. (2010). Representatives of *T. baccata* from adjacent areas (Mediterranean Basin, North and Central Europe), as well as from the Madeiran and Azorean haplotype, referenced by Schirone *et al*. (2010) and Vessella *et al*. (2013) and available in NCBI Database, were also included in the dataset to establish a reference for comparison (Table 2). Sequences were analysed and aligned using MEGA7.

RESULTS AND DISCUSSION

The alignment includes a set of 43 *T. baccata* sequences; 36 novel and 7 extracted from NCBI database. The novel includes 28 cultivated yew plants from 16 locations and wild plants from 8 distinct locations in the island of Madeira (Table 2).

The cpDNA sequences in the dataset showed two polymorphic sites, one in the position 486 (T/G) and another in position 596 (A/G) (Table 2), consistent with the results described by Schirone *et al*. (2010) and Vessella *et al*. (2013). According to these authors, samples sharing the same nucleotide substitutions can be clustered into two groups: one including Madeiran and Azorean wild plants and another including Euro-Mediterranean *Taxus baccata* (see Table 2; sequences 1 and 2 – Macaronesian haplotype and sequence 11 to 15 – Euro-Mediterranean haplotype).

All the Madeiran wild yew plants tested in this study fell into the Macaronesian haplotype group. On the other hand, all cultivated yew plants in the dataset (samples 16 to 43) showed the same sequence and substitutions, consistent with the Euro-Mediterranean lineage and indicative that all these plants are from Continental provenance. Based on the size of the plants and information gathered from personnel working in the gardens, most of these plants were probably planted during the end of the 19th century and first half of the 20th century.

Special awareness should be directed to the yew plant samples 36 to 43, especially those located at the "Casa de Abrigo do Pico Ruivo" and "Posto Florestal da Boca da Corrida". These plants, all tested as from Euro-Mediterranean lineage, are in or near the Natural Park of Madeira and in some cases close to extant wild plants of *T. baccata*, located on nearby cliffs. In these areas, where natural vegetation is mostly a transition between "Madeiran laurisilva" to the "Madeiran cloud heaths", regeneration of indigenous yew plants may occur, without being noted due to the very rugged terrain and steep cliffs. Considering this proximity of plants of the two distinct lineages, the possibility of crossbreeding between them cannot be excluded, especially considering the anemophilous pollination of yew. Male plants freely expel a myriad of pollen grains specialized for long distance transportation by wind, estimated up to 700 m (Chybicki & Oleksa, 2018).

The yew plants located in the two Governmental Forest Department nurseries: "Viveiro Florestal do Pico das Pedras" and "Viveiro Florestal da Casa Velha", were also shown to belong to the Euro-Mediterranean lineage. The presence or removal of these plants should be adequately addressed, as these nurseries are the main areas in Madeira for propagation of plants of several species for conservation purposes, including yew.

The indigenous *T. baccata* plants are scarce and seriously threatened by extinction. In August 2010, a wildfire severely affected the wild yew populations and habitat, leading to the loss of around 30 of the 61 known plants. Since then, new yew plants have been found, but the total number is still less than 50, critically low and inadequate for the long-term survival of the species in Madeira (IUCN, 2012). Although the best strategy to conserve this lineage is *in situ* conservation through preservation of the natural habitat, wildfires are still a major threat, very unpredictable and difficult to address, especially when considering the island's topography. Thus, the recruitment of new plants must have high priority, with reinforcement of populations and reinstallation of plants over a broad array of locations, particularly in those where yew is known to have occurred in the past. This recruitment should also consider tackling possible genetic processes, in action due to reduced population size and severe fragmentation that may act as an additional limiting factor for the recovery of the species.

Maintaining plants of endangered species in gardens or parks is an important and valid conservation measure (Borsh & Lohne, 2014). At the least, the cultivated plants are an important source of seeds or other plant material necessary for propagation. But only well documented plants are adequate sources for scientific research as well as *ex situ* or *in situ* conservation programs (Rae, 2011). It is expected that the data brought here will contribute to the awareness of this circumstance and contribute to the development of a conservation strategy for the Macaronesian yew.

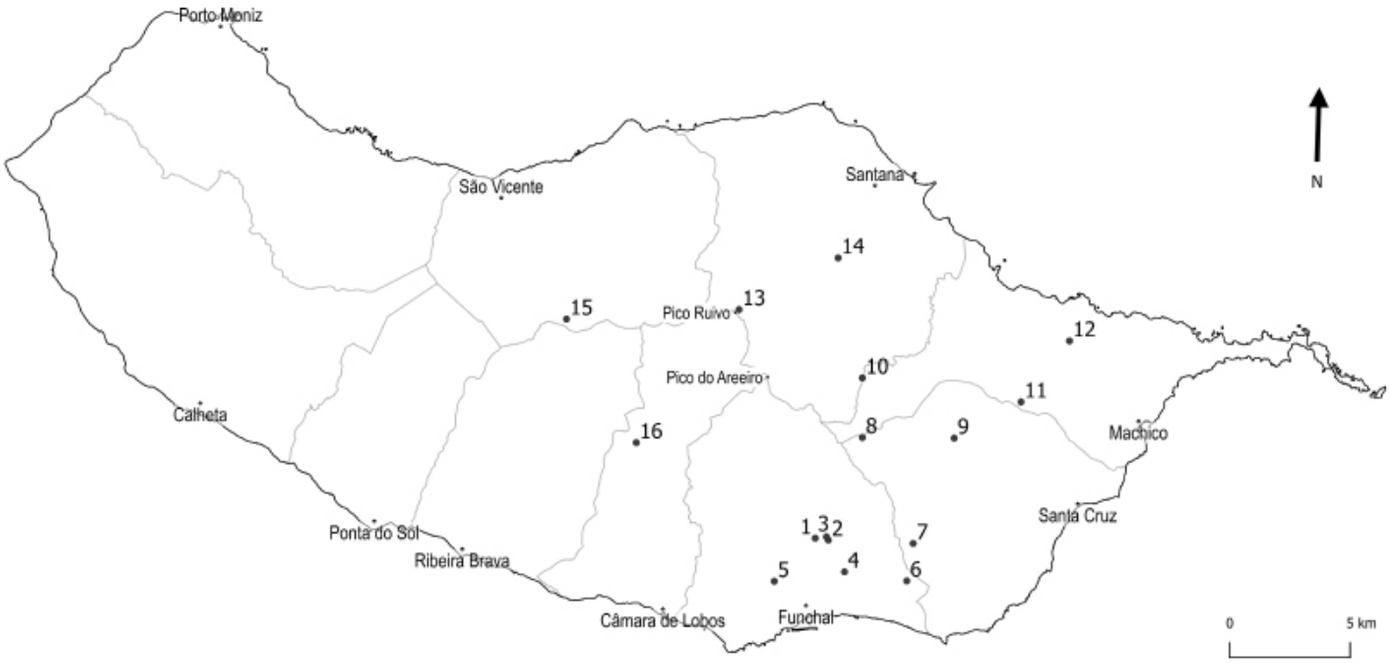

Fig. 1 – Madeira Island. Each numbered point indicates the location of cultivated *T. baccata* plants analysed in this work. See Table 1 for description of location number.

Table 1 – Location and number of cultivated *T. baccata* plants sampled. The numbers for each location match the numbers on Fig. 1.

Number in Map (Fig.1)	Location	Number of Plants
1	Jardim do Imperador	1
2	Quinta Monte Palace	3
3	Jardim Municipal do Monte	1
4	Jardim Botânico da Madeira Eng.º Rui Vieira	3
5	Jardim do Tecnopolo	1
6	Quinta do Palheiro Ferreiro	3
7	Quinta do Padre Américo	4
8	Posto Florestal do Poiso	1
9	Viveiro da Casa Velha	1
10	Parque Florestal do Ribeiro Frio	1
11	Quinta do Santo da Serra	2
12	Parque Florestal das Funduras	1
13	Casa de Abrigo do Pico Ruivo	3
14	Viveiro Florestal do Pico das Pedras	1
15	Posto Florestal da Encumeada	2
16	Posto Florestal da Boca da Corrida	1

Table 2 – Relevant positions in the alignment of the chloroplast *trnS–trnQ* spacer sequences that differentiate Macaronesian and Euro-Mediterranean haplotype of *T. baccata*. Black arrows indicate polymorphism in positions 486 and 596. Wild group corresponds to Madeiran native plants sampled for this analyses. Cultivated group indicates cultivated plants sampled for this study. GenBank sequences – NCBI group (Accession code in brackets) serve as reference for comparison.

					486												596									
Name	Group		483	484	485	↓	487	488	489	490	491						593	594	595	↓	597	598	599			
1. Azores_Pico Island (GU320044.1)	NCBI	...	C	C	A	G	A	A	T	A	G	...	...	...	...	...	A	T	G	G	A	A	A	...	...	...
2. Madeira_haplytype (JN255689.1)	NCBI	...	C	C	A	G	A	A	T	A	G	...	...	...	...	...	A	T	G	G	A	A	A	...	...	...
3. Sao Vicente (F48)	Wild	...	C	C	A	G	A	A	T	A	G	...	...	...	...	...	A	T	G	G	A	A	A	...	...	...
4. Boaventura (U37)	Wild	...	C	C	A	G	A	A	T	A	G	...	...	...	...	...	A	T	G	G	A	A	A	...	...	...
5. Curral-das-Freiras (C83)	Wild	...	C	C	A	G	A	A	T	A	G	...	...	...	...	...	A	T	G	G	A	A	A	...	...	...
6. Santana (V58)	Wild	...	C	C	A	G	A	A	T	A	G	...	...	...	...	...	A	T	G	G	A	A	A	...	...	...
7. Santana (N41)	Wild	...	C	C	A	G	A	A	T	A	G	...	...	...	...	...	A	T	G	G	A	A	A	...	...	...
8. Santana (T63)	Wild	...	C	C	A	G	A	A	T	A	G	...	...	...	...	...	A	T	G	G	A	A	A	...	...	...
9. Santana (Q27)	Wild	...	C	C	A	G	A	A	T	A	G	...	...	...	...	...	A	T	G	G	A	A	A	...	...	...
10. Santana (L36)	Wild	...	C	C	A	G	A	A	T	A	G	...	...	...	...	...	A	T	G	G	A	A	A	...	...	...
11. Continental_haplotype (JN255688)	NCBI	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
12. United Kingdom_Wales (GU320039.1)	NCBI	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
13. Spain_Font Roja (KP115931.1)	NCBI	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
14. Italy_Sardinia (GU320034.1)	NCBI	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
15. Morocco (GU320038.1)	NCBI	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
16. Jardim do Tecnopolo	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
17. Jardim do Imperador	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
18. Jardim Municipal Monte	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
19. Quinta Monte Palace_1	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
20. Quinta Monte Palace_2	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
21. Jardim Botanico da Madeira_1	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
22. Jardim Botanico da Madeira_2	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
23. Jardim Botanico da Madeira_3	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
24. Quinta do Palheiro Ferreiro 1	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
25. Quinta do Palheiro Ferreiro 2	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
26. Quinta do Palheiro Ferreiro 3	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
27. Quinta do Padre Americo_1	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
28. Quinta do Padre Americo_2	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
29. Quinta do Padre Americo_3	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
30. Quinta do Padre Americo_4	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
31. Posto Florestal do Poiso	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
32. Viveiro Florestal da Casa Velha	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
33. Quinta do Santo da Serra_1	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
34. Quinta do Santo da Serra_2	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
35. Parque Florestal das Funduras	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
36. Parque Florestal do Ribeiro Frio	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
37. Viveiro Florestal do Pico das Pedras	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
38. Casa de abrigo do Pico Ruivo_1	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
39. Casa de abrigo do Pico Ruivo_2	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
40. Casa de abrigo do Pico Ruivo_3	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
41. Posto Florestal Encumeada_1	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
42. Posto Florestal Encumeada_2	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...
43. Posto Florestal da Boca da Corrida	Cultivated	...	C	C	A	T	A	A	T	A	G	...	...	...	...	...	A	T	G	A	A	A	A	...	...	...

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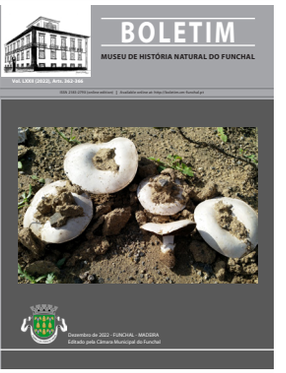

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Agaricus bitorquis (Quél.) Sacc. (Agaricaceae), a new record for the island of Porto Santo (Madeira, Portugal)

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With 2 figures

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ABSTRACT: Porto Santo is a small volcanic island that belongs to the Portuguese archipelago of Madeira and is located in central East-Atlantic. The mycobiota of this island comprises 19 species of fungi. With the present work, a new record is added to the checklist of fungi from the archipelago of Madeira, *Agaricus bitorquis* (Quél.) Sacc.

Key words: Agaricales, new record, Porto Santo.

RESUMO: O Porto Santo é uma pequena ilha vulcânica que pertence ao arquipélago da Madeira e localiza-se no Atlântico. A micobiota desta ilha compreende 19 espécies de fungos. Com o presente trabalho, um novo registo é adicionado à listagem dos fungos do arquipélago da Madeira, *Agaricus bitorquis* (Quél.) Sacc.

Palavras-chave: Agaricales, novo assinalamento, Porto Santo.

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INTRODUCTION

Porto Santo is a volcanic island that belongs to the Portuguese archipelago of Madeira and is located in central East-Atlantic, approximately 700 km off NW-Africa (Schmidt & Schmincke, 2002). It is a small island (42,2 km^2) extending between 32º 59' and 33º 07' N and 16º 16' and 16º 24' W. Together with the archipelagos of Madeira, Selvagens, Azores, Canary Islands and Cape Verde, is part of the Macaronesia biogeographical region (Shandilya, 2017).

In contrast with the abrupt sea cliffs of the northern coast of Porto Santo, the southern coast presents an extensive 9 km beach, mainly formed by calcareous sand that resulted from the fragmentation of shells, corals and calcareous algae, giving it its characteristic yellow colour. The sands results from erosive processes associated with rain and surface runoff towards the south coast of the island, which are responsible for transporting the sand from the calcareous sandstones, located in the central west region, of the island to the beach (Ferreira, 2014).

According to Shandilya (2017), the island of Porto Santo has temperate oceanic semi-arid climate, deeply influenced by its location, relief, dimension, altitude and the dominant northeastern trade wind system.

The island has a low annual rainfall, usually less than (300-) 400 mm and a mean annual temperature of 18 ºC (Jardim & Menezes de Sequeira, 2014). November and December are the wettest month while it rains very little during summer months (Shandilya, 2017).

The mycoflora of the island of Porto Santo, according to Melo & Cardoso (2008) comprises 14 species of fungi. Since then, five new addition to Porto Santo's mycoflora, were published (Calonge & Menezes de Sequeira, 2003, 2007, 2011 a, b, c, 2014; Calonge *et al*., 2008 a, b, 2009, 2010, 2012, 2013; Iglesias et al., 2014; Fernández-Vicente *et al*., 2016). Thus, this collection represents the twentieth species found for the island of Porto Santo.

A. bitorquis (Quél.) Sacc. does not occur in the other archipelagos of Macaronesia (Bañares Baudet, 2005; Beltrán Tejera, 2010; Melo *et al*., 2010).

MATERIAL AND METHODS

The specimens of *Agaricus bitorquis* are deposited in the fungi collection of the Natural History Museum of Funchal (MMF) and, a duplicate, in the Moravian Museum (BRNM). Microscopic characters were observed on dried material mounted in water and Congo Red using an Olympus BX-50 light microscope with a magnification of 400x and 1000x. Microscopic description is based on 30 measurements of basidiospores, basidia, cheilocystidia and pileipellis elements.

RESULTS

Fungi
Basidiomycota, Agaricomycotina,
Agaricomycetes, Agaricomycetidae, Agaricales,
Agaricaceae, Agaricus,
Agaricus bitorquis
(Quél.) Sacc., Syll. fung. (Abellini) 5: 998 (1887).

STUDIED MATERIAL

Portugal, Porto Santo:
On sandy substrate, Campo de Baixo, 17. XII. 2021, Juan Silva *leg*., Hana Ševčíková det., 33° 02.371 'N 16° 21.583 'W, 2 m *a.s.l*. (MMF 49145; BRNM 829058).

DESCRIPTION

Pileus – 40-95 mm in diameter, plano-convex to applanate with a shallow to distinct depression in the centre. Pileus surface smooth, whitish. Margin of the pileus in some basidiomata indistinctly involute, without striation.

Lamellae – free, crowded, brown with pink tinge or reddish brown, then chocolate brown.

Stipe – 30-55 x 10-20 mm, cylindrical to narrowly clavate, slightly thickened to indistinctly bulbous near the base, smooth, white.

Annulus – white, double, the lower thin, resembling a volva.

Context – firm, white at first, later turning pale greyish-brown.

Taste – mushroomy, smell pleasant.

Spores – (4.2-)5.0-6.5(-7) x (4-)4.5-5(-5.5) µm, broadly ellipsoid to subglobose, thick-walled.

Basidia – 20-25 x 6-10 µm, tetrasporic or bisporic, cylindrical to clavate, with sterigmata up to 3.5 µm.

Cheilocystidia – common, with or without 1-3 septa at the base, thin-walled to slightly thick-walled, mostly clavate.

Pileipellis – cutis made of cylindrical hyphae 3-10 µm wide.

Fig. 1 – *Agaricus bitorquis* (Quél.) Sacc.: general aspect.

Fig. 2 – *Agaricus bitorquis* (Quél.) Sacc.: close-up of the context and lamellae.

DISCUSSION

The indigenous forest of the island of Porto Santo was irrevocably devastated in the centuries that followed the arrival of the first settlers (Campinho, 2021). Potentially, the native olive tree forest (*zambujal*) and the Mediterranean laurel forest of the Canary laurel would cover this island.

Regarding land use on the island of Porto Santo, according to the second forest inventory of the Autonomous Region of Madeira (Direção Regional das Florestas, 2015), 60% of the island's area (2,566 ha) is occupied by bushes and herbs, 12% by urbanized area (505 ha), 8% by cultivated forest (362 ha) and 6% by agricultural fields (240 ha).

The geological characteristics of the island of Porto Santo, its orography, size, the poor and arid soil (sandy-clay), the reduced average annual precipitation, the exposure of the island to wind, sea air and the sun may justify the low mycological diversity of this island. *Agaricus bitorquis* is a resilient species that can cope with these adverse conditions.

Agaricus bitorquis is a widespread and common species all over Europe, frequent on coastal dunes (Parra-Sánchez, 2008) and also in localities strongly influenced by humans – parks, gardens, paths. This species can even break through older asphalt roads. *Agaricus bitorquis* is an edible species collected for cooking in Central and East Europe, only taste of very old basidiomata can be disagreeable (Capelli, 1984). This species can be confused by non-specialists with toxic *Agaricus xanthodermus* Genev., a fungus present on the island of Madeira and Porto Santo (Calonge & Menezes de Sequeira, 2011b) and some similar species from *A. xanthodermus* group. This species is conspicuous by intensely and quickly chrome-yellowing basidiomata, especially at the base of the stipe and has an unpleasant smell of iodine, phenol, etc. (Capelli, 1984; Calonge & Menezes de Sequeira, 2011b). Somewhat similar edible species *Agaricus arvensis* also grows on the island of Madeira (Calonge & Menezes de Sequeira, 2011b), but significantly differs by anise smell and context which turns yellow when cut.

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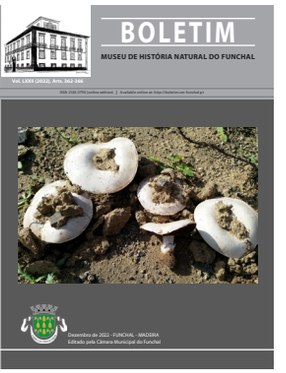

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New records of alien vascular plants from the island of Madeira (Portugal)

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ABSTRACT: As a result of recent fieldwork in the island of Madeira (Portugal), 32 non-native vascular plant taxa: *Aptenia ×vascosilvae, Calystegia silvatica, Cardamine occulta, Casuarina cunninghamiana* and *C. glauca, Convolvulus farinosus, Cotoneaster pannosus, Diplotaxis tenuifolia, Epilobium ciliatum, Erigeron floribundus, Euphorbia hypericifolia, E. maculata, E. serpens, Hedychium coronarium, Kalanchoe ×houghtonii, Lemna minuta, Lepidium oblongum, Malephora purpureocrocea, Metrosideros excelsa, Oenothera glazioviana, Oxalis dillenii, Phytolacca icosandra, Pistia stratiotes, Rumex palustris, Schinus terebinthifolia, Sisyrinchium micranthum* (incl. *S. rosulatum*), *Soliva sessilis, Sphagneticola trilobata, Tithonia diversifolia, Verbena incompta, V. litoralis* and *Youngia japonica*, are reported as naturalized, 26 of them for the first time. All these taxa are reportedly known as weeds or invasive, in climatologically comparable regions elsewhere in the world. In addition, records are provided for several taxa that are considered to be ephemerals at present, but for which a future naturalization is not unlikely. Finally, some miscellaneous notes are presented, on poorly known or recently reported aliens (for instance, the presence of *Solanum chenopodioides* is confirmed and in some habitats it even behaves as an invasive species). Identification keys for some species groups (*Erigeron, Euphorbia* subgenus *Chamaesyce*) are provided and many of the taxa are illustrated.

Key words: vascular plants, non-native, new records, Madeira Island.

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RESUMO: Como resultado do trabalho de campo realizado recentemente na ilha da Madeira (Portugal), 32 *taxa* de plantas vasculares, não nativas, são aqui referidos, 26 deles pela primeira vez, como naturalizados: *Aptenia ×vascosilvae, Calystegia silvatica, Cardamine occulta, Casuarina cunninghamiana* e *C. glauca, Convolvulus farinosus, Cotoneaster pannosus, Diplotaxis tenuifolia, Epilobium ciliatum, Erigeron floribundus, Euphorbia hypericifolia, E. maculata, E. serpens, Hedychium coronarium, Kalanchoe ×houghtonii, Lemna minuta, Lepidium oblongum, Malephora purpureocrocea, Metrosideros excelsa, Oenothera glazioviana, Oxalis dillenii, Phytolacca icosandra, Pistia stratiotes, Rumex palustris, Schinus terebinthifolia, Sisyrinchium micranthum* (incl. *S. rosulatum*), *Soliva sessilis, Sphagneticola trilobata, Tithonia diversifolia, Verbena incompta, V. litoralis* e *Youngia japonica*. Todos estes *taxa* são reconhecidos como sendo ervas daninhas ou espécies invasoras noutras partes do mundo, com um clima semelhante ao da ilha da Madeira. Na presente publicação, são assinalados registos de vários *taxa*, com uma presença considerada efémera, mas, para os quais, não se pode descartar a possibilidade de uma futura naturalização. Finalmente, são apresentadas algumas notas sobre espécies alienígenas pouco conhecidas ou assinaladas recentemente (como por exemplo, confirma-se a presença de *Solanum chenopodioides*; *taxon* com um comportamento local de espécie invasora). São fornecidas chaves de identificação para algumas espécies (*Erigeron*, *Euphorbia* subgénero *Chamaesyce*) e muitos dos *taxa* estão acompanhados por fotografia.

Palavras-chave: plantas vasculares, não nativas, novos assinalamentos, ilha da Madeira.

INTRODUCTION

Despite the long tradition of studies on the flora of the island of Madeira, native and introduced, there is a constant and almost uninterrupted amount of new taxonomic and distributional data. Particularly the non-native flora is still imperfectly known and the number of intentional as well as accidental, new introductions, still seems to continue to increase. According to Menezes de Sequeira update (*pers. comm*., 2018), the flora of the archipelagos of Madeira and Selvagens, comprises 1,268 taxa of vascular plants (species and subspecies). Of these, 402 to 442 taxa are 'introduced' and 29 taxa are 'possibly introduced'.

This paper reports some newly-detected alien vascular plants found in the island of Madeira, mostly in the autumn of 2021 and the spring of 2022. Thirty-two naturalized or invasive taxa, most of them new to Madeira, are presented herein. Several others are, at least at present, considered to be ephemerals. Some further observations are added for taxa that are otherwise of interest.

MATERIALS AND METHODS

Records presented here are the result of several weeks of fieldwork in the island of Madeira conducted by the first author, between 10th and 24th September 2021 and between 18th April and 2nd May 2022. Herbarium specimens were collected for most of the taxa and these are deposited in the herbaria BR and MADM (Thiers, 2022). The actual presence or absence on the island of Madeira of the non-native taxa here presented was checked against data provided by *e.g*. Press & Short (1994), Vieira (2002), Jardim & Sequeira (2008); Menezes de Sequeira *et al*. (2012), Muer *et al*. (2020) and the Euro+Med PlantBase (2022). For some recently introduced species, several additional papers were checked. Both authors searched for additional useful information in the herbarium MADM.

The present paper is divided in three parts:

1 – Naturalized and invasive taxa:
a) First records from Madeira;
b) Other previously recorded taxa.

Each entry includes: the scientific name of the taxon (if useful accompanied by one or more homo- or heterotypic synonyms), the family to which the taxon belongs, an enumeration of selected herbarium collections and/or personal observations, primary as well as secondary distribution range and the species' estimated degree of naturalization in Madeira. When relevant, some additional information is provided (nomenclatural or taxonomic comments, etc.).

2 – Ephemeral taxa.

3 – Miscellaneous records, for some critical alien taxa for which the degree of naturalization has changed

(*e.g*. taxa that were thought to be ephemerals but that are thoroughly naturalized instead or that were only recently reported for the first time from Madeira).

For convenience, within each of these parts, all taxa are presented in alphabetical order (families, then species). Familial and generic classifications are in accordance with APG IV (2016). For the taxa treated herein, this means that Malaceae are included in Rosaceae and Lemnaceae in Araceae.

All field observations, many further substantiated by photographs, were registered in the observation.org (https://observation.org/) online database that is also published through the Global Biodiversity Information Facility (GBIF; https://www.gbif.org/).

RESULTS

1 – Naturalized and invasive taxa:

a) First records from Madeira:

Aizoaceae

Aptenia* ×*vascosilvae Gideon F. Sm., E. Laguna, F. Verloove & P. P. Ferrer, *Phytotaxa*, **441** (2): 221-224 (2020). (Fig. 1).

Syn.: *Mesembryanthemum* ×*vascosilvae* (Gideon F. Sm., E. Laguna, F. Verloove & P. P. Ferrer) L. Sáez & Aymerich.

This hybrid of *Aptenia cordifolia* (L. f.) Schwantes x *haeckeliana* (Berger) Bittrich ex Gerbaulet parentage, both native to South Africa, is one of the most widely grown mesembs globally (Smith *et al*., 2019). It easily escapes from cultivation and is currently part of the exotic floras of several countries, especially in regions with a Mediterranean climate. For quite a long time, it was only known under its cultivar name 'Red Apple' but Smith *et al*. (2020) formalized its nomenclature. The flowers of *A.* ×*vascosilvae* are bright strawberry red and not bright pinkish purple as in *A. cordifolia* and its leaves are not cordate at base as in the latter species.

In the island of Madeira, both the hybrid and *A. cordifolia* are very commonly grown as ornamentals but only the latter has been reported as an escape (Press & Short, 1994; Vieira, 2002). In fact, both are probably fairly widespread and sometimes grow in close proximity, for instance on coastal cliffs in Funchal (Ponta da Cruz).

According to some authors (*e.g*. Klak *et al*., 2007; Klak & Bruyns, 2013), *Aptenia* N. E. Br. is better included in a broadly circumscribed genus *Mesembryanthemum* L.; Sáez & Aymerich (2020) proposed a combination under the latter genus.

Fig. 1 – *Aptenia* ×*vascosilvae*, Funchal, coastal cliff, September 2021, F. Verloove.

Malephora purpureocrocea (Haw.) Schwantes, *Gartenflora*, **77**: 69 (1928).

This South African ornamental is much cultivated in Macaronesia and other regions with similar climatic conditions. In the Canary Islands, it is recorded as a naturalizing escape (Padrón-Mederos *et al*., 2009) and the same applies to the Mediterranean area (*e.g*. Sciberras & Sciberras, 2010). The species was recently recorded for the first time in Argentina (Jocou *et al*., 2019) and is also known from California (Bleck, 2003). It was not known from the archipelagos of Madeira, Selvagens, Azores and Cape Verde (Sánchez-Pinto *et al*., 2005; Jardim & Sequeira, 2008; Silva *et al*., 2010).

A small, seemingly established population of *Malephora purpureocrocea* was discovered on a coastal cliff, in April 2022, in Caniço, where it grows together with *Carpobrotus edulis* (L.) N. E. Br.

Anacardiaceae

Schinus terebinthifolia Raddi, *Mem. Mat. Fis. Soc. Ital. Sci. Modena, Pt. Mem. Fis.*, **18**: 399 (1820).

This South American (Argentina, Brazil and Paraguay) ornamental shrub is much grown in the subtropics, including the islands of Madeira and Porto Santo. Frugivorous birds feed on its berries and play an important role in the species' dispersal in areas where it has been introduced (Dlamini *et al*., 2018). As a result, it is increasingly escaping and more and more regarded as an invasive exotic (*e.g*. Williams *et al*., 2007).

From the island of Madeira and Porto Santo, it was, not reported, so far, in the wild (*e.g*. Press & Short, 1994; Vieira, 2002; Jardim & Sequeira, 2008; Menezes de Sequeira *et al*., 2012). Yet, it is frequently escaping and young, self-sown individuals are observed *e.g*. in drains, banana plantations, semi-dried out riverbeds, dunes (Porto Santo), etc. In some areas (*e.g*. Funchal, Ponta de São Lourenço, Caniçal) small, more or less established populations, with flowering and fruiting individuals, have been observed. Similar behavior was recently reported from the Canary Islands as well (Verloove & Reyes-Betancort, 2011; Verloove, 2013; Verloove, 2017).

Araceae

Lemna minuta Kunth in F. W. H. von Humboldt, A. J. A. Bonpland & C. S. Kunth, *Nov. Gen. Sp.*, **1**: 372 (1816).

This American weed is still poorly known in parts of Europe, where confusion with native *L. minor* L., lingers on. It is distinguished from the latter by its smaller, narrower fronds (ca. 0.8-3 mm long, up to twice as long as wide) with a single, raised vein. Despite being smaller in size, it is much more expansive and often considered to be an aggressive invader (Ceschin *et al*., 2016).

In Macaronesia, it was probably overlooked for quite a long time. As a result, this taxon was not reported before, for the archipelagos of Madeira, Selvagens, Azores and Cape Verde (Press & Short, 1994; Vieira, 2002; Sánchez-Pinto *et al*., 2005; Jardim & Sequeira, 2008; Acebes Ginovés *et al*., 2010; Silva *et al*., 2010; Menezes de Sequeira *et al*., 2012). Its presence was recently detected in the Canary Islands, often in massive stands (Gran Canaria, La Palma, Tenerife: Verloove, 2013; Otto & Verloove, 2020; Verloove, 2021).

In September 2021, it was discovered in two localities in the island of Madeira, Machico (Matur) and Câmara de Lobos (Ribeira dos Socorridos), although no special attention was paid to it. It is likely much more widespread but widely overlooked.

Pistia stratiotes L., *Sp. Pl*., **963** (1753). (Fig. 2).

This species has a pantropical distribution. It is widely grown as an aquatic ornamental, water lettuce, and readily becomes an aggressive invader (*e.g*. Brundu *et al*., 2012), although in some areas where it is considered as such, it may as well be native, for instance in Florida (Evans, 2013).

Surprisingly, in Macaronesia it is only known, so far, from the Azores (Faial) where it is classified as casual (Silva *et al*., 2010) and Canary Islands (Acebes Ginovés *et al*., 2010), where it is known as an invasive species.

In September 2021, it was observed on several occasions in Madeira. In Câmara de Lobos it was repeatedly seen in temporary ponds and shallow water in the Ribeira dos Socorridos, between Ponte dos Socorridos and the beach, where it looks naturalized, with 100's of individuals over quite a distance. In Maroços, in the Ribeira de Machico, a small population in standing water was observed and in Ponta do Sol, at the mouth of the stream, at the beach, a monospecific stand of ca. 50 x 30 m, was observed.

Fig. 2 – *Pistia stratiotes*, Ponta do Sol, beach, September 2021, F. Verloove.

Asteraceae

Erigeron floribundus (Kunth) Sch. Bip., *Bull. Soc. Bot. Fr*., **12**: 81 (1865).

Syn.: *Conyza floribunda* Kunth, incl. *C. bilbaoana* J. Rémy.

Herbarium: Santa Cruz, Santo António da Serra, ER 224 south of golf court, roadside, scattered individuals, also elsewhere in this area, 24 Sept. 2021, *F. Verloove* 14126 (BR).

Current-day authors accept three species from the genus *Conyza* Less. (now, usually included in *Erigeron* L.), all native to the New World, as occurring in Madeira: *E. bonariensis* L., *E. canadensis* L. and *E. sumatrensis* Retz. (*e.g*. Press & Short, 1994; Vieira, 2002; Jardim & Sequeira, 2008; Menezes de Sequeira *et al*., 2012). The latter is a relatively recent introduction, first reported by Hansen (1973) under the erroneous name of *E. floribundus*.

Erigeron floribundus is a taxonomically critical taxon. Pruski & Sancho (2006) subsumed it under *E. sumatrensis* (as var. *leiotheca* (S. F. Blake) Pruski et G. Sancho). Strother (2006) only accepted *E. floribundus* for North America, whereas Nesom (2018) demonstrated that both *E. floribundus* and *E. sumatrensis* are present in that area. *E. floribundus* is in fact, more or less intermediate between *E. sumatrensis* and *E. canadensis*. With the latter species, it shares the glabrous phyllaries, with the former the 5-lobed tubular corollas and the absence of ligules. It is more hirsute hairy than either species.

All these species are morphologically similar, yet easily distinguished:

1 – Leaves nearly glabrous above or with scattered hairs along midrib only, margins distinctly ciliate (at least in lower third, ciliae often 1 mm long). Involucral bracts nearly glabrous. Capitulae ca. 2-4 mm wide at anthesis --- 2
1′ – Leaves densely shortly pubescent above, margins hardly ciliate (ciliae, if present, very short). Involucral bracts softly hairy. Capitulae ca. 4-10 mm wide at anthesis ------- 3
2 – Inner (tubular) florets mostly 4-lobbed. Ligules always present, white, distinctly exceeding involucre. Inflorescence often cylindric, much longer than wide. Plant annual, usually yellowish-green, stem not hirsute ---------- *Erigeron canadensis*
2′ – Inner (tubular) florets mostly 5-lobed. Ligules absent or rudimentary, not exceeding involucre. Inflorescence much broader, usually only slightly longer than wide. Plant annual or short-lived perennial, dull greyish-green, stem hirsute ---------- ***E. floribundus***
3 – Leaves narrow, less than 5 mm wide, the uppermost linear. Inflorescence often with greatly enlarged side branches overtopping the main axis. Apex of involucral bracts often purplish. Capitulae ca. 6-10 mm at anthesis. Pappus brownish ---------- *E. bonariensis*
3′ – Most leaves wider, 3-20 mm wide, never linear. Side branches of the inflorescence not overtopping the main axis. Apex of involucral bracts not purplish. Capitulae ca. 4-6 mm at anthesis. Pappus whitish ---------- *E. sumatrensis*

In the island of Madeira, the presence of *E. floribundus* was recorded in the wide area of Santo António da Serra. In addition to the locality cited above, it was also observed, in relative abundance, in a roadside and alongside a stream, west of this village, near to the ER 110 road. Elsewhere in Macaronesia, this species is known from the Canary Islands, although many claims from there may refer to similar species (see, however, Otto & Verloove, 2016).

Soliva sessilis Ruiz et Pav., *Fl. Peruv. Prodr.*, **113** (1794).
(Fig. 3).

(incl. *S. pterosperma* (Juss.) Less.).

Herbarium: Funchal, Pico de São Martinho, rotunda GAG2, lawn, common but overlooked weed, 19 Apr. 2022, *F. Verloove* 14279 (BR); Machico, Achada, track north of the village towards Portela, track in woodland, relatively remote, common, 22 Apr. 2022, *F. Verloove* 14270 (BR); dupl. MADM 7132.

Fig. 3 – *Soliva sessilis*, Palheiro Ferreiro, lawn, April 2022, F. Verloove.

This South American weed was already known from the Azores and continental Portugal (Menezes de Sequeira *et al*., 2012) but not yet from Madeira. However, given its current distribution on the island, it doubtlessly has been overlooked so far or – alternatively and perhaps less likely – must have spread very fast following a recent introduction. In fact, in April and May 2022, it was observed in numerous localities throughout the island (Arco de São Jorge, Calheta, Camacha, Funchal, Machico, Palheiro Ferreiro, Santa Cruz, Santo António da Serra). It is usually found in more or less disturbed lawns but also along tracks, between cobblestones, on the verge of golf courts, etc. It is often quite abundant.

Sphagneticola trilobata (L.) Pruski, *Mem. New York Bot. Gard*., 78: **114** (1996). (Fig. 4).

Syn.: *Wedelia trilobata* (L.) Hitchc.

Herbarium: Santana, Faial, Praia do Faial, below steep rocks, close to the sea, a small established population, 15 Sept. 2021, *F. Verloove* 14148 (BR); Machico, Porto da Cruz, riverlet at Rua da Alagoa, semi-dried out riverbed, near to the sea, a small established population, 23 Sept. 2021, *F. Verloove* 14195 (BR).

Fig. 4 – *Sphagneticola trilobata*, Porto da Cruz, dried out riverbed, September 2021, F. Verloove.

This species is native to Mexico, Central America (Belize, Costa Rica, Guatemala, Honduras, Nicaragua and Panama), the Caribbean and tropical South America. It is widely grown as an ornamental (for ground cover), easily escapes and naturalizes and is classified as a noxious invader in several countries, for instance in China where it intergrades with the native congener *S. calendulacea* (L.) Pruski (Wu *et al*., 2013). According to the IUCN, it is one of the world's 100 worst invasive species.

Although widely cultivated as an ornamental in Macaronesia, it has only recently been first reported as an escape and apparently only from the Canary Islands so far (Gran Canaria and La Palma: Verloove, 2017; Otto & Verloove, 2018). In the island of Madeira, it was recently observed in two localities (see above) but it doubtlessly also occurs elsewhere: on observation.org a further record (https://observation.org/observation/184740845/) is available from the mountainous area near Calheta and in April 2022, we also observed it, as a lawn weed, *e.g*. in Machico.

Tithonia diversifolia (Hemsl.) A. Gray, *Proc. Amer. Acad. Arts*, **19**: 5 (1883). (Fig. 5).

This species is native to Mexico and Central America but has a nearly pantropical distribution as an introduced (ornamental) species. It has often been recorded as a harmful invasive plant that disturbs native plant communities (*e.g*. Yang *et al*., 2012).

Fig. 5 – *Tithonia diversifolia*, Garajau, roadside slope, September 2021, F. Verloove.

Although widely grown as an ornamental, it apparently has not been recorded in the wild so far in Madeira (Press & Short, 1994; Vieira, 2002; Jardim & Sequeira, 2008; Menezes de Sequeira *et al*., 2012). In September 2021, it was observed on several occasions in the southern part of the island. It was found in the semi-dried out riverbed of the Machico stream (a few individuals only) and in the Ribeiro Seco riverbed, in Funchal, where it was more numerous (and already present in 2016; observation.org). It is, however, most common (and obviously naturalized) in the coastal area between Garajau and Funchal.

Elsewhere in Macaronesia, *T. diversifolia* has been reported from La Palma and Tenerife, in the Canary Islands (Hansen, 1975; Santos *et al*., 2014).

Brassicaceae

Cardamine occulta Hornem., *Hort. Bot. Hafn. Suppl*., **71** (1819).

Herbarium: Machico, roundabout near Ribeira de Machico, north of Ponte de Machico, plantation weed, 11 Sept. 2021, *F. Verloove* 14125 (BR); Funchal, Levada dos Piornais, by small canal, 19 Apr. 2022, *F. Verloove* 14250 (BR).

This East Asian weed has been present in Europe since several decades but was initially referred to as 'Asian' *C. flexuosa* (Bleeker *et al*., 2008), then as *C. hamiltonii* (Bomble, 2014). Marhold *et al*. (2016) finally solved this issue and figured out that *C. occulta* is the correct name for it. It is distinguished from *C. flexuosa* by middle stem leaflets predominantly glabrous on the upper surface; basal leaves not rosulate; stem hairy or glabrous basally, glabrous or rarely sparsely hairy in the upper part; terminal leaflet of the middle stem leaf (one-) three- to five- (to seven-) lobed with deep and sharp sinuses (Šlenker *et al*., 2018). *C. hirsuta* L., also known from Madeira, is also similar but this species is entirely glabrous (except for few hairs at the base of stem leaves), basal leaf rosette present and stamens are four (rarely five or six) in number.

This poorly known but quite widespread weed, of irrigated ornamental plantations, lawns, etc. was recently first reported from the Canary Islands (Gran Canaria and Tenerife: Verloove & Reyes-Betancort, 2011; Verloove, 2013).

In September 2021 and April 2022, its presence was also confirmed in various localities in Madeira. In addition to the two localities cited above, it was also observed in Lugar de Baixo (Ponta do Sol; as a weed in a small banana plantation), Câmara de Lobos, Faial, São Jorge (Fajã Alta) and Boaventura. It is probably more widespread but easily overlooked. It may turn out to be an invasive species in more natural habitats, for instance alongside *levadas*.

Lepidium oblongum Small, Fl. S. E., U. S.: **468** (1903). (Fig. 6).

Herbarium: Faial, Praia do Faial, parking lot near the sea, 24 Apr. 2022, *F. Verloove* 14314 (BR, MO).

This American weed is native to the southern U.S.A., Mexico and Central America. Since a few years, it is known from Europe as a naturalized and increasing alien along railway lines in Hungary and Romania (Sîrbu *et al*., 2014; Schmidt *et al*., 2022). Rollins (1986) further reported it from Hawaii.

Lepidium oblongum is much reminiscent of the South American weed *L. bonariense* L., both share pinnately lobed cauline leaves. The latter is a rare alien in Madeira (Press & Short, 1994; Vieira 2002; Jardim & Sequeira, 2008). *L. oblongum* often has several decumbent or ascending stems from base and fruits 2-3 mm wide. By contrast, *L. bonariense* has single erect stems from base and fruits 2.7-3.5 mm wide (Al-Shehbaz & Gaskin, 2010). In addition, leaves tend to be smaller, less hairy and with more or less rounded lobes.

In April 2022, this alien was observed on several occasions. It is relatively frequent on the sand beach of Ribeira Brava, between the river and the lighthouse, and also occurs in Funchal. It either has been overlooked so far (as a result of confusion with *L. bonariense*) or is a recent, fast spreading introduction.

Fig. 6 – *Lepidium oblongum*, Ribeira Brava, beach, April 2022, F. Verloove.

Casuarinaceae

Casuarina cunninghamiana Miq., *Nieuwe Verh. Eerste Kl. Kon. Ned. Inst. Wetensch. Amsterdam*, ser. 2, **13**: 56 (1848). (Fig. 7).

Herbarium: Machico, Ribeira de Machico, gravelly riverbed, two self-sown individuals, ca. 4-5 m tall, 11 Sept. 2021, *F. Verloove* 14164 (BR); Câmara de Lobos, Ribeira dos Socorridos, dried-out riverbed, a common escape, several hundreds, incl. fruit bearing individuals, 19 Apr. 2022, *F. Verloove* 14287 (BR); Machico, Matur, abandoned hotel complex, in cracks of concrete near the former swimming pool, ca. 50 individuals, the tallest ones 4-5 m, 1 May 2022, *F. Verloove* 14285 (BR).

Fig. 7 – *Casuarina cunninghamiana*, Machico, abandoned resort, May 2022, F. Verloove.

Casuarina glauca Sieber ex Spreng., *Syst. Veg*., ed. 16, **3**: 803 (1826). (Fig. 8).

Herbarium: Caniçal, Rochinha, cliffs above the sea, rough ground, etc., abundantly reproducing from seed, 17 Sept. 2021, *F. Verloove* 14193 (BR).

This genus is poorly known in the island of Madeira. Vieira (2002) only mentioned *Casuarina equisetifolia* L. as an ephemeral escape from cultivation. No species were reported by Press & Short (1994), Jardim & Sequeira (2008) and Menezes de Sequeira *et al*. (2012). In fact, during our fieldwork in 2021 and 2022, *C. equisetifolia* was not observed as an escape. Instead, two other casuarinas were noticed, both at least locally naturalized. They are separated in the following simplified key:

1 – Leaf teeth > 12. Root suckers present ---------- ---------- ***Casuarina glauca***
1' – Leaf teeth < 12. Root suckers absent ---------- 2
2 – Leaf teeth light brown to gray with a brown transverse band about halfway between the tip of the tooth and its base ---------- ***C. cunninghamiana***
2' – Leaf teeth light green to light yellow without any transverse banding ---------- *C. equisetifolia*

Casuarina cunninghamiana is definitely naturalized in the semi-dried out riverbed of the Ribeira dos Socorridos, in Câmara de Lobos. It is present there with 100's of individuals, ranging in size from saplings to mature, fruit-bearing individuals. Muer *et al*. (2020) reported this species from Caniço (Santa Cruz). In similar circumstances, it was also seen, at least in two localities, in Machico.

Casuarina glauca is apparently rarer but, as a result of sucker-formation, escaped individuals can build relatively large stands as observed in Caniçal. Identical behavior was recently also reported from a locality in Gran Canaria (Verloove, 2017).

Fig. 8 – *Casuarina glauca*, Caniçal, rough ground near the sea, September 2021, F. Verloove.

Convolvulaceae

Calystegia silvatica (Kit.) Griseb., *Spic. Fl. Rumel.*, **2**: 74 (1844). (Fig. 9).

Herbarium: Santa Cruz, Santo António da Serra, center of the village, rough ground, very common in this area, 17 Sept. 2021, *F. Verloove* 14140 (BR).

This native of southern Europe is much reminiscent of *C. sepium* (L.) R. Brown, only the latter being known from the island of Madeira (it is naturalized since at least the 19th century according to Lowe, 1872). Both are relatively easy to distinguish: in *C. silvatica* the margins of the bracts are overlapping at least half their length and bracts are distinctly inflated (saccate) at base, whereas in *C. sepium* the margins of the bracts do not or scarcely overlap (or only at the base) and bracts are flat (not or scarcely saccate). However, in areas where both species grow in close proximity, hybrids are very easily produced (*C.* ×*lucana* (Tenore) G. Don), thus seriously blurring the boundaries between the two.

In September 2021, all flowering individuals of *Calystegia* R. Brown observed in Madeira clearly belonged to *C. silvatica*. Large naturalized populations were seen in the wide area of Santo António da Serra (see above). In addition, it was also observed in Monte, near to the Quinta "Jardins do Imperador".

As a genus, *Calystegia* seems to have become rather common in Madeira (while it was still considered to be very rare, only a few decades ago; Press & Short, 1994). It will be worth checking whether indeed two species are still present on the island.

Fig. 9 – *Calystegia silvatica*, Santo António da Serra, rough ground, September 2021, F. Verloove.

Convolvulus farinosus L., *Mant. Pl.*, **2**: 203 (1771). (Fig. 10).

Herbarium: Ribeira Brava, Serra de Água, Ribeira da Serra de Água, track alongside riverlet, on the verge of sugarcane field, commonly naturalized, 14 Sept. 2021, *F. Verloove* 14154 (BR).

This East and South African weed somehow resembles *C. arvensis* L. but it is readily recognized by the triangular-ovate, shortly pubescent to farinose, very acute leaves and small, deeply lobed white corollas (Wood *et al.*, 2015). In Macaronesia, it is known, according to Acebes Ginovés *et al.* (2010), from the Canary Islands (Tenerife) where it is locally naturalized since several decades and from the Azores (São Miguel) where it is casual (Silva *et al.*, 2010). Verloove *et al.* (2019) presented an overview of its actual distribution in Europe.

In September 2021, it was recorded on several occasions and in widely scattered localities in Madeira, suggesting that – although still rare – it has recently naturalized on a relatively wide scale. In addition to the locality mentioned above, it was also observed in Boaventura (São Vicente), near Ribeira dos Moinhos, in Funchal (semi-dried out riverbed of Ribeira de Santa Luzia) and in Porto da Cruz, near Ribeira do Juncal. In all these localities, it looks quite well established. Even in its native area, this weed is hard to control (Bromilow, 1995).

Fig. 10 – *Convolvulus farinosus*, Funchal, dried out riverbed September 2021, F. Verloove.

Crassulaceae

Kalanchoe* ×*houghtonii D. B. Ward, *Cact. Succ. J.* (Los Angeles), **78**: 94 (2006). (Fig. 11).

This hybrid doubtlessly has been overlooked so far in the island of Madeira. It is very reminiscent of *Kalanchoe daigremontiana* Raym.-Hamet & H. Perrier, one of its parent species, but distinguished by its narrowly deltoid leaves with cuneate to subpeltate bases (vs. broadly deltoid leaves with distinctly peltate leaf bases). Shtein *et al.* (2021) recently pointed out that it in fact includes several morphotypes, some artificial, others arisen naturally where both parent species occur sympatrically.

It was only recently described (Ward, 2006) but appears to be very widely dispersed, in cultivation as well as in the wild. Although exclusively reproducing clonally, it is very prolific and often regarded as a nuisance (Ward, 2008; Wang *et al*., 2016; *Herrando-Moraira et al*., 2020).

In September 2021 and April 2022, *Kalanchoe* ×*houghtonii* was observed on several occasions in the island of Madeira, for instance in São Vicente (on top of an old wall), Assomada – Caniço (by track), Câmara de Lobos (common on stone walls of Forno da Cal), Caniço de Baixo (sea cliffs), etc.

Fig. 11 – *Kalanchoe* ×*houghtonii*, Garajau, coastal cliff, April 2022, F. Verloove.

Euphorbiaceae

Euphorbia maculata L., *Sp. Pl.*, **1**: 455 (1753). (Fig. 12).

Herbarium: Machico, Rua Infante Dom Henrique 23, sidewalk, foot of wall, 11 Sept. 2021, *F. Verloove* 14187 (BR); Santa Cruz, Santo António da Serra, center of the village, near the church, between cobblestones, frequent, 16 Sept. 2021, *F. Verloove* 14130 (BR).

Euphorbia maculata has become a widespread weed in temperate regions across the world. It is presumably native to eastern and central North America. In Macaronesia, it is commonly naturalized in the Canary Islands (as *Chamaesyce maculata*, Acebes Ginovés *et al*. (2010) in Tenerife, Gran Canaria and, as *Euphorbia maculata* (Otto & Verloove, 2016), in La Palma). In the Azores, it occurs in all islands except Corvo (Silva *et al*., 2010; Menezes de Sequeira *et al*., 2012). Surprisingly, it had not been reported yet from the island of Madeira where it was noticed on several occasions, often in abundance. In addition to the localities mentioned above, it was also recorded between cobblestones in Funchal, at the Quinta "Jardins do Imperador" (at Casa Darlington).

This species superficially looks like the widespread weed *E. prostrata* but is distinguished by capsules with evenly distributed hairs (vs. hairy along keels only). Its leaves adaxially usually have an irregular reddish streak along midvein.

Fig. 12 – *Euphorbia maculata*, Santo António da Serra, between cobblestones, September 2021, F. Verloove.

Euphorbia serpens Kunth in F. W. H. von Humboldt, A. J. A. Bonpland & C. S. Kunth, *Nov. Gen. Sp.*, **2**: 52 (1817). (Fig. 13).

Herbarium: Câmara de Lobos, Passeio Marítimo, at the sea, cracks in concrete, scattered, 12 Sept. 2021, *F. Verloove* 14144 (BR); Ponta do Sol, Lugar de Baixo, abandoned harbour, on sand, several dozens, 21 Sept. 2021, *F. Verloove* 14220 (BR).

Euphorbia serpens is one of the most widespread species of the genus in the New World. It is weedy and has been introduced to and became widely distributed in the Old World. In Macaronesia, it is commonly naturalized in the Canary Islands (all islands) and as casual, in Santa Maria, in the Azores (Silva *et al.*, 2010). Surprisingly, it had not yet been reported from Madeira where it was noticed on several occasions in September 2021 and April 2022, often in abundance. In addition to the localities mentioned above, it was also observed in São Vicente (ER 211, close to the sea), Funchal (Ponta da Cruz: Passeio Público Marítimo), Ponta do Sol (Madalena do Mar, rough ground near the sea), Ponta de São Lourenço (Quinta do Lorde) and Santa Cruz (common along the VR-1 motorway, at the airport).

This species is easily recognized by its glabrous branches that are rooting at the nodes, its connate, deltate stipules, orbicular leaves with entire margins, glabrous capsules and smooth seeds.

The species of *Euphorbia* subgenus *Chamaesyce* section *Anisophyllum* currently known from the island of Madeira are distinguished in the key below (newly reported species in bold):

1 – Capsules and stem hairy ---------- 2
1′ – Capsules glabrous. Stem glabrous or hairy ---------- 3
2 – Capsules with all hairs appressed, uniformly distributed. Leaves usually with a central purplish spot ---------- ***Euphorbia maculata***
2′ – Capsules with all hairs patent, hairy on angles only. Leaves not spotted ---------- *E. prostrata*
3 – Stem erect. Cyathia in clusters. Largest leaves > 15 mm long, much longer than wide ---------- 4
3′ – Stem procumbent, rooting at the nodes. Cyathia solitary in leaf-axils. Leaves much smaller, nearly orbicular ---------- ***E. serpens***
4 – Plant hairy (at least in upper part and young leaves). Capsule often > 1.9 mm long ---------- *E. nutans*
4′ – Plant glabrous. Capsule always < 1.9 mm long ---------- *E. hypericifolia*

Fig. 13 – *Euphorbia serpens*, São Vicente, gravelly area near the sea, September 2021, F. Verloove.

Myrtaceae

Metrosideros excelsa Sol. ex Gaertn., *Fruct. Sem. Pl.*, **1**: 172 (1788). (Fig. 14).

Herbarium: Ponta de São Lourenço, Quinta do Lorde, dried out riverbed (also seen as epiphyte on *Phoenix* trunks), scattered individuals, 22 Apr. 2022, *F. Verloove* 14256 (BR).

Fig. 14 – *Metrosideros excelsa*, Faial, rocky slope near the sea, April 2022, F. Verloove.

This ornamental shrub is native to New Zealand. It is much grown in the island of Madeira but was apparently not yet recorded in the wild (it was not mentioned by Vieira, 2002; Jardim & Sequeira, 2008 or Menezes de Sequeira *et al*., 2012). Spontaneous, escaped individuals were observed in April 2022. In Ponta de São Lourenço, it was observed in a dried out riverbed and as epiphyte on *Phoenix* trunks. Probably more disturbing is its presence on natural rocks at the coast in Faial. There, the species penetrates natural vegetation and could become a troublesome environmental weed, like in *e.g*. South Africa. It is also considered to be invasive in the Azores where it is present in the islands of Corvo, Flores, Faial, Pico, Graciosa and São Miguel (Silva *et al*., 2010).

Onagraceae

Epilobium ciliatum Raf., *Med. Repos*., **2** (5): 361 (1808).

Herbarium: Santana, Faial, river south of bridge ER 101, sandy riverbank, near quarry, common, 15 Sept. 2021, *F. Verloove* 14156 (BR); Funchal, Estrada da Fundoa, gravelly dried-out riverbed, common, 22 Sept. 2021, *F. Verloove* 14196 (BR); Funchal, Ribeira de João Gomes N of VR1-motorway, riverside, 20 Apr. 2022, *F. Verloove* 14277 (BR); São Vicente, Boaventura, Ribeira dos Moinhos S of bridge VE-1 road, riverside and adjacent rough ground, common, 30 Apr. 2022, *F. Verloove* 14272 (BR); São Jorge, Fajã da Corsa, Ribeira de São Jorge, banana plantation, arable land along river, etc., a common weed, 30 Apr. 2022, *F. Verloove* 14281 (BR).

This American invasive weed was observed on several occasions in September 2021 and April 2022. In addition to the specimens cited above, it was also observed near Porto da Cruz and São Jorge, often in large numbers, suggesting that it is a recent, fast-spreading introduction or a long-overlooked species. Although superficially similar to congeneric species, already known from Madeira, it is quite characteristic in having a glandular hairy inflorescence, seeds with a distinctly striate pattern and a conspicuous appendage (see illustrations in Krajšek Strgulc & Jogan, 2004).

Epilobium ciliatum itself is also quite variable and sometimes considered to represent a complex of morphologically similar species, rather than a single species, especially by Scandinavian and Russian authors (*e.g*. Byalt *et al*., 2020). Contemporary North American authors, however, tend to accept only a single species with two subspecies: subsp. *ciliatum* and subsp. *watsonii* (Barbey) Hoch & P. H. Raven (Wagner *et al*., 2007). The plants from the island of Madeira belong to subsp. *ciliatum*.

This species has become the most widespread and abundant species of *Epilobium* worldwide and is often considered to be an undesirable weed. As an alien species, it often grows in secondary habitats along roads and in settlements. However, it is also found, like in Madeira, in more natural, swampy habitats like along river shores and banks and in wet meadows.

Oenothera glazioviana Micheli in C. F. P. von Martius & auct. suc. (eds.), *Fl. Bras*., **13** (2): 178 (1875). (Fig. 15).

Oenothera L. section *Oenothera* subsection *Oenothera* is a very complex assemblage that, depending on the authority, accommodates 14 (Wagner *et al*., 2007) or more than 100 species (Rostański *et al*., 2010). In Madeira, it is only represented by a single species, *O. biennis* L. (Vieira, 2002; Jardim & Sequeira, 2008; Menezes de Sequeira *et al*., 2012). According to Press & Short (1994), however, records of *O. biennis* require confirmation.

Fig. 15 – *Oenothera glazioviana*, Porto da Cruz, roadside, September 2021, F. Verloove.

In September 2021 only a single species from this subsection was observed, *O. glazioviana*. It is easily distinguished from *O. biennis* by its much larger petals (30-55 mm long), its red-striped sepals, its stem with hairs with distinct red bulbous base and its stigma that is usually distinctly elevated above the anthers at anthesis.

O. glazioviana is relatively widespread throughout the island. It either is a fast-spreading recent introduction or it has been confused so far with *O. biennis*. It was observed for instance in Porto da Cruz (Referta), Santana (Ribeira do Faial) and São Jorge, often in abundance (river banks, roadsides, fallow fields, etc.).

Oxalidaceae

Oxalis dillenii Jacq., *Oxalis*, **28** (1794).

Herbarium: Câmara de Lobos, Ribeira dos Socorridos, dried-out gravelly riverbed, 12 Sept. 2021, *F. Verloove* 14145 (BR).

This weed is native to North America but widely naturalized in many parts of Europe. It is very reminiscent of *O. corniculata* L. and, as a result, often overlooked. It differs from the latter in having stems that are not rooting at nodes, a typical strigillose vestiture (hairs straight and antrorsely appressed), stipules lack apical auricles and its seeds have transverse ridges with more conspicuous grayish or white lines.

In September 2021, it was observed in relative abundance in the semi-dried out riverbed of Ribeira dos Socorridos, a typical habitat for this species, in Câmara de Lobos. It should be looked for, in similar habitats, elsewhere in Madeira. It has apparently not been recorded before in Macaronesia (Sánchez-Pinto *et al*., 2005; Acebes Ginovés *et al*., 2010; Silva *et al*., 2010).

Phytolaccaceae

Phytolacca icosandra L., *Syst. Nat*., ed. 10, **2**: 1040 (1759). (Fig. 16).

Herbarium: Santa Cruz, Ribeira de Santa Cruz, riverside, in several small populations, 22 Apr. 2022, *F. Verloove* 14257 (BR).

Phytolacca icosandra has its native range from Mexico to Venezuela and Bolivia, and the Caribbean. It is sometimes used as a medicine and for food. It is very reminiscent of the widespread *P. octandra* L. and both are sometimes considered to be conspecific (*e.g*. Rzedowski & Calderón de Rzedowski, 2000). Yet, both species are genetically distinct (Xie *et al*., 2017). The inflorescences that are longer than the subtending leaves and the stamens in two whorls, ca. 20 in number, distinguish it from *P. octandra* (Nowicke, 1968; Nienaber & Thieret, 2003). Its completely united carpels (incl. apices), perfect flowers, very long and slender, spike-like inflorescences with sessile or very shortly pedicelled flowers distinguish it from *e.g*. *P. americana* L., a similar species already known from the island of Madeira (Jardim & Sequeira, 2008).

In April 2022, *P. icosandra* was discovered in several places in the valley of Ribeira de Santa Cruz, in Santa Cruz. It mainly grows on the margin of the stream but was also observed as a roadside weed and in an adjacent orchard. Although in small numbers, given the relatively wider distribution in this valley, the species is believed to be naturalized there.

Outside of its native distribution range, *P. icosandra* has been recorded in *e.g*. the U.S.A. and Taiwan (Nienaber & Thieret, 2003.; Hsieh et al., 2012) although many records of *P. octandra* may (at least in part) also refer to this species. It was recently recorded for the first time in Europe, in the Balearic Islands (Sáez *et al*., 2016).

Fig. 16 – *Phytolacca icosandra*, Santa Cruz, streamside, April 2022, F. Verloove.

Polygonaceae

Rumex palustris Sm., *Fl. Brit*., **1**: 394 (1800). (Fig. 17).

Herbarium: Machico, Ribeira de Machico, close to the sea, semi-dried out gravelly riverbed, well established but only locally, 11 Sept. 2021, *F. Verloove* 14155 (BR).

Rumex palustris is native to most of Europe and western Asia and occasionally naturalized elsewhere in the world. It was recently reported for the first time from Macaronesia: it is found – in abundance and apparently well established – in a few places in dried-out water reservoirs in southern Tenerife (Verloove, 2017).

In September 2021, numerous individuals were observed on an exposed stream bank in Machico, close to the beach.

This species is easily distinguished from its congeners in Madeira by its fruiting valves (all bearing a tubercle) with at each side subulate-filiform teeth that are usually as long as the width of the valve and its narrow, lanceolate leaves.

Fig. 17 – *Rumex palustris*, Machico, semi-dried out riverbed, September 2021, F. Verloove.

Rosaceae

Cotoneaster pannosus Franch., *Pl. Delavay*., 223 (1890). (Fig. 18).

Herbarium: Machico, Matur, abandoned holiday complex, grass- and shrubland, a frequent, naturalized escape in this area, 1 May 2022, *F. Verloove* 14306 (BR).

This shrub is native to south central China but it has been introduced as an ornamental to other areas of the world, including southern Africa, the Mediterranean area and Australia. It is dispersed by berry-eating birds and easily becomes naturalized wherever planted. In some areas it has become a troublesome noxious weed, for example in parts of Australia, California and Hawaii.

In the locality known as Matur (Machico), this species was formerly planted at the (now abandoned) Atlantis holiday complex. It is reproducing from seed in the surrounding grass- and shrubland, along with, among others, *Lantana* spec. It looks perfectly established.

Verbenaceae

Verbena incompta P. W. Michael, *Telopea*, **6**: 181 (1995). (Fig. 19).

Herbarium: Machico, Ribeira de Machico, gravelly dried-out riverbed, rather frequent, 11 Sept. 2021, *F. Verloove* 14142 (BR).

This is a poorly known but invasive weed. Although described from Australia (Michael, 1995), it certainly is native to South America, like the other members of this group, viz *V. bonariensis* L., *V. brasiliensis* Vell. and *V. litoralis* Kunth. In the island of Madeira, it is quite widespread and doubtlessly corresponds – at least for the most part – with what has been called *V. bonariensis* up to the present (compare with Press & Short, 1994; Vieira, 2002). In fact, *V. incompta* rather looks like *V. brasiliensis* in general appearance, except for the sessile, almost clasping leaf bases. For that reason, Yeo (1990) considered this species to be an individual variation of the latter, without formally describing it. True *V. bonariensis* is, outside its native distribution range, an ornamental rather than a weed, with much more conspicuous corollas (longer and with a wider limb) and a more congested, capitate inflorescence. In addition, in *V. incompta* stems, peduncles and calyces

Fig. 18 – *Cotoneaster pannosus*, Machico, grass- and shrubland, a) shows an inflorescence and b) an infrutescence, May 2022, F. Verloove.

are eglandular, spikes much longer (up to 55 mm in fruit), floral bracts longer (3-4 mm) and nutlets smaller (1-1.2 (-1.4) mm) (Nesom, 2010).

It should be noted that, not all contemporary authors accept the species status of *V. incompta*. According to Munir (2002) and O'Leary *et al*. (2007), it is conspecific with *V. bonariensis*, because of a different interpretation of the Linnaean type of the latter species. In fact, var. *conglomerata* Briq. of the latter, as accepted by these authors, corresponds with Linnaeus' concept of *V. bonariensis*.

Although only relatively recently described, *V. incompta* has been reported from rather numerous countries in the past two decades. It is weedy and invasive in seasonally wet places, creek and river sides, mesic disturbed woods, fields, clearing, swales, ditches, borrow pits and disturbed sites and has been known from North and Central America, Europe (naturalized in Italy and Spain, casual elsewhere), Asia, Africa, Pacific Islands (Fiji, New Zealand, Norfolk Island, Papua New Guinea) and Australia (Michael, 1995; Nesom, 2010; Verloove, 2011).

In September 2021, *V. incompta* was observed on numerous occasions and in widely scattered localities throughout the island. In addition to the documented herbarium record mentioned above, it was also noticed in Funchal (Vitória, São Gonçalo), Machico (Fajã dos Rolos, Lameirão), Porto da Cruz, Ribeira Brava, Serra de Água, Câmara de Lobos, Faial, Caniço, Santo António da Serra, Caniçal (Rochinha), Vargem (São Vicente) and Madalena do Mar). Interestingly, although already known from the Funchal area more than a century ago (Menezes, 1914, sub *V. bonariensis*), this species long remained quite localized. According to Press & Short (1994), it only occurred in two discrete areas: the Funchal area and the area between Prazeres and Calheta in the southwest of the island. Vieira (2002), provided a similar distribution pattern. Barely twenty years later, it has become quite widespread almost throughout the island. It is often seen in relatively remote areas and is fast spreading; it can be considered as an invasive species in the sense of Richardson *et al.* (2000).

Fig. 19 – *Verbena incompta*, Machico, gravelly dried-out riverbed, September 2021, F. Verloove.

Verbena litoralis Kunth in F. W. H. von Humboldt, A. J. A. Bonpland & C. S. Kunth, *Nov. Gen. Sp.*, **2**: 276 (1818). (Fig. 20).

Herbarium: Funchal, 6 Aug. 1996, *J. G. Quinn* s.n. (MADM 4771; sub *V. officinalis*); Machico, Ribeira de Machico, semi-dried out riverbed, scattered individuals, 11 Sept. 2021, *F. Verloove* 14227 (BR); Câmara de Lobos, Praia de Vigário, riverlet, near the beach, 4 individuals, 19 Apr. 2022, *F. Verloove* 14252 (BR); Funchal, Ribeira de João Gomes N of VR1-motorway, riverside, four individuals, 20 Apr. 2022, *F. Verloove* 14263 (BR); Machico, Ribeira de Machico, gravelly riverside, few plants, 22 Apr. 2022, *F. Verloove* 14264 (BR, MADM); Ribeira Brava, Meia Légua, arable land along river, a single tall individual, 30 Apr. 2022, *F. Verloove* 14273 (BR).

Like the preceding species, *Verbena litoralis* is a native of South America. Both belong to serie *Pachystachyae* (O'Leary *et al*., 2007). Its leaves are basally attenuate to short-petiolate, a character shared with *V. brasiliensis* Vell. Compared with the latter it has an open and loosely paniculate inflorescence with narrower and longer fruiting spikes (2-3 mm wide and up to 150 mm long), with fruits usually becoming remote at maturity, at least in the proximal portion (Nesom, 2010). In fact, in general appearance (and even more so in the absence of lower leaves), this species can resemble *V. officinalis* L. a lot and these species have often been confused in herbaria (Munir, 2002). The latter is distinguished by variously incised lower leaves and densely glandular inflorescence branches (at least in var. *officinalis*). Its stems are also less sharply quadrangular.

Interestingly, Menezes (1914) already reported a "V. littoralis var. pycnostachya" from the Funchal area. This is an invalid name but indeed refers to the species here concerned, *V. litoralis* s. str. (O'Leary *et al*., 2007; Nesom, 2010). However, according to Press & Short (1994), these findings were erroneous and referable to *V. bonariensis* L., which is rather unlikely since Menezes l.c. also mentioned the latter from Madeira. Unfortunately, in the absence of herbarium vouchers, it is impossible to assess the identity of these plants.

In September 2021, a small population of *V. litoralis* was found in the semi-dried out river bed of Ribeira de Machico, in Machico. In addition, in April 2022, the species was found in several additional localities (Câmara de Lobos, Funchal, Ribeira Brava), although always in small numbers. Moreover, in MADM a further specimen was detected, collected in 1996, in Funchal, but erroneously ascribed to *V. officinalis*.

Verbena litoralis is obviously naturalized in the island of Madeira but apparently rare. All records are from dried-out riverbeds. As a weed, it is likely to occur elsewhere in Madeira where it may have passed unnoticed so far. To our knowledge, this species has not been reported before from Macaronesia (Sánchez-Pinto *et al*., 2005; Acebes Ginovés *et al*., 2010; Silva *et al*., 2010), nor from Europe. Outside South America, it has naturalized in the West Indies, South Africa, Indian Ocean Islands (Reunion, Mauritius), Pacific Islands and Australia (Munir, 2002; Nesom, 2010). It is often considered to be a weed or invasive species.

Fig. 20 – *Verbena litoralis*, Machico, semi-dried out riverbed, September 2021, F. Verloove.

Zingiberaceae

Hedychium coronarium J. Koenig in A. J. Retzius, *Observ. Bot*., **3**: 73 (1783). (Fig. 21).

This showy species is probably native to the Himalayas but it has been widely cultivated in warm-temperate and subtropical regions around the world. It differs from *Hedychium gardnerianum* Sheppard ex Ker-Gawl., a very noxious invader in the island of Madeira, by its white flowers and broad and overlapping bracts that hide the main axis.

In September 2021, a well-established population of *H. coronarium* was observed in São Jorge (Santana), on a steep damp slope alongside the ER101 road, next to the Ribeira de São Jorge. These plants were already discernible on Google Streetview images from 2009. In similar circumstances, a few plants were noticed on the steep rocks bordering the Ribeira Brava river, close to the Repsol petrol station, in April 2022.

In Macaronesia, this species was already known from the Azores (islands of Flores and São Miguel) where it is considered to be invasive (Silva *et al*., 2010; Menezes de Sequeira *et al*., 2012) and it was recently first found in La Palma, in the Canary Islands (Otto & Verloove, 2016).

This species is readily escaping wherever introduced and often found to be invasive, for instance in Brazil (Costa *et al*., 2019), but also in Hawaii, South Africa and New Caledonia.

Fig. 21 – *Hedychium coronarium*, São Jorge, damp roadside slope, September 2021, F. Verloove.

1 – Naturalized and invasive taxa:
b) Other previously recorded taxa:

Asteraceae

Youngia japonica (L.) DC., *Prodr.*, **7** (1): 194 (1838).

Herbarium: Funchal, near crossing of Rua da Praia Formosa and Estrada Monumental, border of lawn, 12 Sept. 2021, *F. Verloove* 14136 (BR); Funchal, Estrada de São João, lawn, several dozens, 12 Sept. 2021, *F. Verloove* 14175 (BR); Funchal, Rua do Gorgulho, foot of wall, a common weed, 19 Apr. 2022, *F. Verloove* 14251 (BR).

This weed is a native of temperate and tropical East Asia. It now has become a nearly pantropical and invasive species (*e.g.* Nakamura *et al*., 2013) that is probably dispersed through the horticultural trade. It is remarkably often observed as a weed in turf lawns and in ornamental plantings. It is a very diminutive species with tiny corollas, which are only open for a few hours a day and thus easily overlooked.

During the preparation of this manuscript, Jardim & Menezes de Sequeira (2021) also published some records from the island of Madeira, all from the area of Funchal. In September 2021 and April 2022, it was observed on numerous occasions, often in abundance; it is clearly naturalized and surely has been present for quite some time. In addition to Funchal, it was also recorded in Calheta, Câmara de Lobos, Faial, São Jorge, Porto Moniz, Ponta do Sol, Ribeira Brava and Santa Cruz. It was mostly seen as a lawn weed but also in ornamental plantations, on sidewalks or at the foot of walls. In 2018, it was already observed at the Reis Magos beach in Caniço (observation.org).

In Macaronesia, it was recently reported, in identical circumstances, for the first time in the Canary Islands, from Gran Canaria, La Palma and Tenerife (Siverio Núñez *et al*., 2013; Verloove, 2017; Otto & Verloove, 2018).

Brassicaceae

Diplotaxis tenuifolia DC., *Syst. Nat*., **2**: 632-633 (1821).

Herbarium: Santa Cruz, Caniço (Caniço de Baixo), at Hotel Riu Palace, gravelly riverbed close to the sea, 15 Sept. 2021, *F. Verloove* 14131 (BR); Funchal, Rua do Gorgulho, at

Hotel Allegro Madeira, 26 Apr. 2022, *F. Verloove* s.n.; dupl. MADM 7133.

This common weed is native in the southern half of Europe, West Asia and North Africa but very widely introduced and naturalized elsewhere in the world. Yet, until recently, it had not been reported from Macaronesia (Sánchez-Pinto *et al*., 2005; Silva *et al*., 2010). Since about ten years it has been known from the Canary Islands (Gran Canaria, La Palma and Tenerife: Verloove, 2013; Verloove, 2017, Otto & Verloove, 2020). In 2013, it was collected for the first time in the island of Porto Santo and reported by Jardim & Menezes de Sequeira (2014). During the preparation of this manuscript, Jardim & Menezes de Sequeira (2021) published a collection made in Funchal, in 2017.

In September 2021, its presence was also detected in several localities in Caniço (Madeira). In addition to the locality mentioned above, it was also observed in Rua do Miradouro da Falésia, Rua D. Francisco Santana (as a common garden weed) and Estrada do Cristo Rei (a few dozen along the road). In April 2022, several additional specimens were observed, all in the Funchal area (Rua dos Ilhéus, Levada dos Piornais, São Pedro, Gorgulho). This species will likely further naturalize in the southern coastal areas of Madeira.

Euphorbiaceae

Euphorbia hypericifolia L., *Sp. Pl*., **2**: 454 (1753). (Fig. 22).

(incl. *E. glomerifera* (Millsp.) L. C. Wheeler).

Herbarium: Funchal, Passeio Público Marítimo, 23 June 2021, *J. Silva* 7131 (MADM); Funchal, below Casino, roadside, foot of rocks, ca. 50 individuals, 18 Sept. 2021, *F. Verloove* 14163 (BR); Funchal, Ponta da Cruz, Passeio Público Marítimo, by track, frequent, 20 Sept. 2021, *F. Verloove* 14197 (BR); Ribeira Brava, VE-3 road leaving the village, next to the river, roadside, ca. 30 individuals, 25 Apr. 2022, *F. Verloove* 14259 (BR).

Euphorbia hypericifolia is a weed native to the southernmost parts of the U.S.A., Mexico, the West Indies, Central America and South America. It is widely naturalized elsewhere in warm-temperate and subtropical regions of the world. In Macaronesia, it has been known from the Canary Islands (as *Chamaesyce hypericifolia*, Padrón *et al*. (2007) from El Hierro, Tenerife, Gran Canaria and Fuerteventura and (as *Euphorbia hypericifolia*, Otto & Verloove (2016)) from La Palma, where it is naturalized. It is also known from Cape Verde Islands (Arechavaleta *et al*., 2005, as *E. glomerifera*).

In the island of Madeira, it was repeatedly observed in the area of Funchal, in September 2021, especially in Ponta da Cruz, where it is relatively common. During the preparation of this manuscript, Jardim & Menezes de Sequeira (2021) published, as *Chamaesyce hypericifolia*, a record from the same area.

In April 2022, a second area of local naturalization was detected in Ribeira Brava.

This species is very reminiscent of *E. hyssopifolia* L. (reported from Cape Verde Islands) and *E. nutans* Lag. (previously reported from Madeira where it has been known, at least, since the 19th century according to Vieira, 2002). All are robust, erect (often arched at tips) and weedy annuals. *E. hypericifolia* is completely glabrous and cyathia are in dense, axillary and terminal, capitate glomerules with reduced, bract-like leaves subtending cyathia. It has rather large stipules, 1.5-2.2 mm long. The other two species are sparsely to densely hairy, at least proximally, and have shorter stipules. *E. nutans* has relatively large capsules (1.6-2.3 x 1.5-2.4 mm) as compared with *E. hyssopifolia* (1.5-1.6 x 1.7-1.8 mm).

It is unknown if *E. nutans* is still present on the island of Madeira and one might even wonder whether the species has not been confused with *E. hypericifolia*. However, *E. nutans* has also been reliably documented from Madeira. In BR and MADM, the following collections are instead of.

Fig. 22 – *Euphorbia hypericifolia*, Funchal, roadside, September 2021, F. Verloove.

Ribero Seco, Ribero S. Juan, in cultis, 08.1866, *G. Mandon* (Pl. Maderenses, 1865-1866, no. 222) (BR 0000030162099); Funchal, ad vias, 07.1900, *J. Bornmüller* (Plantae exsiccatae Maderenses, no. 1220) (BR 0000030162105); Funchal, in Park Sta. Catarina, Unkraut in Blumenbeeten, 5-10 m, 13 Oct. 1978, *C. Simon* 78-7 (MADM 6381).

Iridaceae

Sisyrinchium micranthum Cav., *Diss*., **6**: 345 (1788). (Fig. 23).

(incl.: *Sisyrinchium rosulatum* E. P. Bicknell).

Herbarium: Funchal, Pico de São Martinho, rotunda GAG2, lawn, common but overlooked weed, 19 Apr. 2022, *F. Verloove* 14337 (BR); Machico, park area next to the river, lawn, a very common weed in lawns, 22 Apr. 2022, *F. Verloove* 14274 (BR); São Jorge, Arco de São Jorge, near viewpoint, between cobble stones, 30 Apr. 2022, *F. Verloove* 14404 (BR).

Sisyrinchium rosulatum is a North American weedy species. It is widely introduced and naturalized beyond its natural distribution range, often as a lawn weed. It is known from various European countries (France, Italy, Spain, etc.; Parent, 1977; Verloove & Gullón, 2012; Nicolella & Ardenghi, 2013) but has apparently not yet been recorded in Macaronesia (Sánchez-Pinto *et al*., 2005; Jardim & Sequeira, 2008; Acebes Ginovés *et al*., 2010; Silva *et al*., 2010). In Madeira it was probably first documented in 2008, from the area between Machico and Porto da Cruz and in 2015, it was also observed in Porto Moniz (https://observation.org/). Back then and in both localities, this species was found in abundance, suggesting that it was probably introduced some time ago already. In April and May 2022, it was indeed found throughout the island, often in large numbers. In addition to the municipalities mentioned above, it was also observed in Boaventura, Calheta, Faial, Fajã Alta, Porto da Cruz and Santa Cruz. It was most frequently seen in irrigated, regularly mown lawns but also in other anthropogenic habitats such as between cobblestones, in quarries, etc.

Compared with other weedy species from this genus, *e.g. S. montanum* Greene, *S. rosulatum* is annual or short-lived perennial (vs. perennial), with a paler (pink to lavender-rose with purple stripes vs. blue), rather campanulate perianth.

Sisyrinchium rosulatum belongs to a taxonomically complex group of closely related species. It is not always easily separated from the South and Central American weed *S. micranthum* Cav. (Shin *et al*., 2016) and sometimes even considered to be conspecific with it although *S. rosulatum* is tetraploid whereas *S. micranthum*, the species with the widest geographical distribution among *Sisyrinchium* species, is polyploid. Plant material from Madeira is not unambiguously assigned to either of these two taxa. Recent multidisciplinary studies indeed indicate that *S. rosulatum* (and *S. laxum* Otto ex Sims, another member of the complex) are in fact the same species as *S. micranthum* (Chauveau *et al*., 2011). All the variation found in DNA C value and number of 35S rDNA sites are not restricted to a species (*S. micranthum* or *S. rosulatum*), a ploidy level (tetraploid or polyploid), a morphological type or a geographical distribution (North or Central and South America) (Tacuatiá *et al*., 2016; comm. Camila Inácio; July 2022). Therefore, all records are here assigned to *S. micranthum*, the binomial that has nomenclatural priority.

Fig. 23 – *Sisyrinchium micranthum*, Funchal, lawn, April 2022, F. Verloove.

2 – Ephemeral taxa:

Comparably less information is provided for the taxa below since they are, based on recent field observations by the authors, at least at present, thought to be merely ephemerals in the island of Madeira. Several of them,

however, are classified as invasive species elsewhere in the world and might become so, in the future, in Madeira as well. From that perspective, it is important to document their first occurrence in the wild, either as weeds or as escapes from cultivation.

Aethusa cynapium L., *Sp. Pl.*, **256** (1753).

(Apiaceae).

Herbarium: Santa Cruz, Santo António da Serra, near Estr. Doutor João de Gouveia, roadside, a single individual, 17 Sept. 2021, *F. Verloove* 14114 (BR).

Commelina erecta L., *Sp. Pl.*, **41** (1753). (Fig. 24).

(Commelinaceae).

Herbarium: Machico (Matur), rough ground, a single clone, 12 Sept. 2021, *F. Verloove* 14226 (BR).

This is a noxious, almost pantropical weed that might naturalize in the near future. In the past years, it has increasingly been reported from southern Europe (see Verloove & Aymerich, 2020 and references therein). In the island of Madeira, it may have been overlooked since it is morphologically similar to *C. benghalensis* L., a naturalized weed there. Both have a basally fused spathe but *C. erecta* is separated by its white (not blue) proximal petal, its perennial (not annual) lifeform and smooth (not slightly reticulate) seeds.

Fig. 24 – *Commelina erecta*, Machico, rough ground, September 2021, F. Verloove.

Erythrina crista-galli L., *Mant. Pl.*, **1**: 99 (1767). (Fig. 25).

(Fabaceae).

Herbarium: Porto da Cruz, riverlet at Rua da Alagoa, semi-dried out riverbed, near to the sea, four subspontaneous shrubs ca. 2 m tall, 23 Sept. 2021, *F. Verloove* 14147 (BR).

A few flowering and fruiting individuals were observed in the absence of mature parent trees. The plants were identified using the keys in McClintock (1953) and Nesom (2015). In this particular type of habitat, *E. crista-galli* is often invasive, for instance in New South Wales, in Australia (Smith, 1996).

Fig. 25 – *Erythrina crista-galli*, Porto da Cruz, semi-dried out riverbed, September 2021, F. Verloove.

Ficus microcarpa L.f., *Suppl. Pl.*, **442** (1782).

(Moraceae).

Observed on several occasions as an escape, germinating in the crevices of trees, rock outcrops or walls from bird droppings, often in abundance (Machico, Funchal, Câmara de Lobos). Birds are believed to be the primary dispersal vector since they continually defecate fig seeds consumed from cultivated trees. The escape of *F. microcarpa* follows the introduction of its host-specific pollinating wasp, *Eupristina verticillata* Waterston, known from Madeira since the 1990's (Koponen & Askew, 2002). A future naturalization and invasive behavior is almost inevitable (compare with Riefner, 2016).

Ficus rubiginosa Desf. ex Vent., *Jard. Malmaison*, **2**: t. 114 (1805).

(Moraceae).

Scattered self-sown individuals were observed in crevices of the wall bordering a ravine next to the Jardim de Santa Luzia, in Funchal.

Heptapleurum actinophyllum (Endl.) Lowry & G. M. Plunkett, *Novon*, **28**: 146 (2020). (Fig. 26).

(Syn.: *Schefflera actinophylla* (Endl.) Harms).

(Araliaceae).

A single young plant, apparently self-sown, was observed on the sea cliffs at Caniço de Baixo.

Fig. 26 – *Heptapleurum actinophyllum*, Caniço de Baixo, sea cliff, September 2021, F. Verloove.

Heptapleurum arboricola Hayata, *Icon. Pl. Formosan.*, **6**: 23 (1916).

(Syn.: *Schefflera arboricola* (Hayata) Merr.).

(Araliaceae).

A self-sown individual was observed in crevices of the wall bordering a ravine next to the Jardim de Santa Luzia, in Funchal.

Ipomoea batatas (L.) Lam., *Tabl. Encycl.*, **1**: 465 (1793). (Fig. 27).

(Convolvulaceae).

Several individuals were observed on the verge of the Ribeira do Caniço, in Reis Magos, and along the road in Calheta. A future naturalization is not unlikely, as has been the case in the Azores (Silva *et al.*, 2010; Menezes de Sequeira *et al.*, 2012) and Cape Verde (Arechavaleta *et al.*, 2005).

Fig. 27 – *Ipomoea batatas*, Reis Magos, streamside, September 2021, F. Verloove.

Lippia alba (Mill.) N. E. Br. ex Britton & P. Wilson, *Bot. Porto Rico*, **6**: 141 (1925). (Fig. 28).

(Verbenaceae).

Herbarium: Machico, Ribeira de Machico, gravelly riverbed, a single shrub (self-sown), 11 Sept. 2021, *F. Verloove* 14118 (BR).

Fig. 28 – *Lippia alba*, Machico, gravelly riverbed, September 2021, F. Verloove.

Nerium oleander L., *Sp. Pl.*, **209** (1753).

(Apocynaceae).

Single subspontaneous individuals were observed on the verge of water courses in Funchal, Machico and Ribeira Brava.

Petunia* ×*atkinsiana (Sweet) D. Don ex W. H. Baxter, *Paxton's Mag. Bot.*, **11**: 7 (1842). (Fig. 29).

(Solanaceae).

Scattered individuals were observed in the gravelly riverbeds of Ribeira dos Socorridos, in Câmara de Lobos and Ribeira de Santa Luzia, in Funchal.

Fig. 29 – *Petunia* ×*atkinsiana*, Câmara de Lobos, dried out riverbed September 2021, F. Verloove.

Platanus* ×*hispanica Mill. ex Münchh., *Hausvater*, **5**: 229 (1770).

(Platanaceae).

Scattered saplings were observed on the gravelly banks of Ribeira da Ribeira Brava.

Psilotum nudum (L.) P. Beauv., *Prodr. Aethéogam.*, **112** (1805).

(Psilotaceae).

Herbarium: Câmara de Lobos, Bairro do Espírito Santo, common weed in pots, 19 Apr. 2022, *F. Verloove* 14276 (BR).

In identical circumstances also observed in Funchal, near the Bom Sucesso trail (Rua Doutor António Costa).

Salvia hispanica L., *Sp. Pl.*, **25** (1753). (Fig. 30).

(Lamiaceae).

Herbarium: Ribeira Brava, beach near the lighthouse, from sewage water, ca. 20 individuals, 25 Apr. 2022, *F. Verloove* 14258 (BR).

Fig. 30 – *Salvia hispanica*, Ribeira Brava, beach, April 2022, F. Verloove.

3 – Miscellaneous records:

Alternanthera pubiflora (Benth.) Kunth, *Revis. Gen. Pl.*, **2**: 538 (1891). (Fig. 31).

Muer *et al.* (2020) cited *A. flavescens* Kunth from the island of Madeira, a South American species not previously

mentioned from the island. It was found in Praia Formosa in March 2016 (comm. T. Muer, 08.2021). Jardim & Menezes de Sequeira (2021) reported *A. pubiflora* from the very same area, a species with main distribution in Central America and western South America. A few years ago, the same species was already detected on Porto Santo as well (Jardim & Menezes de Sequeira, 2015). Both belong to the *A. brasiliensis* complex and are morphological similar: procumbent, shrub-like plants with distinctly pedunculate flower heads. They are best separated on flower characters: in *A. flavescens* flowers are pedicellate with pedicels (0,2-) 0,3-0,5 mm long, whereas in *A. pubiflora* flowers are sessile or with very short pedicels up to 0,1 mm long (Sousa, 2015).

The plants found in Praia Formosa have sessile flowers and indeed belong to *A. pubiflora*, not to *A. flavescens*.

Herbarium: Funchal, Praia Formosa, coastal path towards Câmara de Lobos, on rocks, small population, 12 Sept. 2021, *F. Verloove* 14194 (BR).

Fig. 31 – *Alternanthera pubiflora*, Praia Formosa, on rocks at the beach, September 2021, F. Verloove.

Oenothera rosea L'Hér. ex Aiton, *Hort. Kew.*, **2**: 3 (1789).

This American weed was recently reported for the first time from the island of Madeira (Gonçalves Silva & Ferreira, 2019). It was mentioned from Porto da Cruz, São Vicente and Santana. In September 2021 and April 2022, it was observed in additional localities: Faial, Santo António da Serra, Lugar de Baixo (Ponta do Sol), São Jorge, Machico, Campanário (Ribeira Brava) and Funchal. It is obviously well-established and spreading.

Solanum chenopodioides Lam., *Tabl. Encycl.*, **2**: 18 (1794).

According to Press & Short (1994) this South American weed had been reported from Funchal without further data, suggesting that little was known about its current status and distribution. Vieira (2002), also considered it to be very rare and Menezes de Sequeira *et al.* (2012) no longer reported it from Madeira.

Yet, *S. chenopodioides* is, in fact, not rare at all but probably widely overlooked. In September 2021 and April 2022, it was observed in Machico, Referta, Porto da Cruz (Ribeira do Juncal, Praia da Maiata, etc.), Faial, Caniço (Reis Magos), Santo António da Serra, São Vicente (Barros, Ribeira Grande), Monte and Funchal (São Gonçalo, São Roque, Palheiro Ferreiro). It is often seen in large numbers and in various kinds of habitats, including natural ones (*e.g.* rock crevices). In fact, it is commonly naturalized and locally even invasive.

In a recent monograph of Old World black nightshades, Särkinen *et al.* (2018) also confirmed its presence in Madeira, citing a specimen preserved in BM that was collected between Funchal and Monte, in 1984.

Herbarium: Machico, Ribeira de Machico, gravelly riverbed, common, 11 Sept. 2021, *F. Verloove* 14121 (BR).

Tipuana tipu (Benth.) Kuntze, *Revis. Gen. Pl.*, **3** (2): 72 (1898).

This South American ornamental tree was known to occasionally escape near gardens in Madeira (Vieira, 2002). Locally, however, it seems to be in the process of an incipient naturalization, for instance in Câmara de Lobos where adult subspontaneous trees are currently found along Ribeira dos Socorridos, along with *Casuarina cunninghamiana* Miq., *Melia azedarach* L., *Schinus terebinthifolia* Raddi and *Washingtonia robusta* H. Wendl.

It is locally naturalized in Cape Verde (Arechavaleta *et al.*, 2005) and similar behavior has been observed lately in the Canary Islands as well (Verloove, 2017).

Veronica peregrina L., *Sp. Pl.*, **14** (1753).

The status of this New World weed in Madeira was unknown. Press & Short (1994) and Menezes de Sequeira *et al.* (2012) did not report it from the island and Jardim & Sequeira (2008) included this taxon in the list of problematic species. Vieira (2002) says it is a recent and probably ephemeral introduction. In reality, it is probably not rare at all, more or less widely naturalized but easily overlooked. In April

2022 it was recorded on several occasions, especially in the northeastern part of the island (Arco de São Jorge, Fajã Alta, Santana, São Vicente). It was found in cracks of pavement, between cobblestones, along tracks, as a weed in a banana plantation, etc.

Herbarium: Funchal, Rua Nova do Vale da Ajuda, lawn weed, 19 Apr. 2022, *F. Verloove* 14278 (BR); Faial, Cabeço, weed in quarry, 24 Apr. 2022, *F. Verloove* 14266 (BR); São Jorge, Fajã Alta, Ribeira de São Jorge, banana plantation and track along the river, commonly naturalized, 30 Apr. 2022, *F. Verloove* 14246 (BR); dupl. MADM 7134; Santana, Rua de Santa Ana (city center), between cobble stones, more than 100 individuals, 30 Apr. 2022, *F. Verloove* 14248 (BR); dupl. MADM 7135.

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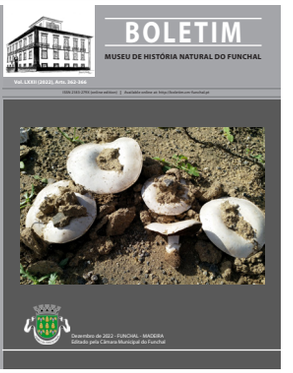

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Intra-island distribution of the wild bee species of Madeira Island, habitat preferences and flower-visiting behaviour (Hymenoptera, Apoidea, Anthophila)

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With 64 figures and 28 tables

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ABSTRACT: The aim of this study was to analyse the intra-island distribution pattern, the habitat preferences, and the flower-visiting behaviour of the wild bee species of Madeira Island. The total dataset from Madeira Island includes 2,226 data from 491 localities (1,029 with flower visits on 112 plant taxa belonging to 39 plant families). We sampled a total of 1,595 data from 1989 to 2022. Additionally, 392 data came from collections of institutions and museums checked by the authors, supplemented by 227 data from the literature, eight data from private collections, and five from further reliable observations.

In all, we detected 18 wild bee species, which reflect the complete species pool of permanently established species as well as single observations. *Anthidium manicatum* and *Xylocopa violacea* are here included as new species for Madeira Island. In some cases, new taxonomic findings have been added to the checklist published by Kratochwil *et al*. (2018). These are listed under 'status'. The distribution of the wild bee species was documented on a base of square-grid cells (1 km x 1 km) based on the military map of the Madeira Archipelago (2004). We were able to analyse data from wild bee specimens on 251 representative square-grid cells (30% of the whole area with 826 square-grid cells), which reflect the proportion of the occurring thermo-, hygro- and vegetation series.

Among the frequently occurring species, *Bombus terrestris lusitanicus*, *Andrena wollastoni*, and *Lasioglossum wollastoni* show the largest distribution areas, whereas most of the populations of *Amegilla quadrifasciata maderae*, *Bombus r. ruderatus*, *Andrena maderensis*, *Osmia madeirensis*, and *O. niveata* colonise the warmer zones. Species-specific habitat preferences were characterised according to the bioclimatic vegetation-series system of Rivas-Martínez (1996, 2009). Flower-visiting preferences were documented on the plant-species level.

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Six of the identified wild bee species and one subspecies can be classified as endemic to Madeira Island or Madeira Archipelago, eight species as introduced or probably introduced, and three species as native or probably native. The endemic wild bee species make up large numbers of individuals. This is also true for *Bombus terrestris lusitanicus* (native, the most frequently recorded species) and *Lasioglossum v. villosulum* (probably native, the third most frequently recorded species).

Key words: endemism, distribution pattern, habitat analyses, flower-visiting behaviour, introduced species, island biogeography, Hymenoptera, Apoidea, Anthophila, Madeira Archipelago, native species, vegetation series.

RESUMO: O objetivo deste estudo foi analisar o padrão de distribuição intra-ilha, as preferências de habitat e o comportamento de visita floral das espécies de abelhas selvagens da Ilha da Madeira. O conjunto de dados total da Ilha da Madeira inclui 2,226 dados de 491 localidades (1,029 com visitas florais em 112 táxons de plantas pertencentes a 39 famílias). 1,595 dados foram amostrados de 1989 a 2022 pelos autores. Além disso, 392 dados vieram de coleções de instituições e museus verificados pelos autores, complementados por 227 dados da literatura, oito dados de coleções particulares e mais cinco observações confiáveis.

Detetámos todas as 18 espécies de abelhas selvagens que constituem o conjunto completo de espécies de abelhas selvagens permanentemente estabelecidas, bem como observações únicas. *Anthidium manicatum* e *Xylocopa violacea* são adicionadas como espécies novas para a Ilha da Madeira.

Em alguns casos, novos achados taxonómicos foram adicionados em comparação com a lista de verificação publicada por Kratochwil *et al*. (2018). Estes estão listados em 'status'. A distribuição das espécies de abelhas selvagens foi documentada na matriz de células de malha quadrada (1 km x 1 km), com base no mapa militar do Arquipélago da Madeira (2004). Conseguimos analisar dados de espécimes de abelhas selvagens em 251 células representativas de grade quadrada (30% de toda a área com 826 células de grade quadrada), que refletem com grande aproximação a proporção de ocorrência de termo, higro e séries de vegetação.

Entre as espécies de ocorrência frequente, *Bombus terrestris lusitanicus*, *Andrena wollastoni* e *Lasioglossum wollastoni* apresentam as maiores áreas de distribuição, enquanto a maioria das populações de *Amegilla quadrifasciata maderae*, *Bombus r. ruderatus*, *Andrena maderensis*, *Osmia madeirensis* e *O. niveata* colonizam as zonas mais quentes. As preferências de habitats específicos das espécies foram caracterizadas com base no sistema bioclimático de séries de vegetação de Rivas-Martínez (1996, 2009). As preferências de visitação de flores foram documentadas ao nível da espécie de planta.

Sete das espécies de abelhas selvagens identificadas e uma subespécie podem ser classificadas como endémicas da Ilha da Madeira ou do Arquipélago da Madeira, oito como espécies introduzidas ou provavelmente introduzidas e três como espécies nativas ou provavelmente nativas. As espécies endémicas de abelhas silvestres compõem um elevado número de indivíduos. Isto também é verdade para *Bombus terrestris lusitanicus* (nativa, a espécie mais frequentemente registada) e *Lasioglossum v. villosulum* (provavelmente nativa, a terceira espécie mais registada).

Palavras-chave: endemismo, padrão de distribuição, análises de habitat, comportamento de visitação de flores, espécies introduzidas, biogeografia insular, Hymenoptera, Apoidea, Anthophila, Arquipélago da Madeira, espécies nativas, séries de vegetação.

Abbreviations:

abbr. = abbreviation(s); agg. = aggregate; appr. = approximately; *a.s.l*. = above sea level; cf. = compare; co. = checked observation(s); E = east, ind. = individual(s); K/S = Kratochwil / Schwabe; leg. = collected; loc. = locality; n = number(s); N = north; *pers. comm*. = personal communication; resp. = respective; S = south; W = west.

Status of bee taxa: endMI = endemic to Madeira Island; endMID = endemic to Madeira Island and Desertas; endMA = endemic to Madeira Archipelago; intr = introduced; intr? = probably introduced; nat = native; nat? = probably native.

Status of plant taxa: cult = cultivated; end = endemic to Madeira Archipelago; intr = introduced; intr? = probably introduced; mac = Macaronesian; nat = native; nat? = probably native.

Plant families: Aca = Acanthaceae, Aiz = Aizoaceae, Api = Apiaceae, Ast = Asteraceae, Big = Bignoniaceae, Bor = Boraginaceae, Bra = Brassicaceae, Cac = Cactaceae, Cae = Caesalpiniaceae, Cle = Clethraceae, Con = Convolvulaceae, Cra = Crassulaceae, Cuc = Cucurbitaceae, Eri = Ericaceae, Eup = Euphorbiaceae, Fab = Fabaceae, Ger = Geraniaceae, Hyd = Hydrangeaceae, Hyp = Hypericaceae, Lam = Lamiaceae, Lil = Liliaceae, Mal = Malvaceae, Nyc = Nyctaginaceae, Ona = Onagraceae, Oxa = Oxalidaceae, Pap = Papaveraceae, Pas = Passifloraceae, Pla = Plantaginaceae, Poa = Poaceae, Pro = Proteaceae, Res = Resedaceae, Ros = Rosaceae, Sax = Saxifragaceae, Scr = Scrophulariaceae, Sol = Solanaceae, Str = Strelitziaceae, Tro = Tropaeolaceae, Val = Valerianaceae, Ver = Verbenaceae.

Collections: HEC = Hope Entomological Collections, Oxford University, England; ICLAM = Laboratório Agrícola da Madeira, Camacha, Portugal; MZHF = Finnish Museum of Natural History, Helsinki, Finland; OLML = Biology Centre of the Upper Austrian Provincial Museum Linz, Austria; SDEI = Senckenberg German Entomological Institute, Müncheberg; UMB = Überseemuseum Bremen, Germany; cAK = collection A. Kratochwil, Germany; cJS = collection J. Smit, The Netherlands.

Symbols: ♀ = female, queen; ♂ = male; ☿ = worker; in the case of *Bombus*: ♀ = queen.

INTRODUCTION

The wild bee faunas of the different archipelagos of the Macaronesian Islands show great differences in species numbers, in numbers of endemic, native and introduced species, and in the biogeographic affiliations of the species (Kratochwil & Schwabe, 2018a). Low species numbers exist in the Azores (n = 17; only one species endemic, 16 species introduced), the Madeira Archipelago (n = 21; nine endemic, four native or probably native, eight introduced or probably introduced), and Cape Verde (n = 17; nine endemic, four native, one introduced), whereas high species numbers are found in the Canary Islands (127 species; 88 endemic, 56 native, seven introduced); Kratochwil & Schwabe (2018a). Knowledge of the bee fauna of Cape Verde is still insufficient.

On Madeira Island, 18 wild bee species were detected (six species and one subspecies endemic; four of them restricted to Madeira Island, with one also found on the Desertas Islands). There were six introduced/ two probably introduced species, and two native/one probably native species.

If wild bee species are compared to the group of Syrphidae (Diptera) with high flight activity, Madeira Island has 25 species, with four endemic ones (Rego *et al*., 2022).

The analysis of the biogeographic spectra of the native wild bee species of the different archipelagos (excluding the Azores, where there are nearly only introduced species) shows that the Madeira Archipelago is characterised by species from the Western Palaearctic-Mediterranean region and the Canary Islands by species from the Western Palaearctic-Mediterranean region complemented by Holomediterranean and mainly Saharan-Arabian elements. Cape Verde is dominated by Ethiopian and Sahelo-Sudanese elements (Kratochwil & Schwabe, 2018a).

The reasons for all these differences (*e.g*. species numbers, endemisms, introductions, biogeographic affiliations) are manifold. They include the evolutionary history and geology of the islands and archipelagos, the number of islands, their climatic conditions, the diversity of the orography of the islands and their habitats, the age of the islands, and the respective distances to sources of settlement (neighbouring islands and mainland); see Kratochwil & Schwabe (2018a); Kratochwil *et al*. (2021).

Different publications on the wild bee fauna of the Madeira Archipelago are available. The first checklist by Fellendorf *et al*. (1999) was supplemented and edited by Kratochwil *et al*. (2008, 2018). It was necessary to clarify many taxonomic questions (Kratochwil & Scheuchl, 2013; Kratochwil *et al*., 2014; Kratochwil, 2018; Kratochwil, 2020; Kratochwil *et al*., 2021). The wild bees of Porto Santo

were analysed in more detail, and grid-based, species-specific distribution maps were worked out (Kratochwil & Schwabe, 2018b). The bee-plant networks of wild bee species on both Porto Santo and Madeira Island could be analysed and compared (Kratochwil *et al*., 2019). More detailed studies were also compiled, including one with a molecular biological approach focused on the species of the *Andrena wollastoni* group, studied on the Canary Islands and the Madeira Archipelago (Kratochwil & Schwabe, 2020; Kratochwil *et al*., 2021).

Analysing the distribution pattern of wild bee species on an island, their habitat preferences, and their flower-visiting behaviour is advantageous if the studied island has a wide range of different habitat types with a large diversity of entomophilous plant species (Kratochwil *et al*., 2019). The high relief structure with pronounced fluvial erosion and steep slopes (altitudes from the sea level to mountain regions more than 1,800 m *a.s.l.*), precipitation and temperature gradients between north and south (partly influenced by the trade-wind system), and the high plant-resource diversity for wild bees (Borges *et al*., 2008) favour Madeira Island as a model object for entomofaunistic studies.

In the following, the wild bee species will be characterised according to their intra-island distribution pattern, their habitat preferences and their flower-visiting behaviour. The checklist by Kratochwil *et al*. (2018) is a reference for further information on the wild bee species of Madeira Island. In some cases, new taxonomic findings were added in the present study.

Here, the following questions are analysed in detail:
- Which wild bee species show the largest distribution pattern on Madeira Island, and which species have a limited distribution?
- What are the preferred habitats of the different species?
- Are there different species groups with the same habitat preferences?
- What differences in flower-visiting behaviour can be observed between the wild bee species, and which plant species and plant families play a key role?

Physico-geographical factors

Overview

Madeira Island has a size of about 740 km^2 and an age of about 4.6 Ma, and is of volcanic origin. The distance between the Madeira Archipelago and mainland Portugal is about 800 km, and that between it and the western coast of Africa about 600 km (Galopim de Carvalho & Brandão, 1991; Geldmacher *et al*., 2000; Borges *et al*., 2008). The sea level during the last glacial optimum was 120 m lower than it is today (Garcia-Talavera, 1999). The highest elevation is the Pico Ruivo de Santana (1,862 m *a.s.l.*). About 90% of the surface lies above 500 m *a.s.l*., while appr. one third of the surface has an elevation of more than 1,000 m *a.s.l*. The island has a diverse orography with high relief energy, especially in the north, and is rich in 'ribeiras' (ravines with steep slopes). Coastlines are mostly steep with rocky habitats, and are often rich in endemic plant species (Capelo *et al*., 2005). The climate is oceanic and influenced mainly above 800-1,000 m/ res. 300 m *a.s.l*. (southern / northern side) by the trade-wind system (blowing from the NE). The windward sides of the island are characterised by high annual precipitation of more than 1,500 mm/a; the leeward sides show about 500 to 800 mm/a of precipitation in the lower zones (de Lima & de Lima, 2009). The driest zones are the southern and eastern coastlines, which have Mediterranean characteristics. Climatic gradients are strong and additionally modified by the steep slopes, most of more than 30% (Mesquita *et al*., 2022), with different types of sun exposure and hygric conditions.

Biogeographic characteristics and potential natural vegetation

Concerning the flora and the wild bee fauna (and many other faunal taxa too), there are mainly strong biogeographical relationships between the Madeira Archipelago and the Canary Islands. The affinities to the Azores and Cape Verde depend on the taxon (*e.g*. the Madeira Archipelago and Azores show high similarities in bryophytes). The flora and different faunal taxa also show connections with the Mediterranean area (Aguin-Pombo & Pinheiro de Carvalho, 2009; Kratochwil & Schwabe, 2018a). Nearly all taxa (species level) of flora, fauna and fungi are rich in endemic species (Borges et al., 2008).

Especially in the lower zones of Madeira Island, the primary vegetation has been replaced since the 15th century by secondary vegetation (the latter mostly rich in introduced plant species) and by settlements as well as agricultural fields (*e.g*., Sjögren, 1972; Oberdorfer, 1975; Capelo *et al*., 1999, 2005; Costa et al., 2012). The Laurisilva forest is still present, with considerable extension, and protected as a 'UNESCO Natural World Heritage Site'. All potential natural vegetation series are excellent indicators of the combined thermo- and ombrotype conditions

according to Rivas-Martínez (1996, 2009), even if they are actually dominated by secondary vegetation types. The system of such vegetation series was also used by Capelo *et al*. (2004, 2005), Mesquita *et al*. (2004, 2022), and Costa *et al*. (2004, 2012) to describe the biogeographic characteristics of Madeira Island.

The types were distinguished according to Costa *et al*. (2004, 2012). In Table 1 we do not use a specific sigmasyntaxonomical nomenclature (*e.g*. Clethro arboreae – Ocoteo foetentis sigmetum), but we regard the specific plant association as a target community for the series (*e.g*. the Clethro arboreae – Ocoteetum foetentis series).

Table 1 – Vegetation series of Madeira Island, used for the habitat characterisation of wild bee species (modified according to Capelo *et al*., 2004, 2005; Mesquita *et al*., 2004; Costa *et al*., 2004, 2012).

a) Mediterranean macrobioclimate, inframediterranean dry series (abbr. May-Ol); Figs. 1 and 2.
The ***Mayteno umbellatae* – *Oleetum maderensis* series** (xerophytic microforest) potentially covers the south coast of Madeira up to altitudes of 200 m *a.s.l*. Further plant communities are, *e.g*., Euphorbietum piscatoriae (*e.g*. *Euphorbia piscatoria*, *Globularia salicina*, *Echium nervosum*), Artemisio argenteae – Genistetum tenerae (*e.g*. *Genista tenera*, *Carlina salicifolia*) and Sedo nudi – Aeonietum glutinosi.

b) Mediterranean macrobioclimate, inframediterranean lower subhumid series (abbr. Hel-Si); Figs. 3 and 4.
The ***Helichryso melaleuci* – *Sideroxyletum marmulanae* series** (meso-xerophytic microforest of *S. mirmulans* = *S. marmulano*) reflects subhumid conditions, influenced by fog and humid winds (altitudes: eastern coast up to 50 m / 80 m *a.s.l*.; southern coast: scattered above type a, between 200 and 300 m *a.s.l*.). Meanwhile, very rare stands of *Juniperus turbinata* subsp. *canariensis* occur. As a secondary plant community, there is a substitution stage of *Helichrysum melaleucum* and *Globularia salicina*. Rock habitats are characterised by the *Sinapidendro gymnocalicis – Sedetum brissemoretii* with *Aeonium glandulosum*.

c) Mediterranean macrobioclimate, upper inframediterran-thermomediterranean series, upper subhumid type (abbr. Sem-Ap 1).
This type (1) of the ***Semele androgynae* – *Apollonietum barbujanae* series** (subhumid forest of *A. barbujana*, *Laurus novocanariensis* and others including lianas, *e.g. S. androgyna*, *Smilax*-species) characterises south-faced altitudes of 300 to 600 m *a.s.l*. Characteristic forest fringes are marked by the *Myrto communis – Hypericetum canariensis*. It is the main area for viniculture and fruit trees.

d) Mediterranean macrobioclimate, thermomediterranean series, lower humid type (abbr. Sem-Ap 2); Figs. 5 and 6.
This type (2) of the ***Semele androgynae* – *Apollonietum barbujanae* series** characterises south-faced (600 to 800 m *a.s.l*.) and north-faced slopes (50-300 / 450 m *a.s.l*.), growing in complex with (tree-)heath communities (*Erica platycodon* subsp. *maderincola*, *Erica arborea*, *Myrica faya*) but still thermophytic elements, *e.g*., *Globularia salicina*.

e) *Temperate* macrobioclimate, infra- to mesotemperate series, humid and lower hyperhumid type (abbr. Cle-Oc); Figs. 7 and 8.
The ***Clethro arboreae* – *Ocoteetum foetentis* series** represents the humid Laurisilva forest complex in the trade-wind zone from altitudes of 800 to 1,450 m *a.s.l*. (south exposed) and 300 to 1,400 m *a.s.l*. (north exposed). The tree stratum is about 30 m tall (*e.g*. *Ocotea foetens*, *Laurus novocanariensis*, *Clethra arborea*, *Persea indica*); lianas are present, and the forests are rich in different strata. Ferns and bryophytes play an important role, partly as epiphytes. In the vegetation complex, there are also tall-herb / shrub communities, *e.g*. the *Pericallido auritae – Geranietum palmatae*. A substitution community is characterised by *Vaccinium padifolium* and *Erica arborea*; the *Vaccinio padifolii – Ericetum maderincolae* also characterises wind-exposed rock cliffs and forms a probably natural community there.

f) *Temperate* macrobioclimate, upper mesotemperate series, upper hyperhumid and ultrahyperhumid type (abbr.: Pol-Er); Figs. 9 and 10.
From appr. 1,400 to 1,650 *a.s.l*. the ***Polysticho falcinelli* – *Ericetum arboreae* series** (high altitude tree-heath series) occurs. A substitution plant community (clearings) is, *e.g*., the *Teucrio francoi – Origanetum virentis*. Large areas are actually characterised by monotonous pastures with the invader *Ulex europaeus*.

g) *Temperate* macrobioclimate, supratemperate series, ultrahyperhumid type (abbr.: Arm-Pa).
The ***Armerio maderensis* – *Parafestucetum albidae* series** (high-altitude rock vegetation complex) characterises the highest peak areas on rocky substrates (> 1,650 m *a.s.l*.). Characteristic species are, *e.g*., *Koeleria loweana* (= *Parafestuca albida*) and *Deschampsia maderensis*. Further plant communities are, *e.g*., the *Sinapidendro frutescentis – Aeonietum glandulosi* and the *Thymetum micantis*.

Fig. 1 – Vegetation series a) with Mediterranean dry macrobioclimate (*Mayteno umbellatae – Oleetum maderensis*). The endemic plant species *Echium nervosum* (Bor) is a key species for flower-visiting wild bee species. Ribeira Brava, Miradouro da Cruz, 01.04.2022; Table 1. Photo A. Schwabe.

Fig. 2 – Vegetation series a) with *Sinapidendron angustifolium* (end, Bra), an important resource for pollen and nectar (same site and date as Fig. 1). Photo A. Schwabe.

Fig. 3 – Vegetation series b) with Mediterranean subhumid macrobioclimate (*Helichryso melaleuci – Sideroxyletum marmulanae*). *Argyranthemum pinnatifidum* subsp. *succulentum* (end, Ast) is regularly visited by *Andrena wollastoni* (end). Ponta de São Lourenço, 26.03.2005; Table 1. Photo A. Schwabe.

Fig. 4 – Close-up of *Argyranthemum pinnatifidum* subsp. *succulentum* (same site and date as Fig. 3). Photo A. Schwabe.

Fig. 5 – Vegetation series d) (transition type between the Mediterranean and temperate zone: *Semele androgynae – Apollonietum barbujanae* 2). The type occurs on the northern slopes even at low altitudes. The coastal rocky sites are characterised, *e.g.*, by *Andryala glandulosa* subsp. *glandulosa* (end, Ast). Near Seixal, 03.04.2022; Table 1. Photo A. Schwabe.

Fig. 6 – Vegetation series d) is rich in traditional cultural landscapes with ruderal vegetation, vegetable gardens, and therefore large quantities of pollen and nectar resources. Arco de São Jorge, 02.04.2022; Table 1. Photo A. Schwabe.

Fig. 7 – Vegetation series e) (Laurisilva, *Clethro arboreae – Ocoteetum foetentis*) is still characterised by considerable areas of Laurel forest and tree-heath substitution stages. In gaps in the Laurisilva zone, the endemic plant species *Melanoselinum decipiens* (Api) offers pollen and nectar (shown: *Bombus terrestris lusitanicus*). 990 m *a.s.l.*, Encumeada, 01.04.2022; Table 1. Photo A. Schwabe.

Fig. 8 – We only got wild bee data for one tree species of the Laurisilva forest [vegetation series e)] (*Clethra arborea*: huge tree in the foreground and flowering / fruiting stage on the inset picture). *Andrena wollastoni* was detected as flower visitor. 1,100 m *a.s.l.*, Ribeiro Frio, 15.03.2012; Table 1. Photo A. Schwabe.

Fig. 9 – Vegetation series f) (*Polysticho falcinelli – Ericetum arboreae*). Large areas are grazed mainly by cattle and have been partly invaded by the introduced species *Ulex europaeus* (Fab). 1,450 m *a.s.l.*, Paúl da Serra, 01.04.2022; Table 1. Photo: A. Schwabe.

Fig. 10 – Some remnants of the endemic tree-heath stands (here with *Vaccinium padifolium*, Eri) are left in vegetation series f) (with inset picture of flowers). 1,550 m *a.s.l.*, 01.04.2022; Table 1. Photo A. Schwabe.

METHODS

Transfer of data in a base map

We used the UTM map of Madeira Island, and prepared maps for different data (*e.g.* vegetation series) and for the wild bee data on this basis. The map is divided into 826 square-grid cells, each measuring 1 km x 1 km. In case of the marginal coastal square-grid cells, the land cover is often small. Each of these square-grid cells was designated to one type of the vegetation series [a)-g); see above], transferred from the map by Capelo *et al.* (2004). In the case of transitions of two series in one square-grid cell, we used the dominant one. The map with the transferred data of the vegetation series (Fig. 11) shows the following distribution data of all square-grid cells (Table 2A) and the square-grid cells with bee data (Table 2B), differentiated into types a)-g).

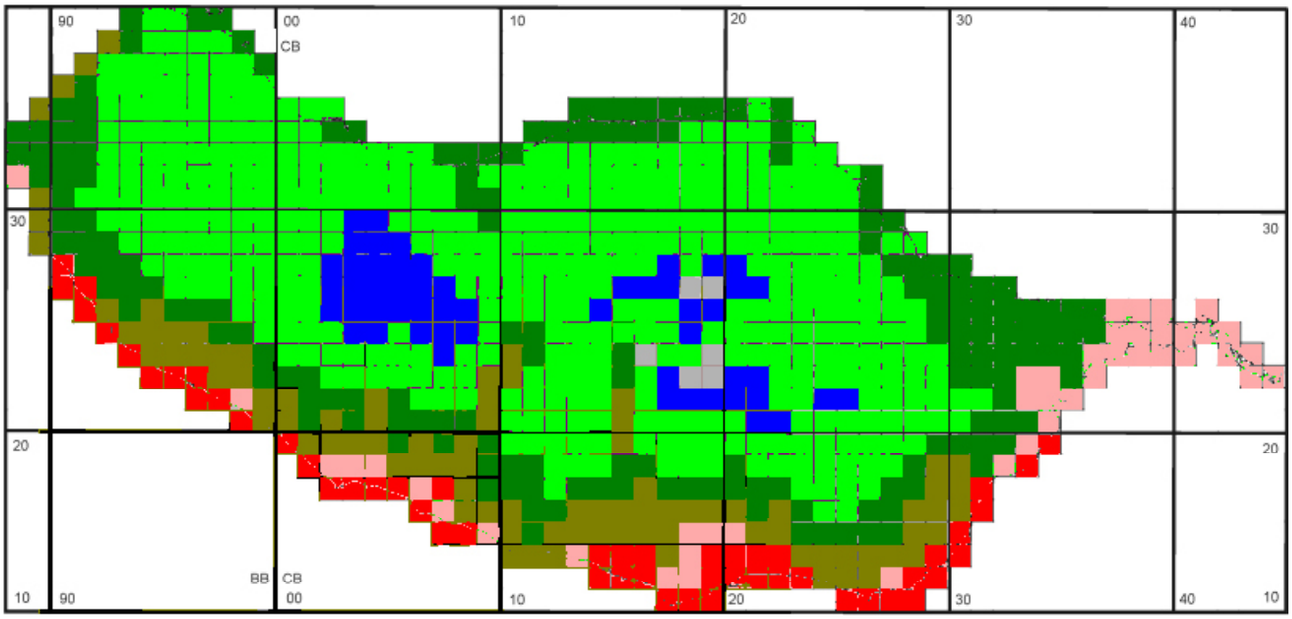

Fig. 11 – Vegetation-series distribution of Madeira Island, reflecting the thermo-hygric and biogeographical conditions (adapted and modified from Capelo *et al.*, 2004, 2005; Mesquita *et al.*, 2004; Costa *et al.*, 2004, 2012; Mesquita., 2022); for abbr., see Table 1.
Red: a) = Mediterranean macrobioclimate, inframediterranean dry series (May-Ol) 'Madeiran oleaster microforest'.
Pink: b) = Mediterranean macrobioclimate, inframediterranean lower subhumid series (Hel-Si) 'Marmulano-tree microforest'.
Olive ocher: c) = Mediterranean macrobioclimate, upper inframediterran-thermomediterranean series, upper subhumid type (Sem-Ap 1) 'Barbusano-tree dry forest'.
Green: d) = Mediterranean macrobioclimate, thermomediterranean series, lower humid type (Sem-Ap 2) 'Barbusano-tree mesic forest'.
Light green: e) = *Temperate* macrobioclimate, infra- to mesotemperate series, humid and lower hyperhumid type (Cle-Oc) 'Stink-laurel forest'.
Blue: f) = *Temperate* macrobioclimate, upper mesotemperate series, upper hyperhumid and ultrahyperhumid type (Pol-Er) 'Tree-heath community'.
Grey: g) = *Temperate* macrobioclimate, supratemperate series, ultrahyperhumid type (Arm-Pa) 'High-altitude rock vegetation complexes'.

Table 2 – Square-grid cell numbers (total and with bee data) and percentages of the different vegetation series [a)-g)]: for abbr., see Table 1. Percentages refer to the sum of square-grid cells that occur (A) or that have been sampled for wild bee data (B). 'B' closely reflects the proportion of occurring vegetation series.

vegetation series	total grid numbers	percentages A	grid numbers with bee data	percentages B
a	53	6	21	8
b	44	5	17	7
c	90	11	29	12
d	170	21	61	24
e	410	50	104	42
f	53	6	16	6
g	6	1	3	1
sum	826		251	

Sampling of wild bee data

Sampling procedure

The total dataset from Madeira Island includes 2,226 data from 491 localities belonging to 18 wild bee species (1,029 specimens with flower visits on 112 plant taxa belonging to 39 plant families). In the period from 1989 to 2022, we sampled 1,595 wild bee data in Madeira Island (1,160 collected specimens, 435 observations). A total of 940 specimens (61%) were collected or observed during flower-visiting, 43 (3%) on nesting sites. In some cases, Moericke traps (yellow, white, and blue pan traps, 7% of collected specimens, n = 104) and Malaise traps (1%, n = 15) were applied. Additionally, we used 392 data from checked museum specimens (ICLAM, MZHF, SDEI, OLML, UMB). Included were 289 reliable literature data, eight data from private collections (M. Andrade, Madeira; M. Boieiro, Azores; R. Santos, Azores; I. Silva, Madeira), and five data with reliable observations (T. Dellinger, Madeira; G. Matzke-Hajek, Germany; F. Rocha, Madeira; H. Schaefer, Germany; P. Wirtz, Madeira). All in all, the data base included 2,226 wild bee specimens belonging to 18 species. The 491 localities could be assigned to 251 of 826 square-grid cells (30%) of the UTM map (grid cell = 1 km x 1 km) (Fig. 12, Table 2).

In the 'Wild Bee Species Characterisation' section, we differentiate the localities for each wild bee species according to altitudes (m *a.s.l.*). It should be noted that in this specific approach, there is no differentiation, *e.g.*, into northern or southern coastal areas or slopes. The areas of the northern coast often show biogeographic characteristics of the Laurisilva biogeographical series [e), Fig. 11].

The wild bee species were classified into the categories 'endemic to the Madeira Archipelago' (endMA), to Madeira Island (endMI), and to Madeira Island and Desertas (MID); 'introduced' (intr), and 'probably introduced' (intr?); 'native' (nat), and 'probably native' (nat?).

Approach to map the single bee taxa

The data were sampled in 251 square grids (whole set: 826 square-grid cells); Fig. 12. We tried to stratify the whole set of square-grid cells according to the vegetation series (which also reflect combined thermo-/ ombrotypes) and sampled the 251 square-grid cells in a (near) similar proportion to the vegetation series comparable to the whole 826 square-grid set (Table 2).

Approach to analysing flower-visiting behaviour and possible habitat preferences

We already elaborated a network study of wild bee and flower-visiting interactions on Madeira Island based on 637 observations, and compared the results with Porto Santo Island, where there were 300 bee-plant interactions (Kratochwil & Schwabe, 2018b; Kratochwil *et al.*, 2019). In our study (Kratochwil & Schwabe, 2018b), we differentiated flower-visiting data observed in the Mediterranean zones (Porto Santo and zones a)-d) on Madeira Island) from the temperate zones e)-g) (which only occur on Madeira Island). Using this approach, we were able to compare both islands.

In this study, we enlarged the data of flower visits. Here, we present summary tables for the single bee species

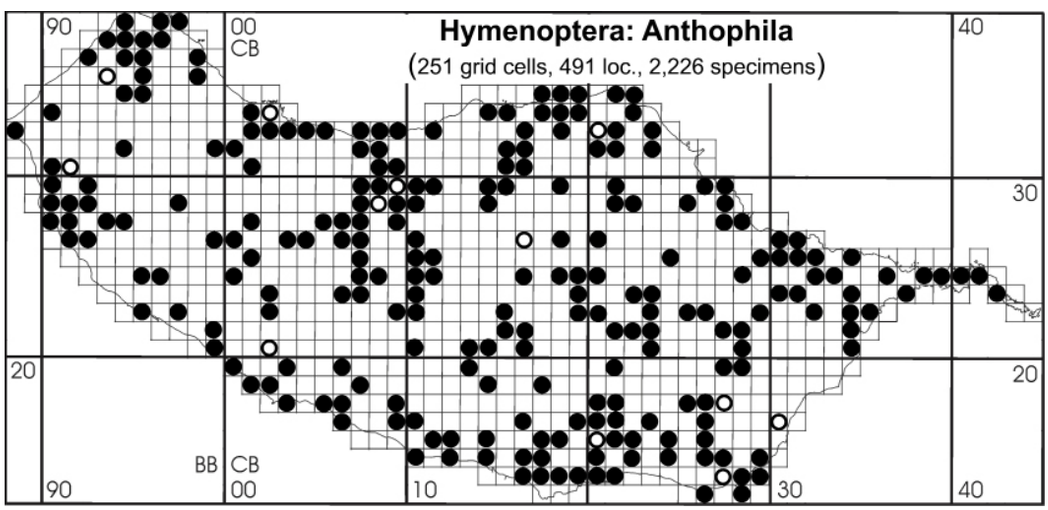

Fig. 12 – Studied square-grid cells on Madeira Island (black dots: authors' data, checked specimens of collections, and checked observations; circles: literature data).

(1,029 flower visits on 115 plant taxa) and overviews of the interactions of the females of the 10 most frequently occurring bee species. We also provide a presence table of all bee species based on the observations in square-grid cells in defined vegetation series. Flower visits of single bee species and preferences of biogeographic zones together will elucidate the habitat preferences.

The nomenclature of plant species follows Jardim & Menezes de Sequeira (2008), with the exception of *Taraxacum*, which refers to Muer *et al*. (2020). The names of plant communities follow Capelo *et al*. (2004). Additionally, we checked Press & Short (1994) and Muer *et al*. (2020) for further information concerning vascular plant species.

Data recording and deposition of the specimens in collections

Voucher specimens are in the private collections of A. Kratochwil (n = 625), A. Aguiar (n = 57), J. Smit (n = 478), C. Praz (Neuchâtel, Switzerland; n = 1), or in the collections of the ICLAM (n = 144), UMB (n = 125); OLML (n = 31), MZHF (n = 90), or SDEI (n = 2). Included were 227 reliable literature data, eight data from private collections (M. Andrade, Madeira, n = 1; M. Boieiro, Azores, n = 4; R. Santos, Azores, n = 2; I. Silva, Madeira, n = 1), two unpublished data with photo documentation (T. Dellinger, Madeira, n = 1; H. Schaefer, Germany, n = 1) and two data without photo documentation (F. Rocha, Madeira, n = 1, P. Wirtz, Madeira, n = 1). Four hundred and thirty-five data are observations by the authors.

The following colleagues contributed additional data: Barkemeyer, W. (Museum of Natural History, Flensburg, Germany; n = 1); Brazão, C. (ICLAM, Camacha; n = 17); Cravo, D. (ICLAM, Camacha; n = 9); Erber, D. (Gießen, Germany; n = 1; cFA); Evenhuis, H. H. (Bennekom, The Netherlands; n = 3; cJS); Freitas, N. (Universidade da Madeira, Funchal; n = 4; ICLAM); Jesus, J. (ICLAM, Camacha; n = 29, in cooperation with A. Aguiar n = 95), Smit, J. T., (Leiden, The Netherlands; n = 299).

Literature data were also used, but there are only a few publications that provide accurate data on wild bee species and their localities. In some cases, the locality data are insufficient to integrate the findings into our grid-cell system. Due to the methods used in Costa (2019) (high proportions of observations on *Echium candicans*), extraordinarily high numbers of interactions (not always different individuals) were recorded, so that a transfer of all these interactions into our data set was not appropriate. Therefore, we only used qualitative data of species with such high interaction numbers as a valuable addition. Fellendorf *et al*. (1999) did not always exactly indicate in their descriptions whether flower-visiting observations were made on Madeira Island or on Porto Santo (Kratochwil *et al*., 2019); these cases had to be excluded if they referred to wild bee or plant species that occur on both islands. In all cases where exact numbers of observations of individuals at each locality or of flower visits were not available, the observation was counted as one individual.

RESULTS AND DISCUSSION

Actualised taxonomic list of the occurring wild bee species of Madeira Island

Eighteen different wild bee species were detected on Madeira Island (Table 3). These wild bee species represent the families Colletidae, Andrenidae, Halictidae, Megachilidae, Anthophoridae and Apidae. The semi-domesticated honeybee *Apis mellifera* Linnaeus, 1758, was not considered. Sixteen species are listed in Kratochwil *et al*. (2019); a new species, *Anthidium manicatum*, identified by Matzke-Hajek (2021), was included, documented by excellent photos. A *Xylocopa* species was observed in several localities in the Funchal area since 1994 and even photographed. Only recently, in 2020, a voucher specimen was collected. We were able to study this specimen, a female of *Xylocopa violacea*, which is deposited in a private collection (I. Silva, Madeira).

For the nomenclature of wild bee species, we updated the checklist from Kratochwil *et al*. (2018).

Wild bee species frequency in all investigated square-grid cells and status

Figure 13 shows the pooled frequency of the species in all square-grid cells with the status of the wild bee species. High and relatively high abundances are indicated for the endemic species (*Andrena wollastoni*, *Lasioglossum wollastoni*, *Osmia maderensis*, *Amegilla quadrifasciata maderae*, *Andrena maderensis*, *Halictus frontalis*). An exception is *Hylaeus maderensis*, which is generally a rare species. The native species *Bombus terrestris lusitanicus* and the probably native species *Lasioglossum v. villosulum* also reach high frequencies. Most of the introduced or probably introduced species (*Megachile versicolor*, *Hylaeus s. signatus*, *Hoplitis acuticornis*, *Anthidium manicatum*, *Megachile pusilla*, *Stelis ornatula*, and *Xylocopa violacea*) have low numbers of individuals; an exception is *Bombus r. ruderatus*.

Table 3 – Wild bee species (Hymenoptera: Anthophila) of Madeira Island (n = number of wild bee data, * = subspecies).

	Species	Abbr.	Status	n
	COLLETIDAE			
1	*Hylaeus (Paraprosopis) maderensis* (Cockerell, 1921)	Hyma	endMA	25
2	*Hylaeus (Prosopis) s. signatus* (Panzer, 1798)	Hysi	intr	12
	ANDRENIDAE			
3	*Andrena (Suandrena) maderensis* Cockerell, 1922	Anmad	endMID	134
4	*Andrena (Micrandrena) wollastoni* (Cockerell, 1922)	Anwo	endMI	403
	HALICTIDAE			
5	*Halictus (Halictus) frontalis* Smith, 1853	Hafr	endMI	112
6	*Lasioglossum (Evylaeus) v. villosulum* (Kirby, 1802)	Lavi	nat?	225
7	*Lasioglossum (Dialictus) wollastoni* (Cockerell, 1922)	Lawo	endMA	255
	MEGACHILIDAE			
8	*Anthidium manicatum* (Linnaeus, 1758)	Anman	intr	2
9	*Hoplitis (Alcidamea) acuticornis* (Dufour & Perris, 1840)	Hoac	intr	8
10	*Megachile (Eutricharea) pusilla* Pérez, 1844	Mepu	intr	1
11	*Megachile (Megachile) versicolor* Smith, 1844	Meve	intr?	13
12	*Osmia (Helicosmia) madeirensis* Van der Zanden, 1991	Osma	endMI	156
13	*Osmia (Helicosmia) niveata* (Panzer, 1798)	Osni	nat	90
14	*Stelis (Stelis) ornatula* (Klug, 1807)	Stor	intr	1
	ANTHOPHORIDAE			
15	*Amegilla quadrifasciata maderae* (Sichel, 1868)	Amqu	endMA*	193
	APIDAE			
16	*Bombus (Megabombus) r. ruderatus* (Fabricius, 1775)	Boru	intr?	104
17	*Bombus (Bombus) terrestris lusitanicus* Krüger, 1956	Bote	nat	488
18	*Xylocopa violacea* (Linnaeus, 1758)	Xyvi	intr	4

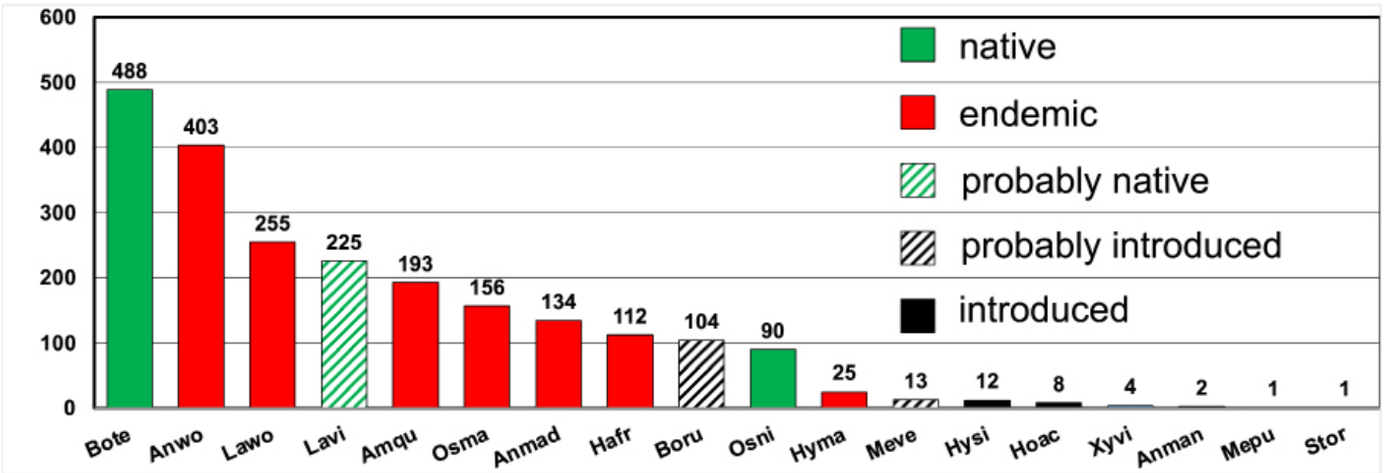

Fig. 13 – Frequency of the collected or observed wild bee specimens of Madeira Island; abbr., see Table 3. Red: endemic (for differentiation, see Table 3); green: native or probably native; diagonally striped: introduced or probably introduced. Xyvi, Anman, Mepu, Stor = introduced.

Wild bee species characterisation

Colletidae

***Hylaeus (Paraprosopis) maderensis* (Cockerell, 1921)**

- **Status**: Endemic to Madeira Archipelago (Fig. 14). H. Dathe (*pers. comm.*) has studied the type specimen of *H. maderensis* (HEC) and compared it with the type specimen of *H. azorae* (Warncke, 1992), endemic to the Azores (deposited at OLML). A high degree of morphological similarity is evident between the two species, which, as shown by morphological analysis, occupy an isolated position compared to all other Palaearctic species. A Neoarctic origin can be excluded (H. Dathe, *pers. comm.*). Unfortunately, only one male of *H. azorae* has been detected so far; the female is unknown.

- **Literature**: Saunders (1903), Cockerell (1921), Erlandson (1983), Kratochwil (2018), Kratochwil *et al.* (2018, 2019).

- **Specimens analysed**: 1♀, 19♂♂.

- **Distribution, habitat characteristics, and flower-visiting behaviour** (Figs. 15 and 16, Tables 4 and 5): There is no clear concentration of *H. maderensis* in specific vegetation series (Table 4). We detected this endemic species locally on coastal rocks (*e.g.* visiting the endemic plant species *Aeonium glutinosum*, see below), and on ruderal sites, but it also occurred at higher altitudes: NW Paúl da Serra at 1,350 m *a.s.l.* (Fellendorf *et al.*, 1999), Rabaçal at 1,080 m *a.s.l.* (Alfken, 1940); area of Pico do Areeiro 1,500 m *a.s.l.*, and 1,800 *a.s.l.* (Costa, 2019).

Hylaeus maderensis was observed on seven plant families (Table 5) and showed a broader polylectic behaviour. This is in accordance with other *Hylaeus* species, *e.g.*, from the Canary Islands: *Hylaeus ater* Saunders, 1903, was detected on Boraginaceae, Brassicaceae, Crassulaceae, Euphorbiaceae, and Rubiaceae; *H. canariensis* Erlandsson, 1983, on Brassicaceae, Fabaceae; and *H. hohmanni* Dathe, 1993, on Asteraceae, Boraginaceae, Brassicaceae, Euphorbiaceae, Fabaceae, and Rubiaceae (Hohmann *et al.*, 1993). On Madeira Island, the endemic species *Aeonium glutinosum* has importance as a source of pollen and nectar, as do *Echium candicans* and *Sinapidendron angustifolium*. Introduced plant species, *e.g. Ageratina adenophora*, are also visited.

- **Flight time**: At lower altitudes, the species was detected from April to June, and at higher altitudes (> 1,080 m *a.s.l.*) from July to August; the first observation was 8th April and the latest observation was 4th September).

Fig. 14 – *Hylaeus maderensis*, frontal view of the endemic bee species with the characteristic mask of the males. This specimen (cAK) visited the endemic plant species *Sinapidendron angustifolium* (Fig. 2) on coastal rocks in Madalena do Mar (SW coast, 08.04.1995; vegetation series c). Photo A. Kratochwil.

- **Data from the authors** (15♂♂): ***cAK*** (1♂): 1♂, Madalena do Mar, 45 m *a.s.l.*, 32° 42′ 12.03″ N, 17° 08′ 13.77″ W, 08.04.1995, leg. K/S. ***cJS*** (14♂♂): 11♂♂, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 07.06.1998, leg. J. T. Smit; 3♂♂, Reis Magos, Caniço, 24 m *a.s.l.*, 32° 38′ 52.23″ N, 16° 49′ 27.46″ W, 09.06.1998, leg. P. Wirtz.

- **Data from collections** (4♂♂): ***ICLAM*** (2♂♂): 1♂, Levada do Norte, Ginjas, 1.8 km NE Estanquinhos, 1,065 m *a.s.l.*, 32º 46′ 17.14′′ N, 17º 03′ 14.27′′ W, 04.09.2008, leg. C. Brazão; 1♂, Machico, 0.3 km NW Pico do Facho, 283 m *a.s.l.*, 32° 43′ 26.97″ N, 16° 45′ 31.49″ W, 05.06.2008, leg. C. Brazão. ***SDEI*** (2♂♂): 2♂♂, NW Paúl da Serra, 1,350m *a.s.l.*, 32° 44′ 0.54″ N, 17° 3′ 11.98″ W, leg. R. Hentscholek, collection of A. W. Ebmer.

- **Data from literature** (3♀♀, 2♂♂, 1 ind.): Alfken (1940): 1♂, Rabaçal, 1,080 m *a.s.l.*, 17.07.1935-04.08.1935, leg. O. Lundblad; Fellendorf *et al.* (1999): 2♀♀, Ponta do Garajau and Ponta dos Reis Magos, S Caniço, 50 m *a.s.l.*, mid-May until July; 1♂, Lombada dos Marinheiros, 700 m *a.s.l.*, August; Costa (2019): 1♀, 25.07.2018 (checked by A. Kratochwil), and another specimen from area of Pico do Areeiro (1,500 m *a.s.l*, 32° 43′ 8″ N, 16° 54′ 31″ W; 1,800 m *a.s.l.*, 32° 44′ N, 16° 55′ 47″ W).

***Hylaeus (Prosopis) s. signatus* (Panzer, 1798)**

- **Status**: Introduced. H. Dathe (SDEI) identified the specimens as subsp. *signatus*.

- **Literature**: Smit & Smit (2003), Dathe (1980), Scheuchl & Willner (2016), Kratochwil *et al.* (2018, 2019).

- **Specimens analysed**: 6♀♀, 6♂♂.

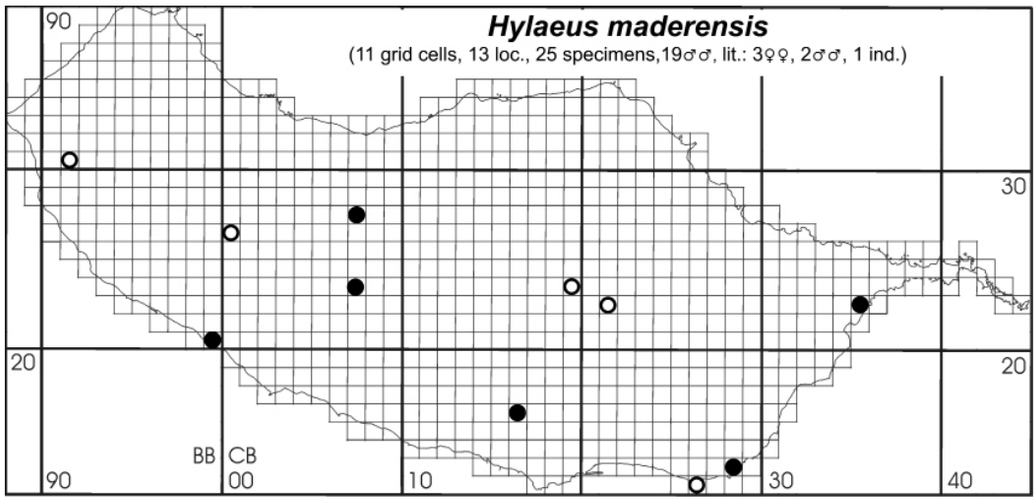

Fig. 15 – Detections of *Hylaeus maderensis* (black dots: authors' data and checked specimens of collections; circles: literature data).

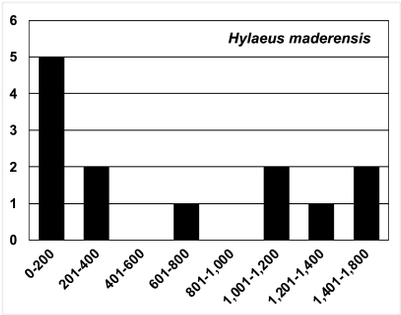

Fig. 16 – Number of localities with *Hylaeus maderensis* detections per altitude level (m *a.s.l.*).

Table 4 – Presence of *Hylaeus maderensis* in square-grid cells of different vegetation series [1].

Vegetation series		Presence %, absolute
May-Ol	a	10%
Hel-Si	b	-
Sem-Ap 1	c	7%
Sem-Ap 2	d	2%
Cle-Oc	e	3%
Pol-Er	f	**13%**
Arm-Pa	g	1

Table 5 – Plant-species spectrum visited by *Hylaeus maderensis*.

Plant species, plant families		Status	n
Petroselinum crispum	Api	intr	1♂
Torilis arvensis subsp. *neglecta*	Api	nat	2♂♂
Ageratina adenophora	Ast	intr	4♂♂
Echium candicans	Bor	end	1♀,1♂
Sinapidendron angustifolium	Bra	end	1♂
Aeonium glutinosum	Cra	end	2♀♀,7♂♂
Hydrangea macrophylla	Hyd	intr	1♂
Rubus fruticosus agg.	Ros	-	1♂
Rubus ulmifolius	Ros	nat	1♂

- **Distribution, habitat characteristics, and flower-visiting behaviour** (Fig. 17): *Hylaeus s. signatus* was found in one raster grid and one locality (6♀♀, 6♂♂, Socorridos valley, W Funchal between Câmara de Lobos and S. Martinho at an altitude of 250-300 m *a.s.l.*, leg. J. Smit, J. T. Smit). The locality where *Hylaeus s. signatus* was found corresponds to zone c (Table 1). It is not possible to predict whether this species will continue to spread on Madeira Island. However, the example of the Azores shows that *H. s. signatus* has a great dispersal potential if the specific food plant (*Reseda*) is available (Weissmann *et al.*, 2017).

Hylaeus s. signatus is oligolectic all over the distribution area on *Reseda* species (Koster, 1981; Scheuchl & Willner, 2016). Smit & Smit (2003) detected *H. s. signatus* on *R. luteola* (females and males). *R. luteola* occurs on Madeira Island at altitudes up to 1,000 m *a.s.l.* (Press & Short, 1994).

- **Flight time**: All detections are from 07.06.1998. In mainland Europe, the species occurs in the first generation in April and May and sometimes in a second generation from August to September (Scheuchl & Willner, 2016).

[1] The synoptic table (Table 28) of all bee species will be presented in the "Major occurrences of wild bee species in vegetation series on Madeira Island" section.

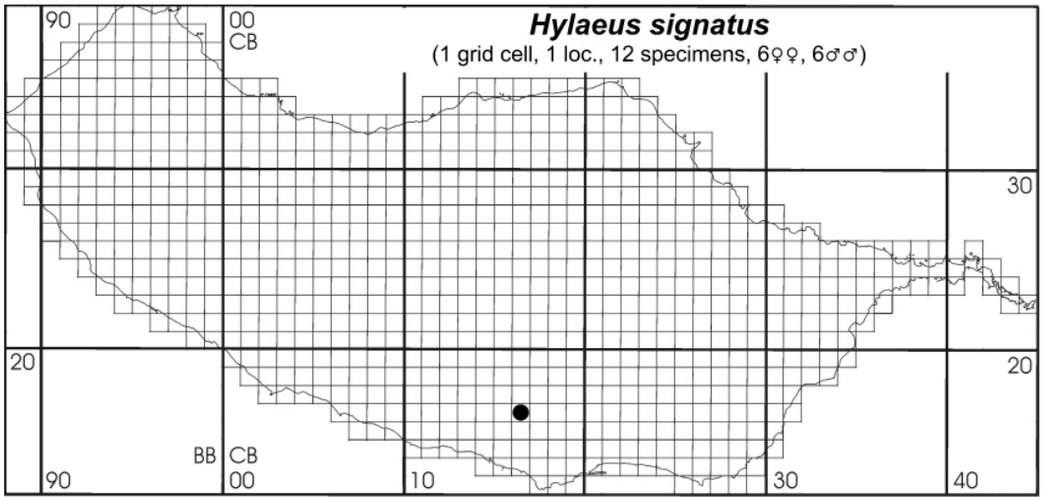

Fig. 17 – Detection of *Hylaeus s. signatus* in one square-grid cell (black dot: data of J. and J. T. Smit).

- **Data from the authors**: 6♀♀, 6♂♂, Socorridos valley, W Funchal, 250-300 m *a.s.l.*, 28.05.1995, 07.06.1995, leg. J. Smit and J. T. Smit (Smit & Smit, 2003).

Andrenidae

Andrena (Suandrena) maderensis Cockerell, 1922

- **Status**: Endemic to Madeira Island (Figs. 18 and 19).

- **Literature**: Cockerell (1922), Warncke (1968), Fellendorf *et al.* (1999), Gusenleitner & Schwarz (2002), Kratochwil *et al.* (2014, 2018, 2019), Kratochwil (2021).

- **Specimens analysed**: 98♀♀, 29♂♂.

- **Distribution, habitat characteristics, and flower-visiting behaviour** (Figs. 20 and 21, Tables 6 and 7): *Andrena maderensis* shows main occurrences in the Mediterranean macroclimate [vegetation series a), mainly b), further c), d)], but there have also been detections at altitudes about 1400 m *a.s.l.* (Dellinger, *pers. comm.*). Coastal rocks with endemic vegetation [vegetation series a), b)] are frequently used as habitat. The range of altitudes reaches from sea level up to about 1,000 m a.s.l. (1,400 m *a.s.l.*); but most of the observations concentrated at lower altitudes (47% of detections are between 0 and 200 m *a.s.l.*).

Sixty-six flower visits were recorded (four plant families). Brassicaceae were the most important resources for the females. These observations support the hypothesis that the species of the subgenus *Suandrena* prefer Brassicaceae (Dylewska, 1983; Kratochwil, 1991). Brassicaceae are essential for the females of this oligolectic species, especially the endemic species *Sinapidendron angustifolium* in the coastal-rocky areas and the Macaronesian species *Erysimum maderense* in other rocky areas. In the cultural landscape (including road sites), ruderal species such as *Raphanus r.* subsp. *raphanistrum* or *Rapistrum rugosum* s.l. are used. This flower-visiting spectrum corresponds partly to that of *A. portosanctana* on Porto Santo (Kratochwil *et al.*, 2014). *A. portosanctana* mainly visits the flowers of *Cakile maritima* subsp. *maritima* (lacking on Madeira Island); or, *e.g.*, *Sinapis arvensis* and *Rapistrum rugosum* s.l. (all Brassicaceae).

- **Flight time and nesting sites**: The flight activity ranges from February (first observation 17th February) to May (latest observation 13th June). The highest frequencies of males and females are reached in April. All *Andrena* species nest in the ground. We found a nesting site on Ponta de São Lourenço (weakly consolidated bare ground).

Fig. 18 – The endemic bee species with preferences for Brassicaceae *Andrena maderensis* (female) was detected in Porto da Cruz (N coast) in ruderal vegetation. The bee collected pollen on *Raphanus r.* subsp. *raphanistrum*. 02.04.2022, vegetation series d). Photo A. Kratochwil.

Fig. 19 – The endemic bee species *Andrena maderensis* (male) in a coastal rock habitat of the N coast (São Cristovão; two males used the nectar in the inflorescences of the native *Crepis vesicaria*, 31.03.2022, vegetation series d). Like other species of the subgenus *Suandrena*, the tergites show a green-metallic sheen. Photo A. Kratochwil.

Table 6 – Presence of *Andrena maderensis* in square-grid cells of different vegetation series.

Vegetation series		Presence %
May-Ol	a	29%
Hel-Si	b	**35%**
Sem-Ap 1	c	18%
Sem-Ap 2	d	17%
Cle-Oc	e	13%
Pol-Er	f	-
Arm-Pa	g	-

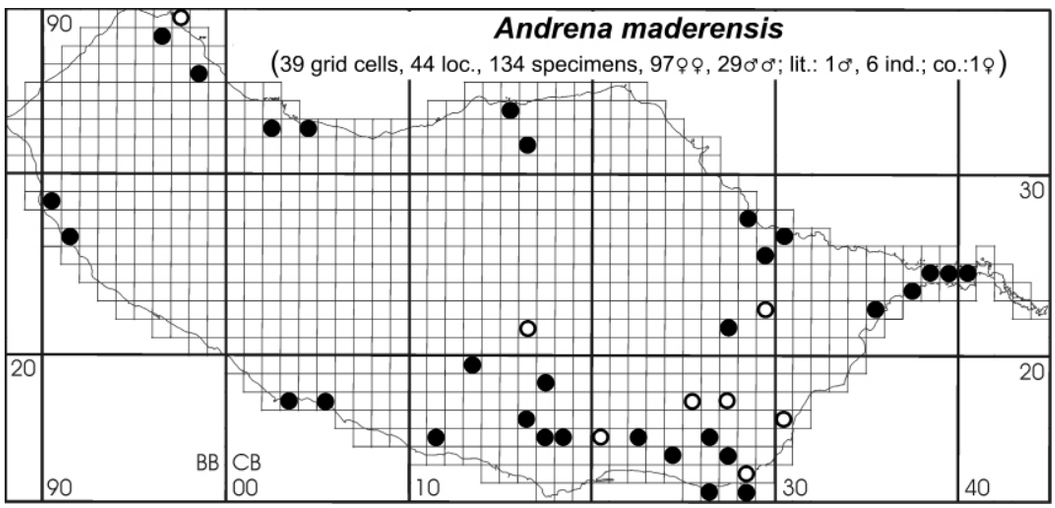

Fig. 20 – Detections of *Andrena maderensis* (black dots: authors' data, checked specimens of collections, one checked observation; circles: literature data).

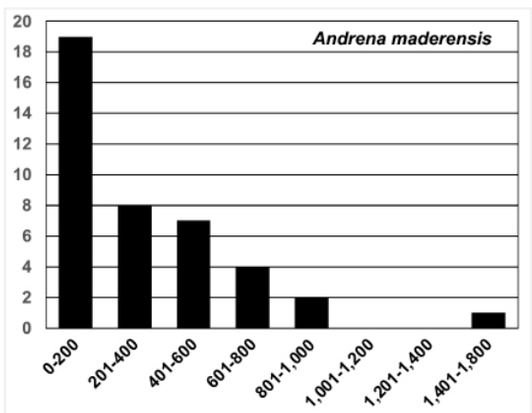

Fig. 21 – Number of localities with *Andrena maderensis* detections per altitude level (m *a.s.l.*).

Table 7 – Plant-species spectrum visited by *Andrena maderensis*.

Plant species, plant families		Status	n
Argyranthemum p. subsp. *pinnatifidum*	Ast	end	1♂
Crepis vesicaria	Ast	nat	4♀♀,4♂♂
Leontodon taraxacoides subsp. *longirostris*	Ast	nat	1♂
Sonchus asper	Ast	nat?	1♀
Sonchus oleraceus	Ast	nat?	1♀
Brassica oleracea	Bra	cul	4♀♀
Erysimum bicolor	Bra	end	1♀
Erysimum maderense	Bra	end	1♀
Raphanus r. subsp. *raphanistrum*	Bra	nat	17♀♀,5♂♂
Rapistrum rugosum s.l.	Bra	nat	2♀♀
Sinapidendron angustifolium	Bra	end	19♀♀
Sinapis arvensis	Bra	nat	2♀
Geranium maderense	Ger	end	1♀
Oxalis pes-caprae	Oxa	intr	1♂

- **Data from the authors** (80♀♀, 26♂♂): ***cAK*** (55♀♀, 13♂♂): 1♀, Cabo do Castelo, S Camacha, 488 m *a.s.l.*, 32° 39′ 51.20″ N, 16° 50′ 46.06″ W, 09.04.1995, leg. K/S; 3♂♂, Ponta de São Lourenço, above Ponta do Buraco, 71 m *a.s.l.*, 32° 44′ 35.16″ N, 16° 42′ 01.06″ W, 10.04.1995, leg. K/S; 1♂, Ponta de São Lourenço, 57 m *a.s.l.*, 32° 44′ 39.19″ N, 16° 43′ 05.43″ W, 26.03.2005, leg. K/S; 1♀, 1♂, Ponta de São Lourenço, above Rochinha, 78 m *a.s.l.*, 32° 44′ 40.19″ N, 16° 43′ 22.21″ W, 26.03.2005, leg. K/S; 1♂, Ponta de São Lourenço, 101 m *a.s.l.*, 32° 44′ 44.01″ N, 16° 43′ 20.74″ W, 26.03.2005, leg. K/S; 1♀, Ponta de São Lourenço, 93 m *a.s.l.*, 32° 44′ 44.34″ N, 16° 43′ 16.19″ W, 26.03.2005, leg. K/S; 1♀, W Ponta do Garajau, S Caniço, 82 m *a.s.l.*, 32° 38′ 23.20″ N, 16° 51′ 13.01″ W, 29.03.2005, leg. K/S; 12♀♀, Larano, E Porto da Cruz, 274 m *a.s.l.*, 32° 45′ 45.14″ N, 16° 48′ 29.69″ W, 29.03.2005, leg. K/S; 4♀♀, W Ponta do Garajau, S Caniço, 82 m *a.s.l.*, 32° 38′ 23.20″ N, 16° 51′ 13.01″ W, 30.03.2005, leg. K/S; 1♀, 1♂, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 02.04.2005, leg. K/S; 10♀♀, W Ribeira Brava, Ribeiro da Caldeira, 37 m *a.s.l.*, 32° 40′ 25.21″ N, 17° 04′ 09.99″ W, 02.04.2005, leg. K/S; 2♀♀, W Ribeira Brava, Ribeiro da Corujeira – Ribeiro da Caldeira, 26 m *a.s.l.*, 32° 40′ 34.34″ N, 17° 04′ 27.05″ W, 02.04.2005, leg. K/S; 4♀♀, above Paúl do Mar, 43 m *a.s.l.*, 32° 45′ 28.83″ N, 17° 13′ 41.69″ W, 03.04.2005, leg. K/S; 1♂, above Porto Moniz, 407 m *a.s.l.*, 32° 51′ 35.12″ N, 17° 10′ 26.56″ W, 03.04.2005, leg. K/S; 13♀♀, 2♂♂, Ponta de São Lourenço, above Rochinha, 78 m *a.s.l.*, 32° 44′ 40.19″ N, 16° 43′ 22.21″ W, 04.04.2005, leg. K/S; 1♀, 1♂, Referta, S Porta da Cruz, 192 m *a.s.l.*, 32° 45′ 18.77″ N, 16° 49′ 7.14″ W, 06.04.2005, leg. K/S; 1♀, Fajã do Penedo, near Boaventura, 238 m *a.s.l.*, 32° 48′ 17.8″ N, 16° 57′ 49.2″ W, 25.03.2022, leg. K/S; 1♀, Funchal, Jardim Botânico, 281 m *a.s.l.*, 32° 39′ 45.9′′ N, 16° 53′ 47.2′′ W, 29.03.2022, leg. K/S; 2♂♂, São Cristovão, 104 m *a.s.l.*, 32° 49′ 39.3′′ N, 16° 58′ 41.2′′ W, 31.03.2022, leg. K/S; 1♀, Ponta de São Lourenço, 66 m *a.s.l.*, 32° 44′ 38.0′′ N, 16° 43′ 32.6′′ W, 02.04.2022, leg. K/S; 1♀, Santa Cruz, 39 m *a.s.l.*, 32° 46′ 15.8′′ N, 16° 49′ 45.2′′ W, 02.04.2022, leg. K/S. ***cFA***: 1♀, Cabo Girão, 597 m *a.s.l.*, 32° 39′ 26.98′′ N, 17° 00′ 18.19′′ W, 11.04.2002, leg. Aguiar / Jesus. ***cJS***: (24♀♀, 13♂♂): 1♂, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 11.02.1998, leg. J. T. Smit; 1♂, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32° 39′ 31.00″ N, 16° 56′ 22.00″ W, 15.02.1998, leg. J. T. Smit; 1♀, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 16.02.1998, leg. J. T. Smit; 2♀♀, Barreira, NW Funchal, 743 m *a.s.l.*, 32° 41′ 11.43″ N, 16° 56′ 47.90″ W, 19.02.1998, leg. J. T. Smit; 1♀, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 24.02.1998, leg. J. T. Smit; 4♀♀, 5♂♂, Ponta de São Lourenço, 77 m *a.s.l.*, 32° 44′ 36.05″ N, 16° 42′ 01.91″ W, 27.02.1998, leg. J. T. Smit; 1♂, Ribeira Brava, 125 m *a.s.l.*, 32° 40′ 32.04″ N, 17° 03′ 55.92″ W, 03.03.1998, leg. J. T. Smit; 1♀, Fajã da Nogueira, N Caniço, 222 m *a.s.l.*, 32° 39′ 09.89″ N, 16° 50′ 07.79″ W, 10.03.1998, leg. J. T. Smit; 3♀♀, 1♂, Ponta de São Lourenço, 77 m *a.s.l.*, 32° 44′ 36.05″ N, 16° 42′ 01.91″ W, 23.03.1998, leg. J. T. Smit; 2♀♀, Funchal, Pico das Romeiras, 423 m *a.s.l.*, 32° 39′ 47.94″ N, 16° 56′ 47.61″ W, 01.04.1998, leg. J. T. Smit; 1♀, 2♂♂, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 03.04.1998, leg. J. T. Smit; 2♂♂, Serra da Eira da Laje, NE Jardim da Serra, 963 m *a.s.l.*, 32° 41′ 29.49″ N, 16° 59′ 03.80″ W, 05.04.1998, leg. J. T. Smit; 1♀, Ponta de São Lourenço, 77 m *a.s.l.*, 32° 44′ 36.05″ N, 16° 42′ 01.91″ W, 17.04.1998, leg. J. T. Smit; 4♀♀, Funchal, Pico das Romeiras, 423 m *a.s.l.*, 32° 39′ 47.94″ N, 16° 56′ 47.61″ W, 22.04.1998, leg. J. T. Smit; 1♀, Palheiro Ferreiro, NW São Gonçalo, 505 m *a.s.l.*, 32° 39′ 15.75″ N, 16° 52′ 17.22″ W, 06.05.1998, leg. J. T. Smit; 3♀♀, Chão da Ribeira, Seixal, 433 m *a.s.l.*, 32° 48′ 33.25″ N, 17° 06′ 55.52″ W, 23.05.1998, leg. J. T. Smit.

- **Data from collections** (17♀♀, 3♂♂): ***ICLAM***: 1♀, Pico do Facho, Machico, 260 m *a.s.l.*, 32° 43′ 26.12′′ N, 16° 45′ 29.00′′ W, 14.04.2003, leg. Aguiar / Jesus. UMB (16♀♀, 3♂♂): 4♀♀, Fajã da Ovelha, 34 km NWN Funchal, 483 m *a.s.l.*, 32° 46′ 27.43″ N, 17° 14′ 2.88″ W, 02.04.1994, leg. H. Hohmann; 1♀, Ribeira da Janela, 639 m *a.s.l.*, 32° 50′ 16.37″ N, 17° 9′ 21.13″ W, 03.04.1994, leg. H. Hohmann; 4♀♀, 2♂♂, Seixal, 260 m *a.s.l.*, 32° 48′ 52.33″ N, 17° 5′ 31.96″ W, 11.04.1994, leg. H. Hohmann; 1♀, João Frino. 856 m *a.s.l.*, 32° 42′ 51.07″ N, 16° 50′ 21.47″ W, 13.04.1994, leg. H. Hohmann; 6♀♀, 1♂, Caniçal, 35 m *a.s.l.*, 32° 44′ 21.44″ N, 16° 44′ 17.38″ W, 31.03.1994, leg. H. Hohmann.

- **Data from literature** (17♀♀, 3♂♂): Warncke (1968): 1♂, Vale Paraíso, W Camacha, 13.06.1957, leg. H. Lindberg; Fellendorf *et al*. (1999): 20♀♀, 6♂♂; 16.03.1997: Gaula, 200 m *a.s.l.*; females, March to June: Funchal, 200 m *a.s.l.*; Reis Magos, about 50 m *a.s.l.*; Camacha, about 600 m *a.s.l.*; Santo António da Serra, about 650 m *a.s.l.*; Porto Moniz, about 50 m *a.s.l.* Due to the lack of differentiation (number of individuals per locality, characterisation ‘female, male’), only one individual is counted per locality (n = 6 ind.).

- **Checked observation**: T. Dellinger (University of Madeira) found the species (1♀) at Miradouro do Paredão, Santo António, 1,433 m *a.s.l.*, 17.02.2022, on *Erysimum bicolor*. A document photo was checked by A. Kratochwil.

Andrena (Micrandrena) wollastoni (Cockerell, 1922)

- **Status**: Endemic to Madeira Island (Figs. 22-24).

- **Literature**: Alfken (1940), Warncke (1968), Cockerell (1922), Fellendorf *et al*. (1999), Gusenleitner & Schwarz (2002), Kratochwil *et al*. (2018, 2019, 2021), Costa (2019), Kratochwil (2020), Kratochwil & Schwabe (2020).

- **Specimens analysed**: 250♀♀, 134♂♂, 2 ind.

- **Distribution, habitat characteristics, and flower-visiting behaviour** (Figs. 25 and 26, Tables 8 and 9): *Andrena wollastoni* is widely distributed in all vegetation series (Fig.

25). Detections reach from sea level up to 1,800 m *a.s.l.*, but most of the observations are concentrated up to 800 m *a.s.l.* (Fig. 26). The very hot and dry sites [vegetation series a)] are obviously sparsely populated (Table 8). This is in line with other taxa of the *A. wollastoni* group (*e.g.*, *A. acuta*, Tenerife; *A. catula*, Gran Canaria; Kratochwil & Schwabe, 2020). Ruderal sites such as fallows, slopes, fringe structures are used, especially in the cultural landscapes of the subhumid vegetation series c). In the Mediterranean vegetation series b), coastal rocks, amongst other habitats, are populated. Coastal rocks with more subhumid conditions and gaps in microforests and Laurisilva belong with high probability to the natural habitats before human impact.

In our observations, this polylectic species used 12 different plant families (Table 9). *E.g.* the flowers of the endemic Laurisilva tree *Clethra arborea* [vegetation series e)] as well as the endemic *Echium candicans* [vegetation series f), punctually also g)] were resources.

- **Flight time and nesting sites**: The flight activity ranges from February (first observation 11th February) to August (latest observation 4th August). *Andrena wollastoni* occurs in higher individual numbers in May and April at lower altitudes. At higher altitudes (> 1000 m *a.s.l.*), the activity starts in April, with the highest individual numbers in July. On the coastal slopes east of Porto da Cruz [vegetation series d) with *Erica arborea*], we found a nesting site on quasi-consolidated loamy substrate in a flattened micro patch, criss-crossed with biological crusts between *Erica arborea* tree heath (micro area of 35 x 35 cm with about 90 nests); Fig. 24. Other nesting sites were found W Boca do Risco (29.03.2006).

Fig 22 – The endemic bee species *Andrena wollastoni* (female), collecting pollen on the native plant species *Rapistrum rugosum* s.l. (Ponta de São Lourenço, roadside, 02.04.2022; [vegetation series b)]. Photo A. Schwabe.

Fig. 23 – *Andrena wollastoni* (male, endemic), visiting the native *Crepis vesicaria* (Urzal, northern slope, 460 m *a.s.l.*; [vegetation series e)]. Photo A. Schwabe.

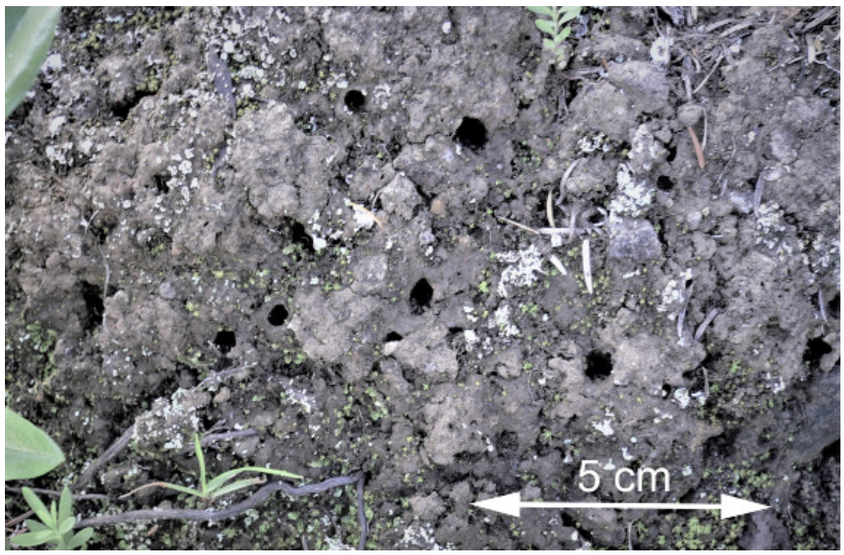

Fig 24 – Nesting site of *Andrena wollastoni* E Porto da Cruz (Cova das Pedras) on a flattened micro patch; N coast [vegetation series d)]. The area with nest holes was 35 x 35 cm, with about 90 holes; see text. 29.03.2005. Photo A. Schwabe.

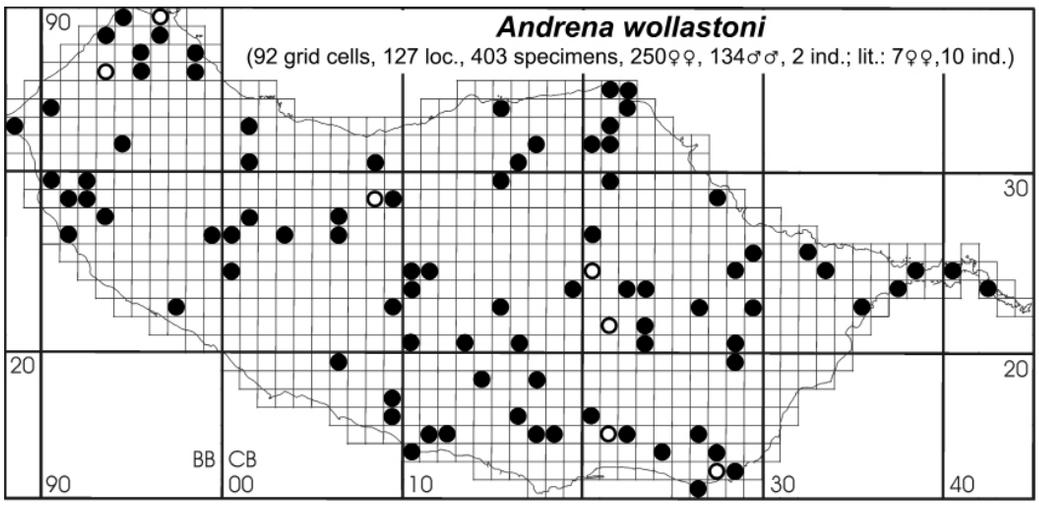

Fig. 25 – Detections of *Andrena wollastoni* (black dots: authors' data, checked specimens of collections; circles: literature data).

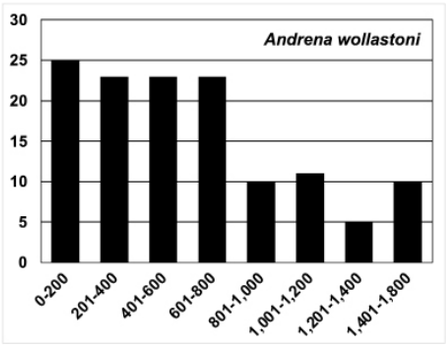

Fig. 26 – Number of localities with *Andrena wollastoni* detections per altitude level (m *a.s.l.*).

Table 8 – Presence of *Andrena wollastoni* in square-grid cells of different vegetation series.

Vegetation series		Presence %, absolute
May-Ol	a	14%
Hel-Si	b	35%
Sem-Ap 1	c	**54%**
Sem-Ap 2	d	37%
Cle-Oc	e	38%
Pol-Er	f	38%
Arm-Pa	g	1

Table 9 – Plant-species spectrum visited by *Andrena wollastoni*.

Plant species, plant families		Status	n
Melanoselinum decipiens	Api	end	1♀
Ageratina adenophora	Ast	intr	2♀♀
Argyranthemum pinnatifidum s.l.	Ast	end	2♀♀, 3♂♂
Argyranthemum pinnatifidum subsp. *succulentum*	Ast	end	5♀♀, 7♂♂
Asteraceae yellow	Ast	-	2♀♀, 1♂
Calendula arvensis	Ast	nat	1♀
Chrysanthemum segetum	Ast	intr	1♀
Crepis vesicaria	Ast	nat	19♀♀, 10♂♂
Erigeron karwinskianus	Ast	intr	1♂
Galactites tomentosa	Ast	nat	3♂♂
Hypochoeris radicata	Ast	intr	1♀, 1♂
Leontodon taraxacoides subsp. *longirostris*	Ast	nat	6♀♀, 4♂
Sonchus asper	Ast	nat?	5♀♀, 7♂♂
Sonchus oleraceus	Ast	nat?	5♀♀
Echium candicans	Bor	end	1♀♀, 2 ind.
Brassica napus subsp. *rapifera*	Bra	cult	1♀, 5♂♂
Brassica oleracea	Bra	cult	1♀, 1 ind.
Crambe fruticosa	Bra	end	3♀♀
Erysimum bicolor	Bra	mac	1♀
Erysimum maderense	Bra	end	1♀
Raphanus r. subsp. *raphanistrum*	Bra	nat	3♀♀, 2♂♂
Rapistrum rugosum s.l.	Bra	nat	7♀♀
Sinapis arvensis	Bra	nat	2♀
Sisymbrium officinale	Bra	nat	4♀♀
Clethra arborea	Cle	end	2♂♂
Aeonium glandulosum	Cra	end	1♀, 5♂♂
Aichryson villosum	Cra	end	3♀
Vaccinium padifolium	Eri	end	1♂
Cytisus scoparius	Fab	intr	1♀, 1 ind.
Geranium maderense	Ger	end	4♀♀
Poaceae	Poa	-	2♀♀, 3♂♂
Digitalis purpurea	Scr	nat	3♂♂
Centranthus calcitrapae	Val	nat	1♂

- **Data from the authors** (180♀♀, 101♂♂, 2 ind.): ***cAK*** (77♀♀, 36♀♀): 12♀♀, Cabo do Castelo, S Camacha, 488 m *a.s.l.*, 32° 39' 51.20" N, 16° 50' 46.06" W, 09.04.1995, leg. K/S; 1♀, 1♂, Pico do Facho, Machico, 266 m *a.s.l.*, 32° 43' 22.49'' N, 16° 45' 30.60'' W, 10.04.1995, leg. K/S; 2♀♀, Ponta de São Lourenço, above Ponta do Buraco, 71 m *a.s.l.*, 32° 44' 35.16" N, 16° 42' 01.06" W, 10.04.1995, leg. K/S; 1♀, Ponta de São Lourenço, above Rochinha, 78 m *a.s.l.*, 32° 44' 40.19" N, 16° 43' 22.21" W, 26.03.2005, leg. K/S; 5♀♀, 6♂♂, Ponta de São Lourenço, 72 m *a.s.l.*, 32° 44' 42.29'' N, 16° 43' 07.48" W, 26.03.2005, leg. K/S; 4♀♀, 1♂, Ponta de São Lourenço 100 m *a.s.l.*, 32° 44' 44.01" N, 16° 43' 20.74" W, 26.03.2005, leg. K/S; 8♀♀, Serra de Água, lookout point, 465 m *a.s.l.*, 32° 43' 50.79" N, 17° 01' 26.59" W, 27.03.2005, leg. K/S; 1♀, Eirinha, above Serra de Água, 506 m *a.s.l.*, 32° 43' 54.22" N, 17° 01' 30.19" W, 27.03.2005, leg. K/S; 3♀♀, 1♂, Câmara do Bispo, S Quinta Grande, 316 m *a.s.l.*, 32° 39' 17.50" N, 17° 01' 02.02" W, 28.03.2005, leg. K/S; 1♀, Fajã dos Padres, W Quinta Grande, 325 m *a.s.l.*, 32° 39' 21.12" N, 17° 01' 04.44" W, 28.03.2005, leg. K/S; 1♀,

5♂♂, Cabo Girão, S Quinta Grande, 603 m *a.s.l.*, 32° 39′ 27.08″ N, 17° 00′ 23.91″ W, 28.03.2005, leg. K/S; 5♂♂, Referta, S Porto da Cruz, 192 m *a.s.l.*, 32° 45′ 18.77″ N, 16° 49′ 7.14″ W, 29.03.2005, leg. K/S; 5♂♂, W Boca do Risco, 708 m *a.s.l.*, 32° 45′ 23.76″ N, 16° 47′ 26.45″ W, 29.03.2005, leg. K/S; 1♀, W Ponta do Garajau, S Caniço, 82 m *a.s.l.*, 32° 38′ 23.20″ N, 16° 51′ 13.01″ W, 30.03.2005, leg. K/S; 1♀, Funchal, in front of Jardim Botânico, 277 m *a.s.l.*, 32° 39′ 41.27″ N, 16° 53′ 41.25″ W, 30.03.2005, leg. K/S; 1♂, Cova do Negro, W Rabaçal, 1,130 m *a.s.l.*, 32° 48′ 23.66″ N, 17° 11′ 50.04″ W, 02.04.2005, leg. K/S; 1♀, above Paúl do Mar, ER 213, 50 m *a.s.l.*, 32° 45′ 29.52″ N, 17° 13′ 41.76″ W, 03.04.2005, leg. K/S; 1♂, above Porto Moniz, 407 m *a.s.l.*, 32° 51′ 35.12″ N, 17° 10′ 26.56″ W, 03.04.2005, leg. K/S; 1♀, Pico do Facho, Machico, 266 m *a.s.l.*, 32° 43′ 22.49′′ N, 16° 45′ 30.60′′ W, 06.04.2005, leg. K/S; 1♀, Ponta de São Lourenço, above Rochinha, 78 m *a.s.l.*, 32° 44′ 40.19″ N, 16° 43′ 22.21″ W, 06.04.2005, leg. K/S; 3♀♀, Referta, S Porto da Cruz, 192 m *a.s.l.*, 32° 45′ 18.77″ N, 16° 49′ 7.14″ W, 06.04.2005, leg. K/S; 7♀♀, S S. Jorge, ER 101, 110 m *a.s.l.*, 32° 49′ 31.59″ N, 16° 53′ 56.82″ W, 06.04.2005, leg. K/S; 4♂♂, S. Jorge, 256 m *a.s.l.*, 32° 50′ 03.66″ N, 16° 54′ 21.61″ W, 06.04.2005, K/S; 1♂, Lombo do Urzal, near Boaventura, 456 m *a.s.l.*, 32° 47′ 04.4″ N, 16° 58′ 37.4″ W, 25.03.2022, leg. K/S; 2♀♀, 2♂♂, Fajã do Penedo near Boaventura, 264 m *a.s.l.*, 32° 47′ 53.6″ N, 16° 58′ 05.5″ W, 25.03.2022, leg. K/S; 4♀♀, Fajã do Penedo, near Boaventura, 238 m *a.s.l.*, 32° 48′ 17.8″ N, 16° 57′ 49.2″ W, 25.03.2022, leg. K/S; 1♀, W P. Moniz, 417 m *a.s.l.*, 32° 51′ 38.2″ N, 17° 12′ 04.1″ W, 26.03.2022, leg. K/S; 1♀, leftside valley of S. Vicente, 200 m *a.s.l.*, 32° 47′ 47.1″ N, 17° 02′ 44.5″ W, 27.03.2022, leg. K/S; 1♀, above P. Moniz, 618 m *a.s.l.*, 32° 51′ 04.3′′ N, 17° 11′ 22.5′′ W, 28.03.2022, leg. K/S; 4♀♀, Jardim Botânico, Funchal, 281 618 m *a.s.l.*, 32° 39′ 45.9′′ N, 16° 53′ 47.2′′ W, 29.03.2022, leg. K/S; 6♀♀, 3♂♂, São Cristovão, coastal rock, 104 m *a.s.l.*, 32° 49′ 39.3′′ N, 16° 58′ 41.2′′ W, 31.03.2022, leg. K/S; 4♀♀, Ponta de São Lourenço, 66 m *a.s.l.*, 32° 44′ 38.0′′ N, 16° 43′ 32.6′′ W, 02.04.2022, leg. K/S. ***cFA*** (15♀♀, 10♂♂): 3♂♂, Ponta de São Lourenço, Casa do Sardinha, 41 m *a.s.l.*, 32° 44′ 32.59′′ N, 16° 41′ 03.09′′ W, 02.04.1989, leg. F. Aguiar; 1♂, Levada do Risco, before reaching the waterfall, 1,054 m *a.s.l.*, 32° 45′ 40.21′′ N, 17° 07′ 40.46′′ W, 01.06.1996, leg. F. Aguiar; 1♂, Achada da Cruz, Santana, 256 m *a.s.l.*, 32° 49′ 21.05′′ N, 16° 53′ 37.98′′ W, 22.04.1997, leg. F. Aguiar; 1♂, Curral das Freiras, land belonging to Comissão de levadas, 525 m *a.s.l.*, 32° 43′ 33.47′′ N, 16° 58′ 05.17′′ W, 07.05.1998, leg. Aguiar / Jesus; 1♀, Boca da Corrida, above forest services post, 1,216 m *a.s.l.*, 32° 42′ 36.75′ ‘N, 16° 59′ 13.65′′ W, 27.05.1999. leg. Aguiar / Jesus; 1♀, 1♂, Queimadas, near the pig breeding, 877 m *a.s.l.*, 32° 47′ 10.52′′ N, 16° 54′ 23.26′′ W, 22.05.2003, leg. Aguiar / Jesus; 1♂, Fajã das Éguas, Serra de Água, 718 m *a.s.l.*, 32° 44′ 34.03′′ N, 17° 01′ 29.98′′ W, 04.05.2006, leg. F. Aguiar *et al.*; 1♂, Caminho de São Lourenço, Calheta, 707 m *a.s.l.*, 32° 46′ 42.02″ N, 17° 13′ 17.94″ W, 08.06.2018, leg. A. Aguiar; 1♀, Caminho de São Lourenço, Calheta, 816 m *a.s.l.*, 32° 47′ 02.94″ N, 17° 13′ 04.58″ W, 08.06.2018. leg. A. Aguiar; 1♀, Caminho de São Lourenço, Calheta, 828 m *a.s.l.*, 32° 47′ 04.27″ N, 17° 12′ 59.40″ W, 08.06.2018. leg. A. Aguiar; 1♀, Achada do Teixeira, Santana, 1,564 m *a.s.l.*, 32° 45′ 49.64″ N, 16° 55′ 12.11″ W, 22.06.2018, leg. A. Aguiar; 1♀, Achada do Teixeira, Santana, 1,573 m *a.s.l.*, 32° 45′ 49.90″ N, 16° 55′ 13.55″ W, 22.06.2018, leg. A. Aguiar; 1♂, Achada do Teixeira, Santana, 1,572 m *a.s.l.*, 32° 45′ 53.21″ N, 16° 55′ 20.71″ W, 22.06.2018, leg. A. Aguiar; 1♀, Achada do Teixeira, Santana, 1,573 m *a.s.l.*, 32° 45′ 53.35″ N, 16° 55′ 22.80″ W, 22.06.2018, leg. A. Aguiar; 4♀♀, Vereda Calheta – Rabaçal, Calheta, 968 m *a.s.l.*, 32° 45′ 19.33″ N, 17° 08′ 37.68″ W, 02.07.2018, leg. A. Aguiar; 3♀♀, Vereda Calheta – Rabaçal, Calheta, 970 m *a.s.l.*, 32° 45′ 19.51″ N, 17° 08′ 37.36″ W, 02.07.2018, A. Aguiar; 1♀, Vereda Calheta – Rabaçal, Calheta, 983 m *a.s.l.*, 32° 45′ 20.48″ N, 17° 08′ 35.09″ W, 02.07.2018, leg. A. Aguiar. ***cJS*** (85♀♀, 50♂♂): 1♀, Funchal, Pico das Romeiras, 423 m *a.s.l.*, 32° 39′ 47.94″ N, 16° 56′ 47.61″ W, 22.04.1997, leg. J. T. Smit; 1♀, Lombada dos Marinheiros, 578 m *a.s.l.*, 32° 47′ 16.13″ N, 17° 14′ 18.83″ W, 15.07.1997, leg. J. Smit; 2♀♀, Fontes, 1,124 m *a.s.l.*, 32° 42′ 33.11′′ N, 17° 00′ 57.13″ W, 16.07.1997, leg. J. Smit; 1♀, João Frino, 698 m *a.s.l.*, 32° 42′ 01.48″ N, 16° 50′ 05.85″ W, 19.07.1997, leg. J. Smit; 2♀♀, Portela, 640 m *a.s.l.*, 32° 48′ 29.79“ N, 16° 51‘ 56.77“ W, 19.07.1997, leg. J. Smit; 4♂♂, Achada do Poiso, 1,374 m *a.s.l.*, 32° 42′ 44.84″ N, 16° 53′ 13.54″ W, 20.07.1997, leg. J. Smit; 18♀♀, Rabaçal, 1,064 m *a.s.l.*, 32° 45′ 43.45″ N, 17° 08′ 03.01″ W, 20.07.1997, leg. J. Smit; 1♀, Paúl da Serra, 1,579 m *a.s.l.*, 32° 45‘ 43.56“ N, 17° 03‘ 54.28“ W, 20.07.1997, leg. J. Smit; 1♀, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 11.02.1998, leg. J. T.Smit; 3♂♂, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32° 39′ 31.00′′ N, 16° 56′ 22.00″ W, 15.02.1998, leg. J. T. Smit; 1♀, Barreira, NW Funchal, 743 m *a.s.l.*, 32° 41′ 11.43″ N, 16° 56′ 47.90″ W, 19.02.1998, leg. J. T. Smit; 3♀♀, 3♂♂, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 24.02.1998, leg. J. T. Smit; 2♀♀, 1♂, Ponta de São Lourenço, 77 m *a.s.l.*, 32° 44′ 36.05″ N, 16° 42′ 01.91″ W, 27.02.1998, leg. J. T. Smit; 2♀♀, Funchal, Pico das Romeiras, 423 m *a.s.l.*, 32° 39′ 47.94″ N, 16° 56′ 47.61″ W, 01.03.1998, leg. J. T. Smit; 7♀♀, 10♂♂, Fajã da Nogueira, N Caniço, 222 m *a.s.l.*, 32° 39′ 09.89″ N, 16° 50′ 07.79″ W, 10.03.1998, leg. J. T. Smit; 12♀♀, 3♂♂, Ponta de São Lourenço, 77 m *a.s.l.*, 32° 44′ 36.05″ N, 16° 42′ 01.91″ W, 25.03.1998, leg. J. T. Smit; 3♀♀, Chão da Ribeira, Seixal, 433 m *a.s.l.*, 32° 48′ 33.25″ N, 17° 06′ 55.52″ W, 25.03.1998, J. T. Smit; 3♀♀, 3♂♂, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 03.04.1998, leg. J. T. Smit; 1♂, Serra da Eira da Laje, NW Jardim da Serra, 963 m *a.s.l.*, 32° 41‘ 29.49“ N, 16° 59‘ 03.80“ W, 05.04.1998, leg. J. T. Smit; 12♀♀, 1♂, Ponta de São Lourenço, 77 m *a.s.l.*, 32° 44‘ 36.05“ N, 16° 42‘ 01.91“ W, 17.04.1998, leg. J. T. Smit; 2♀♀, 3♂♂, São Jorge, 297 m *a.s.l.*, 32° 49‘ 08.85“ N, 16° 54‘ 17.92“ W, 04.05.1998, leg. J. T. Smit; 1♂, Lombada do

Loreto, NE Arco da Calheta, 358 m *a.s.l.*, 32° 43′ 12.71″ N, 17° 09′ 35.85″ W, 05.05.1998, leg. J. Smit; 3♀♀, Ponta do Pargo, 322 m *a.s.l.*, 32° 48′ 44.56″ N, 17° 15′ 38.36″ W, 05.05.1998, leg. J. Smit; 2♂♂, Boa Morte, 483 m *a.s.l.*, 32° 49′ 08.83″ N, 17° 14′ 13.73″ W, 05.05.1998, leg. J. Smit; 1♀, 2♂♂, Palheiro Ferreiro, NW São Gonçalo, 505 m *a.s.l.*, 32° 39′ 15.75″ N, 16° 52′ 17.22″ W, 06.05.1998, leg. J. Smit; 3♀♀, 3♂♂, Pico do Areeiro, 1,730 m *a.s.l.*, 32° 44′ 07.57″ N, 16° 55′ 50.37″ W, 16.05.1998, leg. J. T. Smit; 1♀, Ponta do Pargo, 322 m *a.s.l.*, 32° 48′ 44.56″ N, 17° 15′ 38.36″ W, 19.05.1998, leg. J. T. Smit; 1♀, 10♂♂, Rabaçal, 1,064 m *a.s.l.*, 32° 45′ 43.45″ N, 17° 08′ 03.01″ W, 21.05.1998, leg. J. T. Smit; 1♀, Funchal, Jardim Botânico, 264 m *a.s.l.*, 32° 39′ 43.23″ N, 16° 53′ 48.10″ W, 22.05.1998, leg. J. T. Smit; 1♀, Ribeira da Corujeira, SE Monte, 332 m *a.s.l.*, 32° 40′ 17.84″ N, 16° 54′ 56.80″ W, 24.05.1998, leg. J. T. Smit. ***oFA*** (3♀♀, 5♂♂, 2 ind.): 1 ind., Boca da Corrida, below miradouro, 1,152 m *a.s.l.*, 27.05.1999, 32° 42′ 39.43′′ N, 16° 59′ 07.37′′ W, obs. F. Aguiar; 1 ind. Pinheiro, 1 km SW Serra de Água church, 379 m *a.s.l.*, 22.02.2007, 32º 43′ 17.28′′ N, 17º 02′ 02.72′′ W, obs. F. Aguiar; 2♂♂, Ilha, dirt road above habitational zone, 541 m *a.s.l.*, 31.05.2007, 32º 48′ 09.98′′ N, 16º 54′ 36.35′′ W, obs. F. Aguiar; 1♀, Achadas da Cruz to Fajã Nova, Porto Moniz, 424 m *a.s.l.*, 05.07.2007, 32º 51′ 11.06′′ N, 17º 12′ 30.19′′ W, obs. F. Aguiar; 1♂, Farol to Cais de S. Jorge, 126 m *a.s.l.*, 13.03.2008, 32º 49′ 59.89′′ N, 16º 54′ 06.16′′ W, obs. F. Aguiar; 1♂, Santana, Achada do Teixeira, 1,570 m *a.s.l.*, 01.06.2010, 32º 45′ 55.52′′ N, 16º 55′ 07.44′′ W, obs. F. Aguiar; 1♀, Santana, Achada do Teixeira, 1,575 m *a.s.l.*, 01.06.2010, 32º 45′ 51.94′′ N, 16º 55′ 10.58′′ W, obs. F. Aguiar; 1♀, São Jorge to the sea, Caminho da Saúde, 133 m *a.s.l.*, 24.03.2011, 32º 49′ 44.51′′ N, 16º 54′ 03.84′′ W, obs. F. Aguiar; 1♂, Caminho de São Lourenço, Fajã da Ovelha, dirt road, 733 m *a.s.l.*, 19.05.2011, 32º 46′ 51.15′′ N, 17º 13′ 09.11′′ W, obs. F. Aguiar.

- **Data from collections** (70♀♀, 33♂♂): ***ICLAM*** (16♀♀, 18♂♂): 1♂ Boca da Corrida, below miradouro, 1,152 m *a.s.l.*, 32° 42′ 39.43′′ N, 16° 59′ 07.37′′ W, 27.5.1999, leg. Aguiar / Jesus; 1♀, Pico do Facho, Machico, 266 m *a.s.l.*, 32° 43′ 22.49′ N, 16° 45′ 30.60′′ W, 24.02.2000, leg. Aguiar / Jesus; 1♀, Estrada para o Fanal, 2 km from Paúl da Serra crossing, 1,359 m *a.s.l.*, 32° 46′ 10.41′′ N, 17° 06′ 59.10′′ W, 28.06.2000, leg. Aguiar / Jesus; 1♀, Boca da Corrida, above forest services post, 1,216 m *a.s.l.*, 32° 42′ 36.75′ ‘N, 16° 59′ 13.65′′ W, 07.06.2001, leg. Aguiar / Jesus; 1♂, Chão da Ribeira, behind trout nursery, 617 m *a.s.l.*, 32° 47′ 32.99′′ N, 17° 06′ 53.91′′ W, 13.06.2002, leg. Aguiar / Jesus; 1♂, Levada Rabaçal to Risco, 300m before the waterfall, 1,299 m *a.s.l.*, 32° 45′ 30.18′′ N, 17° 07′ 35.79′′ W, 27.06.2002, leg. Aguiar / Jesus; 1♂, Levada do Norte, near Boa Morte, 421 m *a.s.l.*, 32° 40′ 34.66′′ N, 17° 01′ 56.09′′ W, 27.02.2003, leg. Aguiar / Jesus; 1♀, 2♂♂, Ilha, dirt road, 547 m *a.s.l.*, 32° 48′ 16.64′′ N, 16° 55′ 13.25′′ W, 22.04.2003, leg. Aguiar / Jesus; 1♀, Eira do Serrado, Pico do Serrado, 955 m *a.s.l.*, 32° 42′ 25.14′′ N, 16° 57′ 35.72′′ W, 17.06.2004, leg. Aguiar / Jesus; 3♂♂, Levada Nova, Tabúa to Ponta do Sol, 705 m *a.s.l.*, 32° 41′ 51.22′′ N, 17° 03′ 35.50′′ N, 10.03.2005, leg. F. Aguiar *et al.*; 1♀, Farol to Cais de S. Jorge, 125 m *a.s.l.*, 32° 50′ 04.67′′ N, 16° 54′ 12.45′′ W, 12.05.2005, leg. Aguiar / Jesus; 2♂♂, Fajã das Éguas, Serra de Água, 452 m *a.s.l.*, 32° 44′ 11.36′′ N, 17° 01′ 19.73′′ W, 04.05.2006, leg. F. Aguiar *et al.*; 1♀, Caniçal, Prainha, Ponta de São Lourenço, 71 m *a.s.l.*, 32º 44′ 42.83′′ N, 16º 43′ 08.52′′ W, 26.04.2007, leg. Aguiar / Jesus; 1♀, Vereda Chão das Feiteiras, Ribeiro Frio, 1,167 m *a.s.l.*, 32º 43′ 50.68′′ N, 16º 52′ 58.83′′ W, 17.05.2007, leg. Aguiar / Jesus; 1♂, Lombo Grande, Ilha, dirt road above habitational zone, 542 m *a.s.l.*, 32º 48′ 18.33′′ N, 16º 54′ 49.95′′ W, 31.05.2007, leg. J. Jesus; 1♀, Lombo Grande, Ilha, dirt road above habitational zone, 537 m *a.s.l.*, 32º 48′ 19.24′′ N, 16º 54′ 49.97′′ W, 31.05.2007, leg. F. Aguiar; 2♀♀, Lombo Grande, Ilha, dirt road above habitational zone, 480 m *a.s.l.*, 32º 48′ 19.85′′ N, 16º 54′ 41.99′′ W, 31.05.2007, leg. C. Brazão; 1♀, Vereda Achadas da Cruz to Fajã Nova, beginning of descent, 427 m *a.s.l.*, 32º 51′ 09.31′′ N, 17º 12′ 29.58′′ W, 05.07.2007, leg. J. Jesus; 1♂, Vereda Santo da Serra to Lamaceiros, 1.4 km SW Pico do Suna, 1,060 m *a.s.l.*, 32º 43′ 21.94′′ N, 16º 51′ 21.09′′ W, 07.05.2009, leg. D. Cravo; 1♂, Vereda Santo da Serra to Lamaceiros, 0.6 km SW Forest Guard house, 888 m *a.s.l.*, 32º 44′ 00.68′′ N, 16º 50′ 37.37′′ W, 20.05.2010, leg. D. Cravo; 1♂, Vereda Paúl da Serra to Fanal, 1.7 km SE Fanal Guard house, 1,052 m *a.s.l.*, 32º 47′ 37.40′ ‘N, 17º 07′ 32.51′′ W, 14.04.2011, leg. J. Jesus; 1♂, Roseira, Porto Moniz, 0.34 km N reservoir 631 m *a.s.l.*, 32º 50′ 05.65′′ N, 17º 11′ 00.61′′ W, 05.05.2011, leg. D. Cravo; 2♂♂, Roseira, Porto Moniz, 0.34 km N reservoir, 638 m *a.s.l.*, 32º 50′ 06.51′′ N, 17º 11′ 01.56′′ W, 05.05.2011, leg. D. Cravo; 1♀, Caminho de São Lourenço, 1.6 km NE Fajã da Ovelha church, 756 m *a.s.l.*, 32º 46′ 38.02′′ N, 17º 12′ 54.35′′ W, 19.05.2011, leg. F. Aguiar; 1♀, Levada do Norte, Serra de Água, near the power station, 676 m *a.s.l.*, 32º 44′ 22.17′′ N, 17º 00′ 50.79′′ W, 28.06.2011. leg. J. Jesus; 1♀, Encumeada, Serra de Água, 0.35 km SW Estalagem, 622 m *a.s.l.*, 32º 44′ 35.75′′ N, 17º 01′ 18.30′′ W, 28.06.2011, leg. J. Jesus; 1♀, Serralhal, 1,5 km NW Caniço, 484 m *a.s.l.*, 32° 39′ 51.28′′ N, 16° 50′ 46.77′′ W, leg. Aguiar / Jesus. ***oFA***: 1 ind., Boca da Corrida, below miradouro, 1,152 m *a.s.l.*, 32° 42′ 39.43′′ N, 16° 59′ 07.37′′ W, 27.05.1999, obs. F. Aguiar; 1 ind., Pinheiro, 1 km SW Serra de Água church, 379 m *a.s.l.*, 32º 43′ 17.28′′ N, 17º 02′ 02.72′′ W, 22.02.2007, obs. F. Aguiar; 2♂♂, Ilha, dirt road above habitational zone, 541 m *a.s.l.*, 32º 48′ 09.98′′ N, 16º 54′ 36.35′′ W, 31.05.2007, obs. F. Aguiar; 1♀, Achadas da Cruz to Fajã Nova, Porto Moniz, 424 m *a.s.l.*, 32º 51′ 11.06′′ N, 17º 12′ 30.19′′ W, 05.07.2007, obs. F. Aguiar; 1♂, Farol to Cais de S. Jorge, 126 m *a.s.l.*, 32º 49′ 59.89′′ N, 16º 54′ 06.16′′ W, 13.03.2008, obs. F. Aguiar; 1♀, Santana, Achada do Teixeira, 1,575 m *a.s.l.*, 32º 45′ 51.94′′ N, 16º 55′ 10.58′′ W 10.60.2010, obs. F. Aguiar; 1♂, Santana, Achada do Teixeira, 1,570 m *a.s.l.*, 32º 45′ 55.52′′ N, 16º 55′ 07.44′′ W, 01.06.2010, obs. F. Aguiar; 1♀,

São Jorge, Caminho da Saúde, 133 m *a.s.l.*, 32º 49' 44.51'' N, 16º 54' 03.84'' W, 24.03.2011, obs. F. Aguiar; 1♂, Caminho de São Lourenço, Fajã da Ovelha, dirt road, 733 m *a.s.l.*, 32º 46' 51.15'' N, 17º 13' 09.11'' W, 19.05.2011, obs. F. Aguiar. ***MZHF*** (4♀♀, 5♂♂): 1♀, 1♂, Boa Morte – Quinta Grande, 343 m *a.s.l.*, 32° 40' 20.60" N, 17° 01' 53.64" W, 21.04.1995, leg. M. Koponen; 2♂♂, Porto da Cruz, 16 m *a.s.l.*, 32° 46' 19.20" N, 16° 49' 40.80" W; 20.04.1990, leg. M. Koponen; 2♀♀, Funchal, Jardim Botânico, 293 m *a.s.l.*, 32° 39' 43.20" N, 16° 53' 42.00" W, 16.04.1990; 2♂♂, Estreito de Câmara de Lobos – Caldeira, 550 m *a.s.l.*, 32° 39' 34.04" N, 17° 00' 10.99" W, leg. M. Koponen; 1♀, Garajau, 44 m *a.s.l.*, 32° 38' 13.20" N, 17° 00' 00.00" W, leg. H. Lindberg. ***OLML*** (6♀♀, 5♂♂): 2♀♀, Santo da Serra, 5.V. leg. Frey; 1♀, Caramujo, leg. J. Mateu; 3♀♀, 5♂♂, Ribeira da Janela, 650 m *a.s.l.*, 12.-16.05.2007, leg. R. Hentscholek, det. A. W. Ebmer. ***UMB*** (44♀♀, 5♂♂): 10♀♀, Jardim do Mar, 50 m *a.s.l.*, 32° 44' 18.64" N, 17° 12' 40.44" W, 02.04.1994, leg. Hohmann; 2♀♀, Maloeira, 635 m *a.s.l.*, 32° 45' 55.93" N, 17° 12' 32.23" W, 02.04.1994, leg. Hohmann; 1♀, Ribeira da Janela, 637 m *a.s.l.*, 32° 50' 16.58" N, 17° 9' 21.20" W, 03.04.1994, leg. H. Hohmann; 6♀♀, Rosário, 302 m *a.s.l.*, 32° 46' 36.57" N, 17° 1' 53.54" W, 03.04.1994, leg. H. Hohmann; 3♂♂, Achada do Cedro Gordo, 700 m *a.s.l.*, 32º 44' 57.72'' N, 16º 52' 22.20'' W, 04.04.1994, leg. H. Hohmann; 4♀♀, Paúl da Serra, 1,423 m *a.s.l.*, 32° 45' 26.99" N, 17° 05' 49.83" W, 10.04.1994, leg. H. Hohmann; 2♂♂, João Frino, 766 m *a.s.l.*, 32° 42' 30.19" N, 16° 49' 54.50" W, 13.04.1994, leg. H. Hohmann; 1♀, Reis Magos, 18 m *a.s.l.*, 32° 38' 50.38" N, 16° 49' 27.93" W, 13.04.1994, leg. Hohmann; 20♀♀, Caniçal, 33 m *a.s.l.*, 32° 44' 20.68" N, 16° 44' 17.61" W, 31.03.1994, leg. H. Hohmann.

- **Data from literature** (7♀♀, 5♂♂): Alfken (1940): 4♀♀. Rabaçal, 1,080 m *a.s.l.*, 01.07.-04.08.1935; 2♀♀, Caramujo, 1,250 m *a.s.l.*, 06.-14.08.1935, leg. Lundblad. Warncke (1968): 1♀, Santo António da Serra, 780 m *a.s.l.*, July 1924, leg Liebe. Fellendorf *et al.* (1999): 67♀♀, 32♂♂; Funchal, about 300 m *a.s.l.*; Caniço, about 300 m *a.s.l.*; Gaula, about 200 m *a.s.l.*; Paúl da Serra, about 1,400 m *a.s.l.*; Porto Moniz, about 50 m *a.s.l.*; Achadas da Cruz, about 600 m *a.s.l.*; Ribeiro Frio, about 900 m *a.s.l.*; Fajã da Nogueira, 500 m *a.s.l.* Due to the lack of differentiation (number of individuals per locality, characterisation 'female, male'), only one individual is counted per locality (n = 8 ind.). Costa (2019) from area of Pico do Areeiro (1,500 m *a.s.l.*, 32° 43' 8" N, 16° 54' 31" W; 1,800 m *a.s.l.*, 32° 44' 00'' N, 16° 55' 47" W; n = 2 ind).

Halictidae

Halictus (Halictus) frontalis Smith, 1853

- **Status**: Endemic to Madeira Island (Fig. 27).
- **Literature**: Smith (1853), Blüthgen (1940), Ebmer (1988), Fellendorf *et al.* (1999), Kratochwil *et al.* (2018, 2019), Costa (2019).
- **Specimens analysed**: 74♀♀, 15♂♂, 1 ind.
- **Distribution, habitat characteristics, and flower-visiting behaviour** (Figs. 28 and 29, Tables 10 and 11): *Halictus frontalis* is a characteristic species of the more humid zones (Fig. 28). Detections reach from sea level up to 1,800 m *a.s.l.* Occurrences from 0 to 400 m *a.s.l.* are, however, generally limited to the northern parts of the island (Fig. 29). Apart from this, the range of *H. frontalis* is concentrated in higher altitudes. In our observations, it was especially found in vegetation series f), where potential tree-heath series occur, and to a lesser extent in zones c) to e) (Table 10). The species visited six different plant families. The main pollen resources for the females are endemic or native Asteraceae (Table 11). Areas of series f) are often heavily devasted by intensive cattle impact and enrichment of the invading introduced species *Ulex europaeus*. There are only a few data of flower visits from series f); the most remarkable is the tiny, introduced *Taraxacum hamatum*, with inflorescences pressed to the ground in grazed areas. In lower humid areas [series c), e)] the endemic species *Andryala glandulosa* and the native species *Crepis vesicaria* play a role.
- **Flight time and nesting sites**: The flight activity lasts from March (first observation 10th March) to September (latest observation 17th September). High abundances are reached in the lower altitudes in March, April, and May, and in the higher altitudes in July. Nesting sites in the soil have been found by A. Aguiar (nesting holes sheltered by rocks, Paúl da Serra, 1,584 m *a.s.l.*, dirt road from Estanquinhos to Ginjas; July 2007), and C. Brazão and J. Jesus (Paúl da Serra, 1,586 m *a.s.l.*, 1,588 m *a.s.l.*; August 2007).

Fig. 27 – *Halictus frontalis* (female), collecting pollen on the introduced *Taraxacum hamatum* [vegetation series f)] in the heavily grazed pastures of the potential tree-heath zone. Paúl da Serra, 1,550 m *a.s.l.*, 01.04.2022. Photo A. Kratochwil.

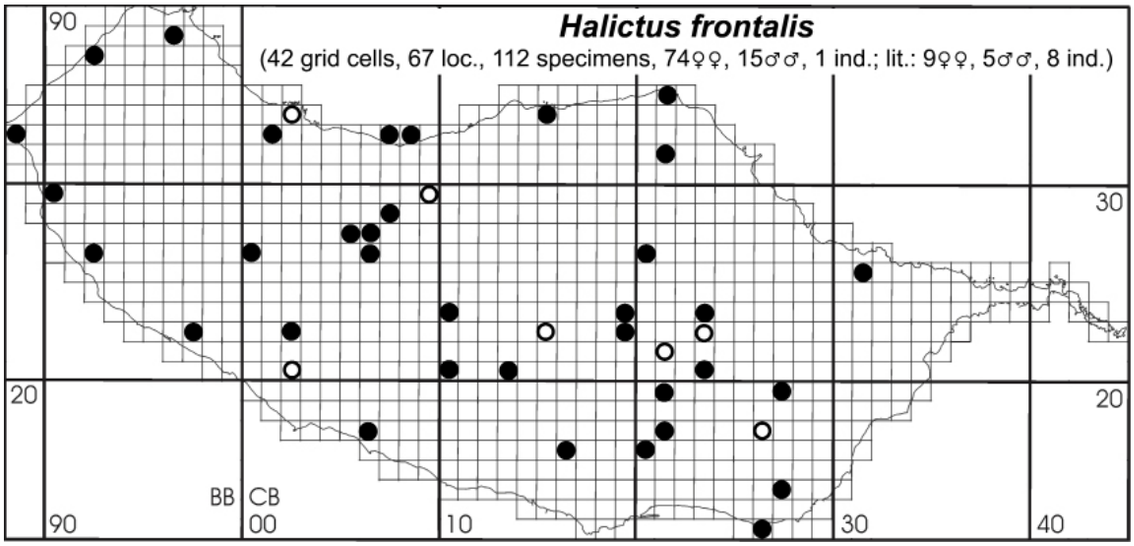

Fig. 28 – Detections of *Halictus frontalis* (black dots: authors' data, checked specimens of collections; circles: literature data).

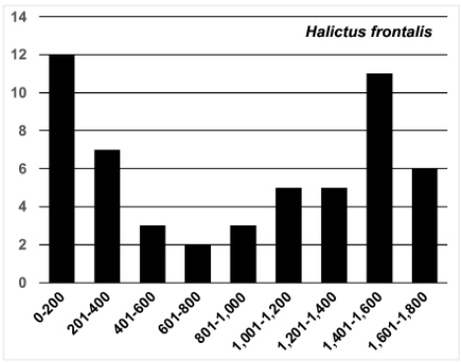

Fig. 29 – Number of localities with *Halictus frontalis* detections per altitude level (m *a.s.l.*).

Table 10 – Presence of *Halictus frontalis* in square-grid cells of different vegetation series.

Vegetation series		Presence %, absolute
May-Ol	a	5%
Hel-Si	b	6%
Sem-Ap 1	c	21%
Sem-Ap 2	d	18%
Cle-Oc	e	15%
Pol-Er	f	**31%**
Arm-Pa	g	2

- **Data from the authors** (66♀♀, 7♂♂, 1 ind.): ***cAK*** (16♀♀): 8♀♀, Serra de Água, lookout point, 465 m *a.s.l.*, 32° 43′ 50.79″ N, 17° 01′ 26.59″ W, 27.03.2005, leg. K/S; 1♀, Eirinha above Serra de Água, 506 m *a.s.l.*, 32° 43′ 54.22″ N, 17° 01′ 30.19″ W, 27.03.2005, leg. K/S; 1♀, W S. Vicente, old road between Ribeiro do Inferno – Ribeiro dos Caimbos, 10 m *a.s.l.*, 32° 48′ 33.51″ N, 17° 03′ 24.31″ W, 03.04.2005, leg. K/S; 1♀, above Porto Moniz, 407 m *a.s.l.*, 32° 51′ 35.12″ N, 17° 10′ 26.56″ W, 03.04.2005, leg. K/S; 3♀, Ponta do Garajau, S Caniço, 112 m *a.s.l.*, 32° 38′ 18.33″ N, 16° 51′ 02.84″ W, 04.04.2005, leg. K/S; 1♀, E S. Vicente near Fajã da Areia, 22 m *a.s.l.*, 32° 48′ 40.3′′ N, 17° 02′ 34.4′′ W., 28.03.2022, leg. K/S; 1♀, Paúl da Serra, 1,578 m *a.s.l.*, 32° 45′ 44.3′′ N, 17° 04′ 12.8′′ W, 01.04.2022, leg. K/S. ***cFA*** (1♀, 1♂): 1♀, Voltas, above Ginjas, S. Vicente, 1,005 m a.s.l., 32° 46′ 23.97′′ N, 17° 03′ 15.20′′ W, 10.04.2003, leg. Aguiar / Jesus; 1♂, Boca da Corrida, gravel road above the house, 1,226 m *a.s.l.*, 32° 42′ 35.04′′ N, 16° 59′ 15.72′′ W, 02.09.2003, leg. Aguiar / Jesus. ***cJS*** (27♀♀): 3♀♀, Parque Ecológico, near Poço da Neve, 1,633 m *a.s.l.*, 32° 43′ 32.87″ N, 16° 55′ 29.69″ W, 11.07.1997, leg. J. Smit; 1♀, Lombada dos Marinheiros, 578 m *a.s.l.*, 32° 47′ 16.13″ N, 17° 14′ 18.83″ W, 15.07.1997, leg. J. Smit; 4♀♀, Fontes, 1,124 m *a.s.l.*, 32° 42′ 33.11″ N, 17° 00′ 57.13″ W, 16.07.1997, leg. J. Smit; 1♀, João Frino, 698 m *a.s.l.*, 32° 42′ 01.48″ N, 16° 50′ 05.85″ W, 19.07.1997, leg. J. Smit; 1♀, Achada do Poiso, 1,374 m *a.s.l.*, 32° 42′ 44.84″ N, 16° 53′ 13.54″ W, 20.07.1997, leg. J. Smit; 1♀, Rabaçal, 1,064 m *a.s.l.*, 32° 45′ 43.45″ N, 17° 08′ 03.01″ W, 20.07.1997, leg. J. Smit; 2♀♀, Fajã da Nogueira, N Caniço, 222 m *a.s.l.*, 32° 39′ 09.89″ N, 16° 50′ 07.79″ W, 10.03.1998, leg. J. T. Smit; 1♀, Ribeira Brava, 125 m *a.s.l.*, 32° 40′ 32.04″ N, 17° 03′ 55.92″ W, 01.05.1998. leg. J. Smit; 1♀, Lombada do Loreto, NE Arco da Calheta, 358 m *a.s.l.*, 32° 43′ 12.71″ N, 17° 09′ 35.85″ W, 05.05.1998, leg. J. Smit; 3♀♀, Ponta do Pargo, 322 m *a.s.l.*, 32° 48′ 44.56″ N, 17° 15′ 38.36″ W, 05.05.1998, leg. J. Smit; 1♀, Terreiro da Luta, N Monte, 886 m *a.s.l.*, 32° 41′ 05.47″ N, 16° 53′ 56.59″ W, 06.05.1998, leg. J. Smit; 1♀, Montado do Barreiro, 1,167 m *a.s.l.*, 32° 42′ 08.08″ N, 16° 54′ 11.43″ W, 15.05.1998, leg. J. T. Smit; 2♀♀, Pico do Areeiro, 1,730 m *a.s.l.*, 32° 44′ 07.57″ N, 16° 55′ 50.37″ W, 16.05.1998, leg. J. T.

Smit; 2♀♀, Chão da Ribeira, Seixal, 433 m a.s.l., 32° 48′ 33.25″ N, 17° 06′ 55.52″ W, 23.05.1998, leg. J. T. Smit; 2♀♀, Ribeira da Corujeira, SE Monte, 332 m *a.s.l.*, 32° 40′ 17.84″ N, 16° 54′ 56.80″ W, 24.05.1998; leg. J. T. Smit; 1♀, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 07.06.1998, leg. J. T. Smit. ***oFA*** (22♀♀, 6♂♂): 2♀♀, Fajã da Quebrada Nova, below Achadas da Cruz, 45 m *a.s.l.*, 32° 50′ 58.50′′ N, 17° 13′ 09.83′′ W, 18.05.2003, obs. F. Aguiar; 1♀, Canhas to Paúl da Serra, gravel road left side, 967 m *a.s.l.*, 32° 43′ 29.28′′ N, 17° 06′ 20.80′′ W, 29.06.2004, obs. F. Aguiar; 1♀, Vereda da Entrosa, Boaventura to Arco de S. Jorge, 122 m *a.s.l.*, 32° 49′ 33.40′′ N, 16° 58′ 06.99′′ W, 31.03.2005, obs. F. Aguiar; 2♀♀, Ilha, dirt road above habitational zone, 532 m *a.s.l.*, 32° 48′ 10.65′′ N, 16° 54′ 37.29′′ W, 31.05.2007 obs. F. Aguiar; 1♀, Farol to Cais de S. Jorge, 146 m *a.s.l.*, 32° 50′ 02.81′′ N, 16° 54′ 10.50′′ W, 21.06.2007, obs. F. Aguiar; 1♀, Farol to Cais de S. Jorge, 76 m *a.s.l.*, 32° 50′ 05.64′′ N, 16° 54′ 11.59′′ W, 21.06.2007, obs. F. Aguiar; 1 ind., Paúl da Serra, dirt road from Estanquinhos to Ginjas, 1,585 m *a.s.l.*, 32° 46′ 11.91′′ N, 17° 04′ 27.59′′ W, 05.07.2007, obs. F. Aguiar; 1♀,1♂, Paúl da Serra, dirt road from Estanquinhos to Ginjas, 1,584 m *a.s.l.*, 32° 46′ 12.10′′ N, 17° 04′ 27.13′′ W, 05.07.2007, obs. F. Aguiar; 3♀, Paúl da Serra, dirt road from Estanquinhos to Ginjas, 1,584 m *a.s.l.*, 32° 46′ 12.10′′ N, 17° 04′ 27.20′′ W, 05.07.2007, obs. F. Aguiar; 2♀♀, Paúl da Serra, dirt road from Estanquinhos to Ginjas, 1,584 m *a.s.l.*, 32° 46′ 12.17′′ N, 17° 04′ 27.11′′ W, 05.07.2007, obs. F. Aguiar; 2♀♀, Paúl da Serra, dirt road from Estanquinhos to Ginjas, 1,518 m *a.s.l.*, 32° 46′ 14.51′′ N, 17° 04′ 09.47′′ W, 05.07.2007, obs. F. Aguiar; 1♂, Paúl da Serra, dirt road from Estanquinhos to Ginjas, 1,518 m *a.s.l.*, 32° 46′ 14.51′′ N, 17° 04′ 09.47′′ W, 05.07.2007 obs. F. Aguiar; 1♂, Poço da Neve, road to Pico do Areeiro, 1,588 m *a.s.l.*, 32° 43′ 27.82′′ N, 16° 55′ 25.92′′ W, 31.07.2008, obs. F. Aguiar; 1♂, Poço da Neve, road to Pico do Areeiro, 1,625 m *a.s.l.*, 32° 43′ 31.76′′ N, 16° 55′ 28.44′′ W, 31.07.2008, obs. F. Aguiar; 1♀, Poiso, vereda from Poiso to Chão das Feiteiras, 914 m *a.s.l.*, 32° 44′ 02.63′′ N, 16° 53′ 10.59′′ W, 23.04.2009, obs. F. Aguiar; 1♀, Estanquinhos, Paúl da Serra, 1,582 m *a.s.l.*, 32° 46′ 08.71′′ N, 17° 04′ 27.69′′ W, 14.05.2009, obs. F. Aguiar; 1♂, Prazeres to Paúl do Mar, vereda near Jardim Atlantico Hotel, 424 m *a.s.l.*, 32° 45′ 15.70′′ N, 17° 13′ 05.40′′ W, 17.09.2009, obs. F. Aguiar; 1♀, Santana, Achada do Teixeira, 1,562 m a.s.l., 32° 45′ 49.71′′ N, 16° 55′ 12.67′′ W, 01.06.2010, obs. F. Aguiar; 1♂, Farol to Cais de S. Jorge, 149 m *a.s.l.*, 32° 49′ 59.13′′ N, 16° 54′ 06.93′′ W, 17.06.2010, obs. F. Aguiar; 1♀, Farol to Cais de S. Jorge, 103 m *a.s.l.*, 32° 50′ 05.28′′ N, 16° 54′ 12.30′′ W, 17.06.2010, obs. F. Aguiar; 1♀, Prazeres to Paúl do Mar, vereda near Jardim Atlantico Hotel, 495 m *a.s.l.*, 32° 45′ 10.34′′ N, 17° 13′ 04.38′′ W, 28.04.2011, obs. F. Aguiar; 1♀, Boca da Corrida, near the Forest Service house, 1,218 m *a.s.l.*, 32° 42′ 39.94′′ N, 16° 59′ 12.63′′ W, 01.03.2012, obs. F. Aguiar.

Table 11 – Plant-species spectrum visited by *Halictus frontalis*.

Plant species, plant families		Status	n
Andryala glandulosa s.l.	Ast	end	2♀♀
Andryala g. subsp. *glandulosa*	Ast	end	2♀♀
Argyranthemum pinnatifidum s.l.	Ast	end	2♀♀
Asteraceae yellow	Ast	-	4♀♀, 4♂♂
Carlina salicifolia	Ast	mac	2♂
Crepis vesicaria	Ast	nat	7♀♀
Galactites tomentosa	Ast	nat	4♀♀
Sonchus oleraceus	Ast	nat?	1♀
Taraxacum hamatum	Ast	intr	1♀
Echium candicans	Bor	end	2 ind.
Erysimum bicolor	Bra	mac	1♀
Erica platycodon subsp. *maderincola*	Eri	end	1♂
Cytisus scoparius	Fab	intr	1♂
Oxalis pes-caprae	Oxa	intr	1♀

- **Data from collections** (8♀♀, 8♂♂): ***ICLAM***: 1♀, Serra de Água, N Terra Grande, 484 m *a.s.l.*, 32° 43′ 52.88′′ N, 17° 01′ 26.21′′ W, 31.07.1998, leg. Aguiar / Jesus; 1♀, Serra das Funduras, near coast, 534 m *a.s.l.*, 32° 45′ 11.96′′ N, 16° 47′ 58.38′′ W, 12.06.2003, leg. Aguiar / Jesus; 1♀, Parque Ecológico, near Poço da Neve, 1,633 m *a.s.l.*, 32° 43′ 32.87″ N, 16° 55′ 29.69″ W, 24.06.2004, leg. Aguiar / Jesus; 1♀, Canhas to Paúl da Serra, gravel road left side, 967 m *a.s.l.*, 32° 43′ 29.28′′ N, 17° 06′ 20.80′′ W, 29.06.2004, leg. Aguiar / Jesus; 1♀, Farol to Cais de S. Jorge, halfway down to sea, 125 m *a.s.l.*, 32° 50′ 04.67′′ N, 16° 54′ 12.45′′ W, 12.05.2005, leg. Aguiar / Jesus; 2♀♀, Paúl da Serra, dirt road from Estanquinhos to Ginjas, 1,586 m *a.s.l.*, 32º 46′ 09.88′′ N, 17º 04′ 26.17′′ W, 30.08.2007, leg. C. Brazão; 1♂, Paúl da Serra, dirt road from Estanquinhos to Ginjas, 1,588 m *a.s.l.*, 32º 46′ 10.99′′ N, 17º 04′ 25.93′′ W, 30.08.2007, leg. J. Jesus; 1♀, 1♂, Paúl da Serra, dirt road from Estanquinhos to Ginjas, 1,531 m *a.s.l.*, 32º 46′ 12.40′′ N, 17º 04′ 09.05′′ W 30.08.2007, leg. J. Jesus; 1♂, Poço da Neve, S Pico do Areeiro, 1,566 m *a.s.l.*, 32º 43′ 23.43′′ N, 16º 55′ 20.96′′ W, 31.07.2008; 1♂, Poço da Neve, S Pico do Areeiro, 1,600 m *a.s.l.*, 32º 43′ 29.98′′ N, 16º 55′ 28.12′′ W, 31.07.2008; 1♂, Poço da Neve, S Pico do Areeiro, 1,611 m *a.s.l.*, 32º 43′ 31.37′′ N, 16º 55′ 29.92′′ W, 18.09.2008, leg. J. Jesus; 1♂, Poço da Neve, S Pico do Areeiro, 1,620 m *a.s.l.*, 32º 43′ 31.65′′ N, 16º 55′ 29.16′′ W, 18.09.2008, leg. J. Jesus; 1♂, Poço da Neve, S Pico do Areeiro, 1,620 m *a.s.l.*, 32º 43′ 32.56′′ N, 16º 55′ 30.46′′ W, 18.09.2008, J. Jesus; 1♂, Vereda Prazeres to Paúl do Mar, Calheta Municipality, 463 m *a.s.l.*, 32º 45′ 14.54′′ N, 17º 13′ 04.06′′ W, 17.09.2009.

- **Data from literature** (9♀♀, 5♂♂, 8 ind.): Blüthgen (1940): 1♀, Feiteiras, S S. Vicente, about 200 m *a.s.l.*, 15.08.1935; 7♀♀, 5♂♂: Rabaçal, about 1,080 m *a.s.l.*, 17.07.-04.08.1935; Fellendorf *et al.* (1999): 13♀♀, 6♂♂; in May: Camacha, about. 600 m *a.s.l.*; Seixal, about 50 m *a.s.l.*; in August: Curral das Freiras, 1,000 m

a.s.l.; 2 km south of Ribeiro Frio, 1,100 m *a.s.l.*; Poiso, 1,400 m *a.s.l.*; in September: Camacha, about 600 m *a.s.l.* Due to the lack of differentiation (number of individuals per locality, characterisation 'female, male'), only one individual is counted per locality (n = 6 ind.); 1♀, beginning of April, Lombo de S. João, 4.5 km NW Funchal, about 500 m *a.s.l.* Costa (2019): 2 ind. from area of Pico do Areeiro (1,500m *a.s.l.*, 32° 43' 8" N, 16° 54' 31" W; 1,800 m *a.s.l.*, 32° 44' N, 16° 55' 47" W).

Lasioglossum (Evylaeus) v. villosulum (Kirby, 1802)

- **Status**: Probably native (Fig. 30).

- **Literature**: Gribodo (1883), Saunders (1903), Blüthgen (1940), Fellendorf *et al.* (1999), Scheuchl & Willner (2016), Kratochwil *et al.* (2018, 2019).

- **Specimens analysed**: 189♀♀, 21♂♂.

- **Distribution, habitat characteristics, and flower-visiting behaviour** (Figs. 31 and 32, Tables 12 and 13): *Lasioglossum v. villosulum* shows high presence mainly in the Mediterranean vegetation series a), c), and d) (from dry to lower humid types). But it has also, albeit rarely, been found in the pastures of Paúl da Serra (see below). Coastal rocks, and in the more humid series c) and d) ruderal sites, pastures and gardens are its main habitat types.

Lasioglossum v. villosulum shows a preference in flower-visiting behaviour (pollen collecting) on Asteraceae in its whole Trans-Palaearctic distribution area, but has no strict habitat preferences (Scheuchl & Willner, 2016). In our observations on Madeira Island, the species visited Asteraceae nearly exclusively. The females were mainly found on Asteraceae-Cichorioideae (exceptions: *Galactites tomentosa*, *Helichrysum foetidum*). The endemic species *Andryala glandulosa* subsp. *glandulosa* and *Crepis andryaloides*, the native species *Crepis vesicaria*, *Leontodon taraxacoides* subsp. *longirostris*, and the probably native species *Urospermum picroides* play a role as resources. In the heavily grazed area Paúl da Serra [vegetation series f)], the tiny, introduced *Taraxacum hamatum* is used (compare *Halictus frontalis*). Hohmann *et al.* (1993) also reported mainly flower visits on Asteraceae in the Canary Islands.

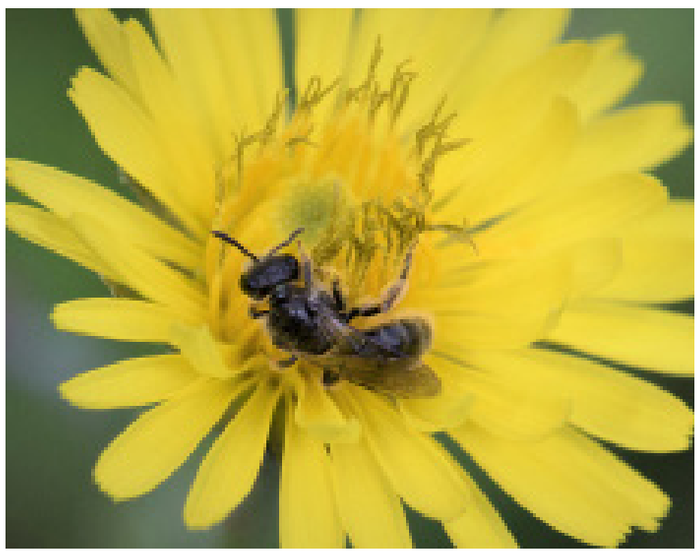

Fig. 30 – The probably native species *Lasioglossum v. villosulum* (female), collecting pollen on the frequently occurring native plant species *Leontodon taraxacoides* subsp. *longirostis*. São Cristóvão, coastal rocky site, 31.03.2022; vegetation series d). Photo A. Kratochwil.

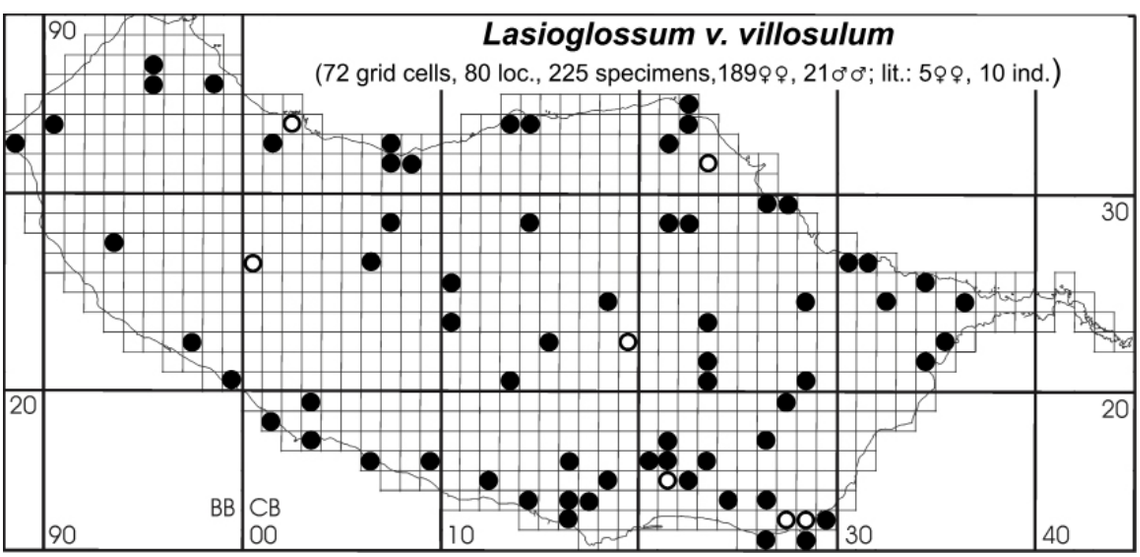

Fig. 31 – Detections of *Lasioglossum v. villosulum* (black dots: authors' data, checked specimens of collections; circles: literature data).

- **Flight time**: Flight-activity data exist from February (first observation 8th February) to December (latest observation 10th December). According to Hohmann *et al.* (1993), the flight activity of *L. villosulum* on Tenerife is year-round. On Madeira Island, *L. villosulum* reaches its highest abundances at lower altitudes in April and May. In large parts of Europe, *L. villosulum* is bivoltine (Scheuchl & Willner, 2016). The data from Madeira Island indicate bivoltinism at lower altitudes.

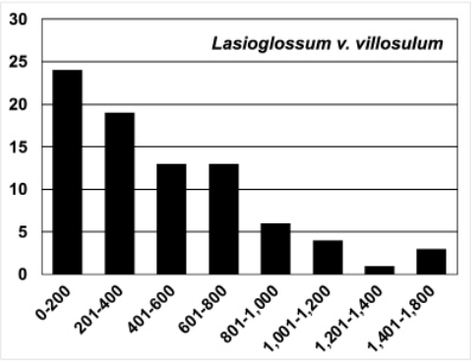

Fig. 32 – Number of localities with *Lasioglossum v. villosulum* detections per altitude level (m *a.s.l.*).

Table 12 – Presence of *Lasioglossum v. villosulum* in square-grid cells of different vegetation series.

Vegetation series		Presence %, absolute
May-Ol	a	**52%**
Hel-Si	b	18%
Sem-Ap 1	c	46%
Sem-Ap 2	d	35%
Cle-Oc	e	21%
Pol-Er	f	13%
Arm-Pa	g	1

Table 13 – Plant-species spectrum visited by *Lasioglossum v. villosulum*.

Plant species, plant families		Status	n
Andryala glandulosa subsp. *glandulosa*	Ast	end	1♀, 1♂
Asteraceae yellow	Ast	-	5♀♀
Crepis andryaloides	Ast	end	1♀
Crepis vesicaria	Ast	nat	8♀♀
Galactites tomentosa	Ast	nat	1♀
Helichrysum foetidum	Ast	intr	2♀♀
Hypochoeris radicata	Ast	intr	1♀
Leontodon taraxacoides subsp. *longirostris*	Ast	nat	18♀♀
Sonchus asper	Ast	nat?	1♀
Sonchus oleraceus	Ast	nat?	1♀
Taraxacum hamatum	Ast	intr	5♀♀
Urospermum picroides	Ast	nat?	14♀♀
Aeonium glutinosum	Cra	end	1♂

- **Data from the authors** (112♀♀, 14♂♂): ***cAK*** (51♀♀): 4♀♀, Pico do Facho, Machico, 266 m *a.s.l.*, 32° 43′ 22.49″ N, 16° 45′ 30.60″ W, 10.04.1995, leg. K/S; 21♀♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 13.04.1995, leg. K/S; 1♀, Serra de Água, lookout point, 465 m *a.s.l.*, 32° 43′ 50.79″ N, 17° 01′ 26.59″ W, 27.03.2005, leg. K/S; 3♀♀, Boca do Risco, 356 m *a.s.l.*, 32° 45′ 18.75″ N, 16° 46′ 13.12″ W, 29.03.2005, leg. K/S; 1♀, Larano, E Porto da Cruz, 275 m *a.s.l.*, 32° 45′ 45.14″ N, 16° 48′ 29.69″ W., 29.03.2005, leg. K/S; 1♀, W Ponta do Garajau, S Caniço, 82 m *a.s.l.*, 32° 38′ 23.20″ N, 16° 51′ 13.01″ W, 30.03.2005, leg. K/S; 5♀♀, W S. Vicente, ER 101, Fajã do Rente, 75 m *a.s.l.*, 32° 48′ 29.57″ N, 17° 03′ 05.00″ W, 03.04.2005, leg. K/S; 1♀, W S. Vicente, old road between Ribeiro do Inferno – Ribeiro dos Caimbos, 10 m *a.s.l.*, 32° 48′ 33.51″ N, 17° 03′ 24.31″ W, 03.04.2005, leg. K/S; 1♀, Ponta dos Reis Magos, SE Caniço, 14 m *a.s.l.*, 32° 38′ 55.50″ N, 16° 49′ 22.06″ W, 04.04.2005, leg. K/S; 4♀♀, Penha d'Águia de Baixo above Faial, 92 m *a.s.l.*, 32° 47′ 7.44″ N, 16° 50′ 56.38″ W, 06.04.2005, leg. K/S; 1♀, Lombo do Urzal near Boaventura, 472 m *a.s.l.*, 32° 46′ 55.6″ N, 16° 58′ 42.3″ W, 25.03.2022, leg. K/S; 1♀, W Achada, Fonte Vermelha, 813 m *a.s.l.*, 32° 50′ 10.7″ N, 17° 11′ 19.0″ W, 26.03.2022, leg. K/S; 1♀, above P. Moniz, 618 m *a.s.l.*, 32° 51′ 04.3′′ N, 17° 11′ 22.5′′ W, 28.03.2022, leg. K/S; 2♀♀, São Cristovão, coastal rock, 104 m *a.s.l.*, 32° 49′ 39.3′′ N, 16° 58′ 41.2′′ W, 31.03.2022, leg. K/S; 4♀♀, Paúl da Serra, 1,578 m *a.s.l.*, 32° 45′ 44.3′′ N, 17° 04′ 12.8 ′′, 01.04.2022, leg. K/S. ***cFA*** (3♀♀, 1♂): 1♀, Ribeira Brava, Miradouro Pico da Cruz, 54 m *a.s.l.*, 32° 40′ 09.25′′ N, 17° 03′ 46.32′′ W, 30.04.1989, leg. F. Aguiar; 1♀, Areeiro, São Martinho, 159 m *a.s.l.*, 32° 38′ 47.11′′ N, 16° 57′ 26.71′′ W, 06.03.1992, leg. F. Aguiar; 1♀, Curral das Freiras, land belonging to Comissão de levadas, 525 m *a.s.l.*, 32° 43′ 33.47′′ N, 16° 58′ 05.17′′ W, 15.04.1999, leg. Aguiar / Jesus; 1♂, Farol, Ponta do Pargo, 248 m *a.s.l.*, 32° 48′ 39.26′′ N, 17° 15′ 34.01′′ W, 23.09.1999, leg. Aguiar / Jesus. ***cJS*** (56♀♀, 13♂♂): 2♂♂, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32° 39′ 31.00″ N, 16° 56′ 22.00″ W, 09.07.1997, leg. J. Smit; 1♀, Funchal, Jardim Botânico, 264 m *a.s.l.*, 32° 39′ 43.23″ N, 16° 53′ 48.10″ W, 09.07.1997, leg. J. Smit; 1♂, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 10.07.1997, leg. J. Smit; 1♀, Madalena do Mar, 31 m *a.s.l.*, 32° 42′ 06.79″ N, 17° 08′ 01.31″ W, 15.07.1997, leg. J. Smit; 1♂, Palheiro Ferreiro, northwest of São Gonçalo, 505 m *a.s.l.*, 32° 39′ 15.75″ N, 16° 52′ 17.22″ W, 19.07.1997, leg. J. Smit; 3♀♀, Palheiro Ferreiro, NW São Gonçalo, 505 m *a.s.l.*, 32° 39′ 15.75″ N, 16° 52′ 17.22″ W, 19.07.1997, leg. J. Smit; 2♀♀, João Frino, 698 m *a.s.l.*, 32° 42′ 01.48″ N, 16° 50′ 05.85″ W, 19.07.1997, leg. J. Smit; 1♂, Machico, 10 m *a.s.l.*, 32° 43′ 05.58″ N, 16° 45′ 48.59″ W, 19.07.1997; leg. J. Smit; 1♂, Achada do Poiso, 1,374 m *a.s.l.*, 32° 42′ 44.84″ N, 16° 53′ 13.54″ W, 20.07.1997; leg. J. Smit; 8♀♀, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 11.02.1998, leg. J. T. Smit; 1♀, Canhas, NW Ponta do Sol, 57 m

a.s.l., 32° 41′ 19.37″ N, 17° 07′ 03.64″ W, 10.04.1998, leg. J. T. Smit; 4♀♀, Ribeira Brava, 125 m *a.s.l.*, 32° 40′ 32.04″ N, 17° 03′ 55.92″ W, 01.05.1998, leg. J. Smit; 2♀♀, Lombada do Loreto, NE Arco da Calheta, 358 m *a.s.l.*, 32° 43′ 12.71″ N, 17° 09′ 35.85″ W, 01.05.1998, leg. J. Smit; 1♀, Caniçal, 86 m a.s.l., 32° 44′ 31.98″ N, 16° 44′ 39.84″ W, 02.05.1998, leg. J. Smit; 1♀, São Jorge, 297 m *a.s.l.*, 32° 49′ 08.85″ N, 16° 54′ 17.92″ W, 04.05.1998, leg. J. Smit; 1♀, Boa Morte, 483 m *a.s.l.*, 32° 49′ 08.83″ N, 17° 14′ 13.73″ W, 05.05.1998, leg. J. Smit; 4♀♀, Terreiro da Luta, N Monte, 886 m *a.s.l.*, 32° 41′ 05.47″ N, 16° 53′ 56.59″ W, 06.05.1998, leg. J. Smit; 7♀♀, Funchal, Pico das Romeiras, 423 m *a.s.l.*, 32° 39′ 47.94″ N, 16° 56′ 47.61″ W, 18.05.1998, leg. J. T. Smit; 1♀, Ponta do Pargo, 322 m *a.s.l.*, 32° 48′ 44.56″ N, 17° 15′ 38.36″ W, 19.05.1998, leg. J. T. Smit; 2♂♂, Ponta do Pargo, 322 m *a.s.l.*, 32° 48′ 44.56″ N, 17° 15′ 38.36″ W, 19.05.1998, leg. J. T. Smit; 5♂♂, Funchal, Jardim Botânico, 264 m *a.s.l.*, 32° 39′ 43.23″ N, 16° 53′ 48.10″ W, 22.05.1998, leg. J. T. Smit; 18♀♀, Chão da Ribeira, Seixal, 433 m *a.s.l.*, 32° 48′ 33.25″ N, 17° 06′ 55.52″ W, 23.05.1998, leg. J. T. Smit; 1♀, Ribeira da Corujeira, SE Monte, 332 m *a.s.l.*, 32° 40′ 17.84″ N, 16° 54′ 56.80″ W, 24.05.1998, leg. J. T. Smit. ***oFA*** (2♀♀): 1♀, Achada do Gramacho, Santana, vereda to Ribeira de São Jorge, 45 m *a.s.l.*, 32º 49′ 44.78′′ N, 16º 53′ 47.40′′ W, 16.04.2009, obs. F. Aguiar, 1♀, Caminho do Cabo de Larano, Porto da Cruz, 340 m *a.s.l.*, 32º 45′ 39.32′′ N, 16º 48′ 04.49′′ W, 23.02.2012, obs. F. Aguiar.

- **Data from collections** (76♀♀, 7♂♂): ***ICLAM*** (17♀♀, 2♂♂): 1♂, Queimadas, Santana, 885 m *a.s.l.*, 32° 46′ 58.80′′ N, 16° 54′ 08.29′′ W, 26.11.1998, leg. Aguiar / Jesus; 2♀♀ Preces, Agricultural Station, Câmara de Lobos, 124 m *a.s.l.*, 32° 39′ 20.53′′ N, 16° 58′ 35.57′′ W, 20.05.1999, leg. Aguiar / Jesus; 1♀, Farol, Ponta do Pargo, 248 m *a.s.l.*, 32° 48′ 39.26′′ N, 17° 15′ 34.01′′ W, 23.09.1999, leg. Aguiar / Jesus; 2♀♀, Pico do Facho, Machico, 252 m *a.s.l.*, 32° 43′ 25.89″ N, 16° 45′ 27.83″ W, 26.03.2002, leg. Aguiar / Jesus; 1♀, Guindaste, Faial, 29 m *a.s.l.*, 32° 47′ 25.46′′ N, 16° 50′ 48.67′′ W, 14.04.2003, leg. Aguiar / Jesus, 2♀♀, Vereda da Entrosa, Boaventura to Arco de S. Jorge, 122 m *a.s.l.*, 32° 49′ 33.40′′ N, 16° 58′ 06.99′′ W, 15.05.2003, leg. Aguiar / Jesus; 1♀, Ribeira da Janela, road to Fanal, 680 m *a.s.l.*, 32° 50′ 04.02′′ N, 17° 09′ 17.27′′ W, 08.07.2004, leg. Aguiar / Jesus; 1♀, Pico do Areeiro to Pico Ruivo, 1,649 m *a.s.l.*, 32° 45′ 03.16′′ N, 16° 56′ 18.47′′ W, 02.06.2005, leg. Aguiar / Jesus; 1♀, Levada do Norte, Serra de Água, 1,150 m *a.s.l.*, 32º 43′ 22.14′′ N, 17º 00′ 08.50′′ W, 12.10.2006, leg. Aguiar / Jesus; 1♀, Levada da Fajã do Rodrigues, S. Vicente, 902 m *a.s.l.*, 32º 46′ 32.22′′ N, 17º 03′ 14.75′′ W, 15.02.2007, leg. Aguiar / Jesus; 2♀♀, Boaventura, S. Vicente, 371 m *a.s.l.*, 32º 49′ 13.85′′ N, 16º 58′ 56.22′′ W, 19.04.2007, leg. Aguiar / Jesus; 1♀, Ribeiro Frio, near the bar, 1,166 m *a.s.l.*, 32º 43′ 52.96′′ N, 16º 52′ 57.74′′ W, 17.05.2007, leg. Aguiar / Jesus; 2♀♀, Serra das Funduras, 0.7 km NE Natural Park house, 299 m *a.s.l.*, 32º 44′ 49.65′′ N, 16º 47′ 00.63′′ W, 21.02.2008, leg. C. Brazão; 1♂, Farol to Cais de S. Jorge, 25 m *a.s.l.*, 32º 49′ 45.81′′ N, 16º 53′ 52.85′′ W, 17.06.2010, leg. F. Aguiar. ***MZHF*** (14♀♀): 1♀, S. Vicente, 27 m *a.s.l.*, 01.7.-02.07.1957, 32° 48′ 28.80″ N, 17° 02′ 49.20″ W, leg. H. Lindberg; 2♀♀, Queimadas, 882 m *a.s.l.*, 24.6.-26.06.1957, 32° 47′ 00.72″ N, 16° 54′ 21.65″ W, leg H. Lindberg; 1♀, Boca da Corrida, 1185 m *a.s.l.*, 10.12.1991, 32° 42′ 39.60″ N, 16° 59′ 09.60″ W, leg. M. Koponen; 1♀, João Frino to Águas Mansas, 720 m *a.s.l.*, 19.12.1994, 32° 41′ 34.80″ N, 16° 50′ 13.20″ W, leg. M. Koponen; 1♀, Boa Morte – Quinta Grande, 416 m *a.s.l.*, 21.04.1995, 32° 40′ 20.60″ N, 17° 01′ 53.64″ W, leg. M. Koponen; 1♀, Monte, 559 m *a.s.l.*, 17.04.1995, 32° 40′ 30.46″ N, 16° 54′ 4.94″ W, leg. M. Koponen; 3♀♀, Palheiro Ferreiro – Babosas, 550-800 m *a.s.l.*, 17.04.1990, 32° 39′ 36.00″ N, 16° 52′ 33.60″ W, leg. M. Koponen; 1♀, Estreito de Câmara de Lobos – Caldeira, 608 m *a.s.l.*, 18.04.1995, 32° 39′ 34.04″ N, 17° 00′ 10.99″ W. leg. M. Koponen; 3♀♀, Funchal, Santo Amaro – Fajã, 300 m *a.s.l.*, 19.04.1995, 32° 39′ 25.20″ N, 16° 56′ 38.40″ W, leg. M. Koponen. ***OLML*** (8♀♀, 3♂♂): 8♀♀, Camacha, 730 m *a.s.l.*, 32° 40′ 47.47″ N, 16° 51′ 1.04″ W, 09.08.1992, leg. P. Wirtz; 3♂♂, Quinta do Palheiro Ferreiro, 569 m *a.s.l.*, 32° 39′ 45.23″ N, 16° 52′ 06.72″ W, 08.08.1966, leg. E. W. Classey. ***UMB*** (37♀♀, 2♂♂): 2♀♀, Achada do Cedro Gordo, 700 m *a.s.l.*, 32º 44′ 57.72′′ N, 16º 52′ 22.20′′ W, 04.04.1994, leg. H. Hohmann; 2♂♂, João Frino, 766 m *a.s.l.*, 32° 42′ 30.19″ N, 16° 49′ 54.50″ W, 13.04.1994, leg. H. Hohmann; 28♀♀, Lombo de São João, 537 m *a.s.l.*, 32° 42′ 10.40″ N, 17° 06′ 9.09″ W, 03.04.1994, leg. H. Hohmann; 1♀, Maloeira, 635 m *a.s.l.*, 32° 45′ 55.93″ N, 17° 12′ 32.23″ W, 02.04.1994, leg. H. Hohmann; 1♀, Ribeira Brava, Miradouro, 59 m *a.s.l.*, 32° 40′ 10.85″ N, 17° 03′ 45.66″ W, 10.04.1994, leg. H. Hohmann; 5♀♀, Ribeira de Janela, 639 m *a.s.l.*, 32° 50′ 16.37″ N, 17° 09′ 21.13″ W, 03.04.1994, leg. H. Hohmann.

- **Data from literature** (5♀♀, 10 ind.): Saunders (1903): 1♀, Monte (Funchal), about 570 m *a.s.l*, 27.02.1902, leg. A. E. Eaton; 2♀♀, Monte (Funchal), about 570 m *a.s.l*, 15.03.1902, leg. A. E. Eaton. Blüthgen (1940): 2♀♀ females, 17.07.-04.08.1935, Rabaçal, about 1000 m *a.s.l*. Fellendorf *et al*. (1999): 45♀♀, 4♂♂, collected in March, April, May, August and September; Caniço, about 300 m *a.s.l.*; Reis Magos, about 50 m *a.s.l.*; Camacha, about 600 m *a.s.l.*; Poiso, 1,400 m *a.s.l.*; Portela, about 660 m *a.s.l.*; Santana, about 400 m *a.s.l.*, João da Ribeira, about 700 m *a.s.l.*; Encumeada, about 1,000 m *a.s.l.*; Funchal, about 300 m *a.s.l*. Due to the lack of differentiation (number of individuals per locality, characterisation 'female, male'), only one individual is counted per locality (n = 9 ind.). Costa (2019): 1 ind. from Pico do Areeiro, 1,800 m *a.s.l.*, 32° 44′ N, 16° 55′ 47″ W).

- **Further checked data** (checked by A. Kratochwil): Boieiro, M., 1♀, Portela, 640 m *a.s.l.*, 32° 48′ 29.79″ N, 16° 51′ 56.77″ W, June 2017, leg. M. Boieiro.

***Lasioglossum (Evylaeus) wollastoni* (Cockerell, 1922)**

- **Status**: Endemic to Madeira Island (Fig. 33).

- **Literature**: Saunders (1903), Cockerell (1922), Blüthgen (1940), Warncke (1975), Fellendorf *et al.* (1999), Kratochwil *et al.* (2018, 2019).

- **Specimens analysed**: 199♀♀, 36♂♂.

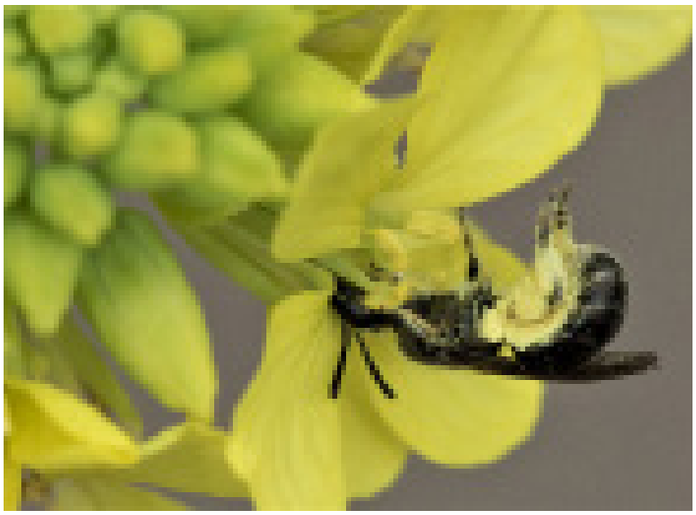

Fig. 33 – *Lasioglossum wollastoni* (female), collecting pollen on the native plant species *Rapistrum rugosum* s.l. (Ponta de São Lourenço, roadside, 02.04.2022; vegetation series b). Photo A. Kratochwil.

- **Distribution, habitat characteristics, and flower-visiting behaviour** (Figs. 34 and 35, Tables 14 and 15): *Lasioglossum wollastoni* shows the highest presence in the grid cells of the subhumid to humid Mediterranean zones [vegetation series b), c), d)]. Coastal rocks, other rocky places and ruderal sites are important habitat types. This polylectic species visits eight different plant families and feeds on the flower resources of endemic plant species, *e.g. Echium nervosum*, *Andryala glandulosa* s.l., *Argyranthemum pinnatifidum* s.l., *Sinapidendron angustifolium*, *Aeonium glutinosum*. Ruderal species such as *Rapistrum rugosum* s.l., *Sonchus oleraceus*, and vegetables in gardens (*Brassica oleracea*) are also used. Some introduced species play a role as well (*e.g. Bidens pilosa*, *Chrysanthemum segetum*, *Helichrysum foetidum*).

- **Flight time and nesting sites**: Flight-activity data exist from February (first observation 15th February) to September (latest observation 20th September). According to the data *L. wollastoni* is active from March to the beginning of August at lower altitudes (with high abundances in March and April). At higher altitudes (from 1,000 to 1,600 m *a.s.l.*), the activity starts later (in July). We did not find nesting sites on Madeira Island, but on Porto Santo there was breeding activity at the end of March 2017 in sandy, weakly consolidated substrate (see photo documentation in Kratochwil & Schwabe, 2018b, Fig. 12c). According to Pauly & Michez (2013), 'nests are constructed in loose aggregations in bare ground'.

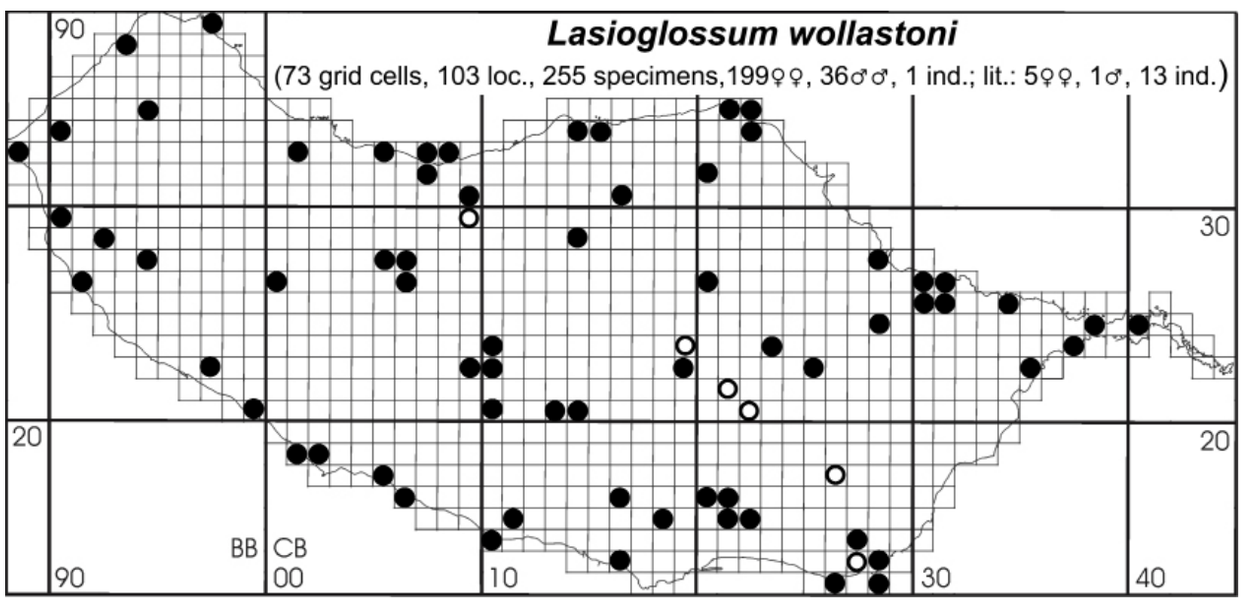

Fig. 34 – Detections of *Lasioglossum wollastoni* (black dots: authors' data, checked specimens of collections; circles: literature data).

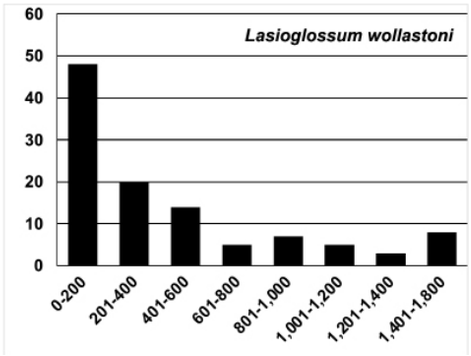

Fig. 35 – Number of localities with *Lasioglossum wollastoni* detections per altitude level (m *a.s.l.*).

Table 14 – Presence of *Lasioglossum wollastoni* in square-grid cells of different vegetation series.

Vegetation series		Presence %, absolute
May-Ol	a	15%
Hel-Si	b	35%
Sem-Ap 1	c	38%
Sem-Ap 2	d	**42%**
Cle-Oc	e	15%
Pol-Er	f	31%
Arm-Pa	g	2

Table 15 – Plant-species spectrum visited by *Lasioglossum wollastoni*.

Plant species, plant families		Status	n
Oenanthe divaricata	Api	end	1♀
Andryala glandulosa s.l.	Ast	end	1♀
Andryala glandulosa subsp. *glandulosa*	Ast	end	2♀♀, 4♂♂
Argyranthemum pinnatifidum s l.	Ast	end	3♂♂
Asteraceae yellow	Ast	-	1♀, 7♂♂
Bidens pilosa	Ast	intr	1♀
Calendula officinalis	Ast	intr	1♀
Chrysanthemum segetum	Ast	intr	1♂
Crepis vesicaria	Ast	nat	14♀♀
Galactites tomentosa	Ast	nat	1♀
Helichrysum foetidum	Ast	intr	1♀, 3♂♂
Lapsana communis	Ast	nat?	1♀
Leontodon taraxacoides subsp. *longirostris*	Ast	nat	14♀♀
Sonchus asper	Ast	nat?	1♀
Sonchus oleraceus	Ast	nat?	3♀♀
Taraxacum officinale agg.	Ast	nat?	3♀♀
Echium nervosum	Bor	end	6♀♀
Brassica oleracea	Bra	cult	2♀♀, 4♂♂
Raphanus r. subsp. *raphanistrum*	Bra	nat	1♀
Rapistrum rugosum s.l.	Bra	nat	3♀♀
Sinapidendron angustifolium	Bra	end	12♀♀
Aeonium glutinosum	Cra	end	1♀, 1♂
Hypericum sp.	Hyp	-	1♀
Eschscholzia californica	Pap	intr	1♀
Digitalis purpurea	Scr	nat?	1♀

- **Data from the authors** (181♀♀, 12♂♂, 1 ind.): ***cAK*** (146♀♀): 3♀♀, Madalena do Mar, 45 m *a.s.l.*, 32° 42′ 12.03″ N, 17° 08′ 13.77″ W, 08.04.1995, leg. K/S; 1♀, Arco da Calheta, ER 101, 333 m *a.s.l.*, 32° 42′ 22.13″ N, 17° 08′ 22.47″ W, 08.04.1995, leg. K/S; 2♀♀, Ponta de São Lourenço, above Ponta do Buraco, 71 m *a.s.l.*, 32° 44′ 35.16″ N, 16° 42′ 01.06″ W, 10.04.1995, leg. K/S; 3♀♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 25.03.2005, leg. K/S; 7♀♀, W Ponta do Sol, between Livramento and Anjos, 38 m *a.s.l.*, 32° 40′ 56.30″ N, 17° 06′ 31.87″ W, 25.03.2005, leg. K/S; 2♀♀, W Ponta do Sol, Anjos, ER 213, 39 m *a.s.l.*, 32° 41′ 27.05″ N, 17° 07′ 12.70″ W, 25.03.2005, leg. K/S; 1♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 26.03.2005, leg. K/S; 2♀♀, Ponta de São Lourenço, 101 m *a.s.l.*, 32° 44′ 44.01″ N, 16° 43′ 20.74″ W, 26.03.2005, leg. K/S; 7♀♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 27.03.2005, leg. K/S; 5♀♀, Serra de Água, lookout point, 465 m *a.s.l.*, 32° 43′ 50.79″ N, 17° 01′ 26.59″ W, 27.03.2005, leg. K/S; 1♀, Eirinha above Serra de Água, 506 m *a.s.l.*, 32° 43′ 54.22″ N, 17° 01′ 30.19″ W, 27.03.2005, leg. K/S; 3♀♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 28.03.2005, leg. K/S; 1♀, Fajã dos Padres, W Quinta Grande, 325 m *a.s.l.*, 32° 39′ 21.12″ N, 17° 01′ 04.44″ W, 28.03.2005, leg. K/S; 4♀♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 29.03.2005, leg. K/S; 2♀♀, Boca do Risco, 356 m *a.s.l.*, 32° 45′ 18.75″ N, 16° 46′ 13.12″ W, 29.03.05, leg. K/S; 1♀, Larano, E Porto da Cruz, 274 m *a.s.l.*, 32° 45′ 45.14″ N, 16° 48′ 29.69″ W, 29.03.2005, leg. K/S; 2♀♀, Ponta da Garajau, S Caniço, 112 m *a.s.l.*, 32° 38′ 18.33″ N, 16° 51′ 02.84″ W, 30.03.2005, leg. K/S; 7♀♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 30.03.2005, leg. K/S; 1♀, Ponta do Garajau, S Caniço, 112 m *a.s.l.*, 32° 38′ 18.33″ N, 16° 51′ 02.84″ W, 01.04.2005, leg. K/S; 4♀♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 01.04.2005, leg. K/S; 1♀, Ponta do Garajau, S Caniço, 112 m *a.s.l.*, 32° 38′ 18.33″ N, 16° 51′ 02.84″ W, 02.04.2005, leg. K/S; 5♀♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 02.04.2005, leg. K/S; 1♀, W Ribeira Brava, Ribeira da Caldeira, E 213, 37 m *a.s.l.*, 32° 40′ 25.21″ N, 17° 04′ 09.99″ W, 02.04.2005, leg. K/S; 3♀♀, W Ribeira Brava, between Ribeiro da Corujeira – Ribeira da Caldeira, E 215, 26 m *a.s.l.*, 32° 40′ 34.34″ N, 17° 04′ 27.05″ W, 02.04.2005, leg. K/S; 1♀, Ponta da Garajau, S Caniço, 112 m *a.s.l.*, 32° 38′ 18.33″ N, 16° 51′ 02.84″ W, 03.04.2005, leg. K/S; 3♀♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 03.04.2005, leg. K/S; 1♀, above Paúl do Mar, ER 213, 43 m *a.s.l.*, 32° 45′ 28.83″ N, 17° 13′ 41.69″ W, 03.04.2005, leg. K/S; 2♀♀, W S. Vicente, ER 101, Fajã do Rente, 75 m *a.s.l.*, 32° 48′ 29.57″ N, 17° 03′ 05.00″ W, 03.04.2005, leg. K/S; 2♀♀, W S. Vicente, old road between Ribeiro do Inferno – Ribeiro dos Caimbos, 10 m *a.s.l.*, 32° 48′ 33.51″ N, 17° 03′ 24.31″

W, 03.04.2005, leg. K/S; 3♀♀, E Seixal, old road between Ilhéu das Ceroulas – Ribeira de João Delgado, 51 m *a.s.l*., 32° 48′ 37.15″ N, 17° 03′ 37.41″ W, 03.04.2005, leg. K/S; 1♀, Ponta do Pargo, near lighthouse, 345 m *a.s.l*., 32° 48′ 50.16″ N, 17° 15′ 30.24″ W, 03.04.2005, leg. K/S; 1♀, E Ribeira da Janela, old road between Ribeira da Janela – Ribeiro Escuro, 17 m *a.s.l*., 32° 48′ 59.01″ N, 17° 05′ 4.72″ W, 03.04.2005, leg. K/S; 1♀, Ponta do Garajau, S Caniço, 112 m *a.s.l*., 32° 38′ 18.33″ N, 16° 51′ 02.84″ W, 04.04.2005, leg. K/S; 1♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l*., 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 04.04.2005, leg. K/S; 4♀♀, Ponta de São Lourenço, above Rochinha, 78 m *a.s.l*., 32° 44′ 40.19″ N, 16° 43′ 22.21″ W, 04.04.2005. leg. K/S; 10♀♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l*., 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 05.04.2005, leg. K/S; 1♀, Ponta de São Lourenço, above Rochinha, 78 m *a.s.l*., 32° 44′ 40.19″ N, 16° 43′ 22.21″ W, 06.04.2005, leg. K/S; 3♀♀, Porto da Cruz, peninsula with ruins; 15 m *a.s.l*., 32° 46′ 28.63″ N, 16° 49′ 38.98″ W, 06.04.2005, leg. K/S; 3♀♀, Lombo do Urzal, near Boaventura, 472 m *a.s.l*., 32° 46′ 54.3″ N, 16° 58′ 45.5″ W, 25.03.2022, leg. K/S; 1♀, Fajã do Penedo, near Boaventura, 323 m *a.s.l*., 32° 47′ 59.8″ N, 16° 57′ 46.3″ W, 25.03.2022, leg. K/S; 30♀♀, E S. Vicente, near Fajã Areia, 22 m *a.s.l*., 32° 48′ 40.3′′ N, 17° 02′ 34.4′′ W, 28.03.2022, leg. K/S; 1♀, 29.03.2022, Funchal, Jardim Botânico, 281 m *a.s.l*., 32° 39′ 45.9′′ N, 16° 53′ 47.2′′ W, leg. K/S; 2♀♀, E Ponta Delgada, old road, 95 m *a.s.l*., 32° 49′ 37.92′′ N, 16° 58′ 49.67′′ W, 31.03.2022, leg. K/S; 2♀♀, São Cristovão, coastal rock, 104 m *a.s.l*., 32° 49′ 39.3′′ N, 16° 58′ 41.2′′ W, 31.03.2022, leg. K/S; 3♀♀, São Lourenço, 54 m *a.s.l*., 32° 44′ 36.5′′ N, 16° 43′ 21.8′′ W, 02.04.2022, leg. K/S; 1♀, São Cristovão, old coastal road, 104 m *a.s.l*., 32° 49′ 39.3′′ N, 16° 58′ 41.2′′ W, 03.04.2022, leg. K/S. ***cFA*** (2♀♀, 1♂): 1♀, Areeiro, São Martinho, 159 m *a.s.l*., 32° 38′ 47.11′′ N, 16° 57′ 26.71′′ W, 23.03.1992, leg. F. Aguiar; 1♂, Boca da Corrida, below Miradouro, 1,152 m *a.s.l*., 32° 42′ 39.43′′ N, 16° 59′ 07.37′′ W, 02.09.2004, leg. Aguiar / Jesus; 1♀, Pinheiro, Ribeira Brava, 394 m *a.s.l*., 32° 43′ 19.37′′ N, 17° 02′ 03.95′′ W, 04.05.2006, leg. F. Aguiar *et al*. ***cJS*** (28♀♀, 4♂♂): 1♀, 1♂, Lombada dos Marinheiros, 578 m *a.s.l*., 32° 47′ 16.13″ N, 17° 14′ 18.83″ W, 15.07.1997, leg. J. Smit; 1♀, Fontes, 1,124 m *a.s.l*., 32° 42′ 33.11″ N, 17° 00′ 57.13″ W, 16.07.1997, leg. J. Smit; 1♂, Ribeiro Frio, 893 m *a.s.l*., 32° 44′ 05.11″ N, 16° 53′ 11.73″ W, 17.07.1997, leg. J. Smit; 1♀, Portela, 640 m *a.s.l*., 32° 48′ 29.79″ N, 16° 51′ 56.77″ W, 19.07.1997, leg. J. Smit; 2♀♀, Paúl da Serra, 1,579 m *a.s.l*., 32° 45′ 43.56″ N, 17° 03′ 54.28″ W, 20.07.1997, leg. J. Smit; 1♀, Funchal, Pico dos Barcelos, 338 m *a.s.l*., 32° 39′ 31.00″ N, 16° 56′ 22.00″ W, 15.02.1998, leg. J. T. Smit; 1♀, Fajã da Nogueira, N Caniço, 222 m *a.s.l*., 32° 39′ 09.89″ N, 16° 50′ 07.79″ W, 10.03.1998, leg. J. T. Smit; 1♀, Chão da Ribeira, Seixal, 433 m *a.s.l*., 32° 48′ 33.25″ N, 17° 06′ 55.52″ W, 21.03.1998, leg. J. T. Smit; 1♀, Calheta, Lombo do Atouguia, 306 m *a.s.l*., 32° 43′ 26.85″ N, 17° 09′ 55.18″ W, 07.04.1998, leg. J. T. Smit; 1♀, Rabaçal, 1,064 m *a.s.l*., 32° 45′ 43.45″ N, 17° 08′ 03.01″ W, 07.04.1998, leg. J. T. Smit; 2♀♀, Chão da Ribeira, Seixal, 433 m *a.s.l*., 32° 48′ 33.25″ N, 17° 06′ 55.52″ W, 14.04.1998, leg. J. T. Smit; 1♀, Funchal, Pico dos Barcelos, 338 m *a.s.l*., 32° 39′ 31.00″ N, 16° 56′ 22.00″ W, 25.04.1998, leg. J. T. Smit; 4♀♀, Ponta do Pargo, 322 m *a.s.l*., 32° 48′ 44.56″ N, 17° 15′ 38.36″ W, 05.05.1998, leg. J. Smit; 1♀, Boa Morte, 483 m *a.s.l*., 32° 49′ 08.83″ N, 17° 14′ 13.73″ W, 05.05.1998, leg. J. Smit; 1♀, Funchal, Pico dos Barcelos, 338 m *a.s.l*., 32° 39′ 31.00″ N, 16° 56′ 22.00″ W, 12.05.1998, leg. J. T. Smit; 1♀, Chão da Ribeira, Seixal, 433 m *a.s.l*., 32° 48′ 33.25″ N, 17° 06′ 55.52″ W, 19.05.1998, leg. J. T. Smit; 1♀, Rabaçal, 1064 m *a.s.l*., 32° 45′ 43.45″ N, 17° 08′ 03.01″ W, 21.05.1998, leg. J. T. Smit; 3♀♀, Chão da Ribeira, Seixal, 433 m *a.s.l*., 32° 48′ 33.25″ N, 17° 06′ 55.52″ W, 23.05.1998, leg. J. T. Smit; 1♀, Ribeira da Corujeira, SE Monte, 332 m *a.s.l*., 32° 40′ 17.84″ N, 16° 54′ 56.80″ W, 24.05.1998, leg. J. T. Smit; 2♀♀, Reis Magos, Caniço, 11 m *a.s.l*., 32° 38′ 45.15″ N, 16° 49′ 30.22″ W, 06.06.1998, leg. J. T. Smit; 1♀, Funchal, Ribeira dos Socorridos, 315 m *a.s.l*., 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 07.06.1998, leg. J. T. Smit; 2♂♂, Reis Magos, Caniço, 11 m *a.s.l*., 32° 38′ 45.15″ N, 16° 49′ 30.22″ W, 09.06.1998, leg. P. Wirtz. ***oFA*** (5♀♀, 7♂♂, 1 ind.): 1♀, Farol to Cais de S. Jorge, 33 m *a.s.l*., 32º 50′ 00.47′′ N, 16º 54′ 01.68′′ W, 21.06.2007, obs. F. Aguiar; 1♀, Farol to Cais de S. Jorge, 147 m *a.s.l*., 32º 50′ 04.18′′ N, 16º 54′ 11.00′′ W, 21.06.2007, obs. F. Aguiar; 1♀, Paúl da Serra, dirt road from Estanquinhos to Ginjas, 1,585 m *a.s.l*., 32º 46′ 11.96′′ N, 17º 04′ 27.15′′ W, 05.07.2007, obs. F. Aguiar; 1♂, Achadas da Cruz to Fajã Nova, Porto Moniz, 423 m *a.s.l*., 32º 51′ 10.97′′ N, 17º 12′ 30.23′′ W, 05.07.2007, obs. F. Aguiar; 1♂, Achadas da Cruz to Fajã Nova, Porto Moniz, 424 m *a.s.l*., 32º 51′ 11.06′′ N, 17º 12′ 30.19′′ W, 05.07.2007, obs. F. Aguiar; 1♂, Achadas da Cruz to Fajã Nova, Porto Moniz, 423 m *a.s.l*., 32º 51′ 11.27′′ N, 17º 12′ 30.40′′ W, 05.07.2007, obs. F. Aguiar; 1 ind., Achadas da Cruz to Fajã Nova, Porto Moniz, 423 m *a.s.l*., 32º 51′ 11.98′′ N, 17º 12′ 31.11′′ W, 05.07.2007, obs. F. Aguiar; 3♂♂, Santo da Serra, dirt road to Pico do Suna, 1,181 m *a.s.l*., 32º 43′ 24.13′′ N, 16º 51′ 42.47′′ W, 20.09.2007, obs. F. Aguiar; 1♀, Portela, dirt road from Portela to Ribeira de Machico, 569 m *a.s.l*., 32º 45′ 24.14′′ N, 16º 48′ 29.13′′ W, 21.02.2008, obs. F. Aguiar; 1♀, Achada do Gramacho, Santana, Vereda to Ribeira de São Jorge, 240 m *a.s.l*., 32º 49′ 35.60′′ N, 16º 53′ 34.63′′ W, 19.08.2008, obs. F. Aguiar; 1♂, Caminho do Cabo de Larano, Porto da Cruz, 320 m *a.s.l*., 32º 45′ 42.53′′ N, 16º 48′ 10.47′′ W, 04.06.2009, obs. F. Aguiar.

- **Data from collections** (18♀♀, 24♂♂): ***ICLAM*** (9♀♀, 20♂♂): 1♂, Boca da Corrida, above Jardim da Serra, 807 m *a.s.l*., 32° 42′ 28.73′′ N, 16° 58′ 54.19′′ W, 27.08.1998, leg. Aguiar / Jesus; 1♂, Ribeira Brava, Miradouro Pico da Cruz, 54 m *a.s.l*., 32° 40′ 09.25′′ N, 17° 03′ 46.32′′ W, 19.06.2000, leg. Aguiar / Jesus; 1♂, Boca da Corrida, above Jardim da Serra, 859 m *a.s.l*., 32° 42′ 28.19′′ N, 16° 58′ 56.31′′ W, 13.07.2000, leg. Aguiar / Jesus; 1♀, Poço da Neve, near Pico do Areeiro, 1,567 m *a.s.l*., 32° 43′ 24.87′′ N, 16° 55′ 28.70′′ W, 11.07.2002, leg. Aguiar / Jesus; 1♂, Pico do

Facho, Machico, 266 m *a.s.l.*, 32° 43′ 14.80′′ N, 16° 45′ 22.82′′ W, 12.06.2003, leg. Aguiar / Jesus; 1♂, Boca da Corrida, above Jardim da Serra, 859 m *a.s.l.*, 32° 42′ 28.19′′ N, 16° 58′ 56.31′′ W, 09.08.2004, leg. Aguiar / Jesus; 1♂, Farol to Cais de S. Jorge, 28 m *a.s.l.*, 32º 49′ 52.45′ 'N, 16º 53′ 56.75′′ W, 12.05.2005, leg. J. Jesus; 1♂, near Eirinha, Serra de Água, 351 m *a.s.l.*, 32° 43′ 40.95′′ N, 17° 01′ 30.88′′ W, 30.08.2005, leg. Aguiar / Jesus; 1♂, Farol to Cais de S. Jorge, 159 m *a.s.l.*, 32º 49′ 56.97′′ N, 16º 54′ 06.85′′ W, 21.06.2007, leg. J. Jesus; 1♂, Farol to Cais de S. Jorge, 159 m *a.s.l.*, 32º 49′ 56.98′′ N, 16º 54′ 06.77′′ W, 21.06.2007, leg. J. Jesus; 1♂, Farol to Cais de S. Jorge, 159 m *a.s.l.*, 32º 49′ 57.07′′ N, 16º 54′ 06.92′′ W, 21.06.2007, leg. C. Brazão; 1♂, Farol to Cais de S. Jorge, 147 m *a.s.l.*, 32º 49′ 57.34′′ N, 16º 54′ 06.47′′ W, 21.06.2007, leg. C. Brazão; 2♂♂, Farol to Cais de S. Jorge, 160 m *a.s.l.*, 32º 50′ 03.28′′ N, 16º 54′ 10.90′′ W, 21.06.2007, leg. F. Aguiar; 1♀, Vereda Achadas da Cruz to Fajã Nova, 441 m *a.s.l.*, 32º 51′ 09.78′′ N, 17º 12′ 30.44′′ W, 05.07.07, leg. C. Brazão; 1♂, Vereda Achadas da Cruz to Fajã Nova, 454 m *a.s.l.*, 32º 51′ 10.53′′ N, 17º 12′ 31.96′′ W, 05.07.2007, leg. J. Jesus; 1♂, Caldeira, Câmara de Lobos, 630 m *a.s.l.*, 32º 39′ 34.31′′ N, 17º 00′ 15.05′′ W, 06.08.2007, leg. C. Brazão; 1♀, Pico Senhora de Fátima, stairs leading to little church, 183 m *a.s.l.*, 32º 47′ 34.20′′ N, 17º 01′ 55.47′′ W, 23.08.2007, leg. C. Brazão; 1♀, Paúl da Serra, dirt road from Estanquinhos to Ginjas, 1,582 m *a.s.l.*, 32º 46′ 11.61′′ N, 17º 04′ 21.68′′ W, 30.08.2007, leg. J. Jesus; 1♂, Paúl da Serra, dirt road from Estanquinhos to Ginjas, 1,578 m *a.s.l.*, 32º 46′ 12.33′′ N, 17º 04′ 15.28′′ W, 30.08.2007, leg. C. Brazão; 1♀, Ilha, dirt road above habitational zone, 580 m *a.s.l.*, 32º 48′ 10.15′′ N, 16º 55′ 14.75′′ W, 28.02.2008, leg. C. Brazão; 1♂, Fonte da Pedra, 1.53 km SE Achadas da Cruz, 983 m *a.s.l.*, 32º 49′ 36.87′′ N, 17º 11′ 42.71′′ W, 07.08.2008, leg. C. Brazão; 1♂, Fonte da Pedra, 1.53 km SE Achadas da Cruz, 985 m *a.s.l.*, 32º 49′ 37.46′′ N, 17º 11′ 48.03′′ W, 07.08.2008, leg. J. Jesus; 1♂, Vereda do Larano, 2.7 km SE Porto da Cruz, 495 m *a.s.l.*, 32º 45′ 28.91′′ N, 16º 47′ 57.39′′ W, 04.05.2009, leg. D. Cravo; 1♀, S. Vicente, 0.2 km E Pico Senhora de Fátima, 201 m *a.s.l.*, 32º 47′ 34.48′′ N, 17º 01′ 51.72′′ W, 18.06.2009, leg. D. Cravo; 1♀, Achada do Teixeira, 130 m S car parking, 1,214 m *a.s.l.*, 32º 45′ 36.88′′ N, 16º 54′ 58.56′′ W, 01.06.2010, leg. D. Cravo; 1♀, road from Paúl da Serra to Prazeres, 782 m *a.s.l.*, 32º 45′ 50.12′′ N, 17º 11′ 29.91′′ W, 24.06.2010, leg. D. Cravo; 1♂, Paúl da Serra, dirt road from Estanquinhos to Ginjas, 1,587 m *a.s.l.*, 32º 46′ 00.16′′ N, 17º 04′ 08.99′′ W, 19.08.2010, leg. J. Jesus; 1♀, Caminho de São Lourenço, 1.85 km NE Fajã da Ovelha church, 753 m *a.s.l.*, 32º 46′ 45.90′′ N, 17º 12′ 47.71′′ W, 19.05.2011, leg. D. Cravo. ***MZHF*** (8♀♀, 1♂): 5♀♀, 1♂, Porto Moniz, 27 m *a.s.l.*, 32° 52′ 01.20′′ N, 17° 10′ 04.80′′ W, 04.07.1957, leg. H. Lindberg, 1♀, Garajau, 52 m *a.s.l.*, 32° 38′ 13.20′′ N, 16° 51′ 00.00′′ W, 19.04.1959, leg. H. Lindberg; 1♀, Caniçal, 15 m *a.s.l.*, 32° 44′ 25.68′′ N, 16° 43′ 47.31′′ W, 29.04.1959, leg. H. Lindberg; 1♀, Ribeiro Frio, 926 m *a.s.l.*, 32° 44′ 17.88′′ N, 16° 53′ 02.63′′ W, 14.05.1959, leg. S. Panelius. ***OLML*** (1♀, 3♂♂): 3♂♂, Funchal, 310 m *a.s.l.*, 32° 40′ 0.96″ N, 16° 55′ 26.6″ W, 17.07.1968, leg. S. Erlandson; 1♀, Monte, 559 m *a.s.l.*, 32° 40′ 30.46″ N, 16° 54′ 4.94″ W, 19.03.1989, leg. J. A. W. Lucas.

- **Data from literature** (5♀♀, 1♂, 13 ind.): Saunders (1903): 1♀ (Monte, Funchal), *Sonchus oleraceus*, 27.02.1902, leg. A. E. Eaton. Blüthgen (1940): 2♀♀, leg. O. Lundblad, 17.07.-04.08.1935, Rabaçal (about 1,000 m *a.s.l.*). 1♀ is deposited in the Biology Centre of the Upper Austrian Provincial Museum Linz (Collection of Warncke); 1♂, 06.-14.08.1935, Caramujo (1,250 m *a.s.l.*); 1♂, 15.08.1935, Feiteiras S S. Vicente (about 200 m *a.s.l.*). In the Biology Centre of the Upper Austrian Provincial Museum Linz (Collection of Warncke) there are 3♂♂ collected by S. Erlandsson (1♂, 17.07.1968; 2♂♂, 19.07.1968), Funchal. In the Biology Centre of the Upper Austrian Provincial Museum Linz (Collection of Warncke) there is a female collected by J. A. W. Lucas, 19.03.1989, Monte, 500-600 m *a.s.l.* Fellendorf *et al.* (1999): 15♀♀, 21♂♂: in January, February, May, July, August and September, Caniço (about 300 m *a.s.l.*), Reis Magos (about 50 m *a.s.l.*), Camacha (about 600 m *a.s.l.*), Pico do Facho (about 300 m *a.s.l.*), Poiso (1,000 m *a.s.l.*), Santo António da Serra (about 650 m *a.s.l.*), João da Ribeira (about 700 m *a.s.l.*), Porto Moniz (about 50 m *a.s.l.*), Ponta S. Lourenço (about 100 m *a.s.l.*), Pico do Areeiro (about 1,800 m *a.s.l.*). Due to the lack of differentiation (number of individuals per locality, characterisation 'female, male'), only one individual is counted per locality (n = 11 ind.). 1♀ (MMF 26626) 1♂ (MMF 26625): Madeira; 7♀♀, Camacha, 09.08.1992, leg. P. Wirtz, det. A. W. Ebmer (OLML). Costa (2019): 2 ind. from area of Pico do Areeiro (1,500 m *a.s.l.*, 32° 43′ 8″ N, 16° 54′ 31″ W; 1,800 m *a.s.l.*, 32° 44′ N, 16° 55′ 47″ W).

Megachilidae

Anthidium manicatum (Linnaeus, 1758)

- **Status**: Introduced.
- **Literature**: Matzke-Hajek (2021).
- **Specimens analysed**: Specimens were identified by Matzke-Hajek (2021) and documented with photos. Based on photo analysis, no assignment to either *Anthidium manicatum manicatum* (common in Europe) or *Anthidium m. barbarum* (common in North Africa) is possible. Both taxa differ in the colour pattern and molecular structure (M. Kasparek, *pers. comm.*).
- **Distribution, habitat characteristics, and flower-visiting behaviour** (Fig. 36): Matzke-Hajek (2021) observed several individuals of *A. manicatum* on the introduced *Salvia leucantha* (Lamiaceae) in the 'Parque de Santa

Catarina' (near the harbour of Funchal), on 29.09.2021 and 01.10.2021. The site corresponds to the Mediterranean macrobioclimate, inframediterranean dry series (May-Ol). The species prefers to visit zygomorphic flowers (Scheuchl & Willner, 2016), as in the case of *Salvia* (see above) and other Lamiaceae and further plant families.

Anthidium manicatum shows a Transpalaearctic distribution, and has been introduced in many places by humans in different regions (the USA, Brazil, Argentina, and Uruguay), as noted by Strange *et al*. (2011). In Central Europe, the species can mainly be found in gardens and parks in urban areas (Scheuchl & Willner, 2016).

In the Macaronesian Islands, the species was introduced to the Azores (first record: 1857, Drouët, 1861; see also Weissmann *et al*., 2017) and the Canary Islands (Lieftinck, 1958). *Anthidium manicatum* is now common on Tenerife, Gran Canaria, and La Palma (https://www.biodiversidadcanarias.es/biota/especie/A00810?lang=de).

The close distance to the port of Funchal suggests a human introduction by shipping. Such an introduction can occur through specimens nesting in stems. Nevertheless, the obviously late introduction to Madeira Island is surprising. It is uncertain whether this species can survive on Madeira Island and spread further.

***Hoplitis (Alcidamea) acuticornis* (Dufour & Perris, 1840)**

- **Status**: Introduced.

- **Literature**: Alfken (1940), Fellendorf *et al*. (1999), Kratochwil *et al*. (2018).

- **Specimens analysed**: 3♀♀, 1♂.

- **Distribution, habitat characteristics, and flower-visiting behaviour** (Figs. 37 and 38, Table 16): The rare *Hoplitis acuticornis* occurred nearly exclusively in the temperate macrobioclimate. Only three flower-visiting data could be obtained (high-altitude pasture, visiting *Echium candicans*; Costa, 2019). According to Scheuchl & Willner (2016), the species has a strong preference for Fabaceae in Central Europe.

- **Further comments**: J. Smit collected *Stelis ornatula* (Klug, 1807), which is a brood parasite specialised on *Hoplitis*, in the same locality (Fontes) and at the same time (15.07.1997). According to Amiet *et al*. (2004) and Scheuchl & Willner (2016), a host species is *H. acuticornis* (Dufour & Perris, 1840). Therefore, we assume that on Madeira Island the host of *S. ornatula* is *H. acuticornis*.

- **Flight time**: The species was observed in June and July.

- **Data from the authors** (1♀, 1♂): ***cJS***: 1♂, Lombada dos Marinheiros, 578 m *a.s.l*., 32° 47' 16.13" N, 17° 14' 18.83" W, 15.07.1997, leg. J. Smit; 1♀, Fontes, 1,124 m *a.s.l*., 32° 42' 33.11" N, 17° 00' 57.13" W, 16.07.1997, leg. J. Smit.

- **Further checked data** (2♀♀; checked by A. Kratochwil): Boieiro, M.; 1♀, Lombo do Mouro, 1,243 m *a.s.l*., 32° 44' 45.06" N, 17° 2' 28.05" W, 27.06.2017, leg. M. Boieiro; Santos, R.: 1♀, Paúl da Serra, 1,423 m *a.s.l*., 32° 45' 26.99" N, 17° 5' 49.83" W, 27.06.2017 leg. R. Santos.

- **Data from literature** (3♀♀, 1♂): Alfken (1940): 1♀, 1♂, Rabaçal, 1,066 m *a.s.l*., 32° 45' 39.71" N, 17° 08' 4.78" W, 17.07.-04.08.1935, leg. O. Lundblad; Costa (2019): 1♀, Pico do Areeiro, 1,800 m *a.s.l*., 32° 43' 8" N, 16° 54' 31" W, leg. R. Costa; 1♀, Pico do Areeiro, 1,500 m *a.s.l*., 32° 43' 8" N, 16° 54' 31" W, leg. R. Costa.

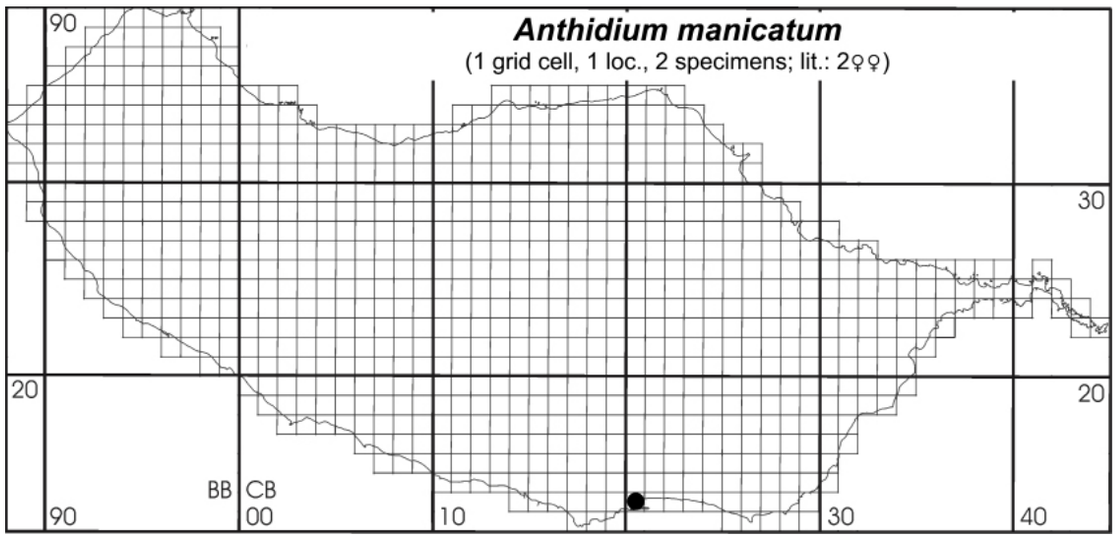

Fig. 36 – Detection of *Anthidium manicatum* (black dot: data of Matzke-Hajek 2021, photos checked by A. Kratochwil).

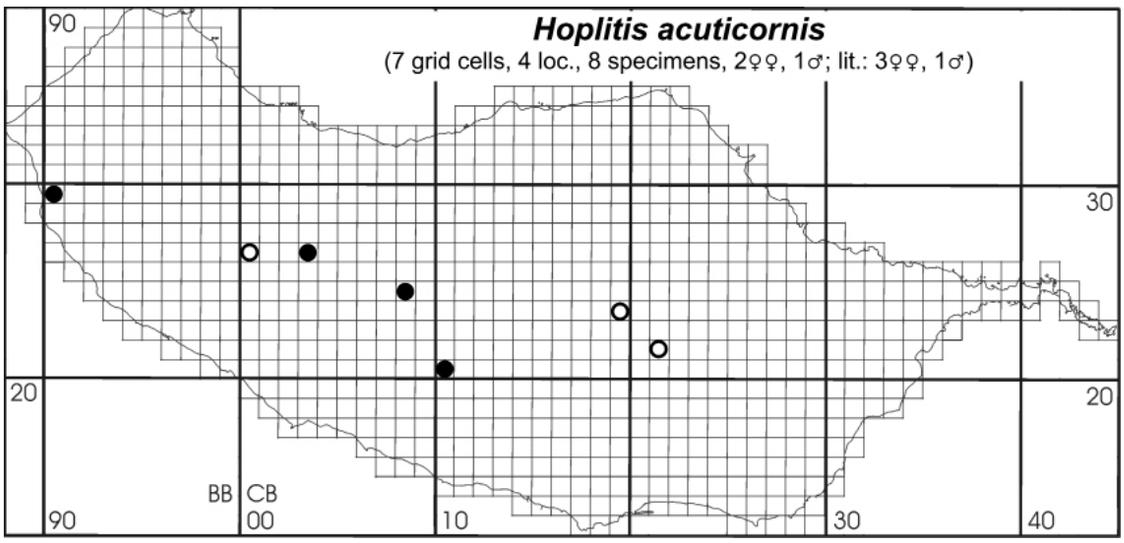

Fig. 37 – Detections of *Hoplitis acuticornis* (black dots: authors' data and checked specimens of collections; circles: literature data).

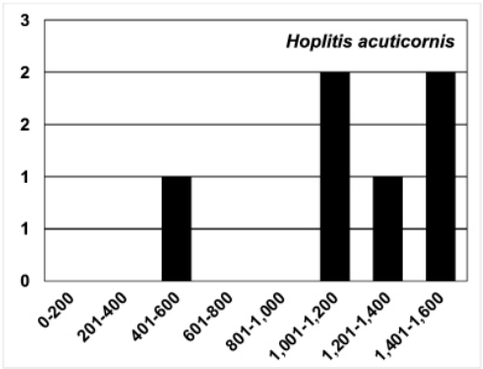

Fig. 38 – Number of localities with *Hoplitis acuticornis* detections per altitude level (m *a.s.l.*).

Table 16 – Presence of *Hoplitis acuticornis* in square-grid cells of different vegetation series.

Vegetation series		Presence %, absolute
May-Ol	a	-
Hel-Si	b	-
Sem-Ap 1	c	-
Sem-Ap 2	d	2%
Cle-Oc	e	2%
Pol-Er	f	**13%**
Arm-Pa	g	2

Megachile (Eutricharea) pusilla Pérez, 1844

- **Status**: Introduced.
- **Literature**: Kratochwil *et al*. (2018).
- **Specimens analysed**: 1♂.
- **Distribution, habitat characteristics, and flower-visiting behaviour** (Fig. 39): M. Andrade collected 1♂ on flowers of the cultivated *Chamaesyce hypericifolia* (Euphorbiaceae, 11.09.2017, central municipal gardens Funchal, 32° 38′ 52.05″ N, 16° 54′ 40.07″ W, 28 m *a.s.l.*). The locality corresponds to the Mediterranean macrobioclimate, inframediterranean dry series (May-Ol). There is no indication that this wild bee species established populations on Madeira Island.

Megachile (Megachile) versicolor Smith, 1844

- **Status**: Introduced?.
- **Literature**: Alfken (1940), Fellendorf *et al*. (1999), Kratochwil *et al*. (2018).
- **Specimens analysed**: 3♀♀, 4♂♂.
- **Distribution, habitat characteristics, and flower-visiting behaviour** (Figs. 40 and 41, Table 17): There are only observations of flower visits of 2♂♂: *Oenanthe divaricata* (Apiaceae), *Echium candicans* (Boraginaceae). According to Scheuchl & Willner (2016), the species is polylectic in Central Europe.
- **Flight time**: The species was observed in July and August.

- **Data from the authors** (3♀♀, 2♂♂): ***cJS***: 2♂♂, Parque Ecológico, near Poço da Neve, 1,634 m *a.s.l.*, 32° 43′ 32.87″ N, 16° 55′ 29.69″ W, 11.07.1997, leg. J. Smit; 3♀♀, Parque Ecológico, near Poço da Neve, 1,634 m *a.s.l.*, 32° 43′ 32.87″ N, 16° 55′ 29.69″ W, 11.07.1997, leg. J. Smit.
- **Further checked data** (2♂♂): Boieiro, M.: 1♂, Folhadal, 948 m *a.s.l.*, 32° 45′ 32.56″ N, 17° 01′ 23.81″ W, July 2017, leg. M. Boieiro; 1♂, Pico do Areeiro, 1,800 m *a.s.l.*, 32° 43′ 8″ N, 16° 54′ 31″ W, July 2017, leg. M. Boieiro.

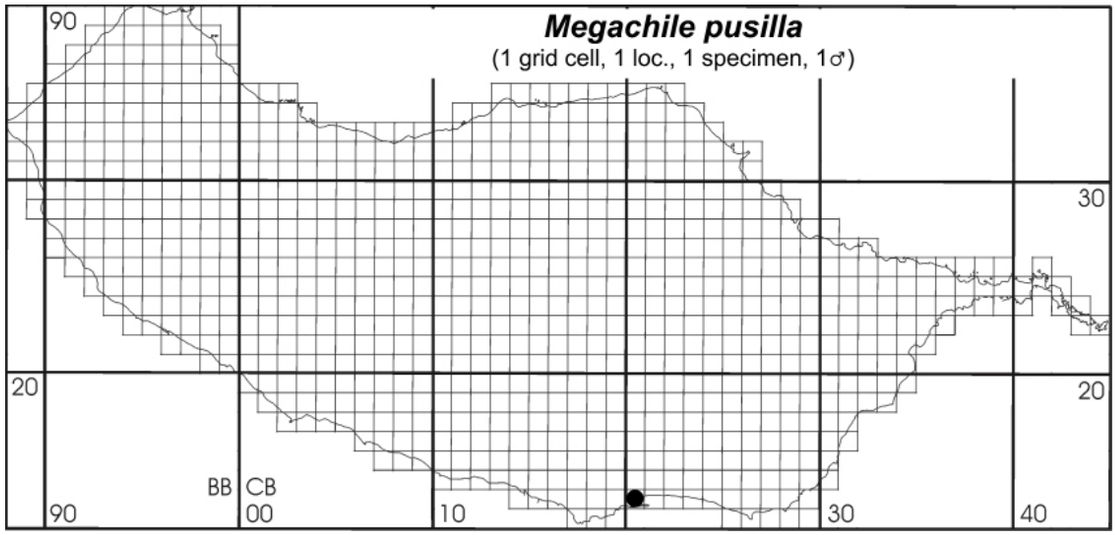

Fig. 39 – Detection of *Megachile pusilla* (black dot: data of M. Andrade, checked by C. Praz).

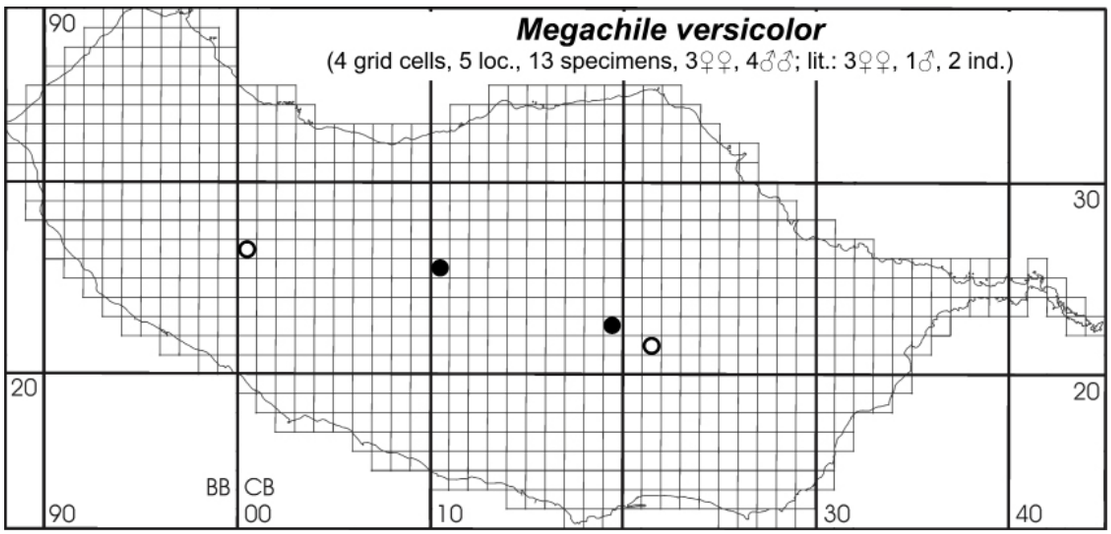

Fig. 40 – Detections of *Megachile versicolor* (black dots: authors' data and checked specimens; circles: literature data).

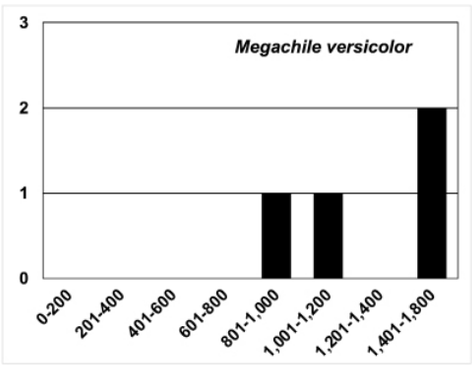

Fig. 41 – Number of localities with *Megachile versicolor* detections per altitude level (m *a.s.l.*).

Table 17 – Presence of *Megachile versicolor* in square-grid cells of different vegetation series.

Vegetation series		Presence %, absolute
May-Ol	a	-
Hel-Si	b	-
Sem-Ap 1	c	-
Sem-Ap 2	d	-
Cle-Oc	e	1%
Pol-Er	f	**6%**
Arm-Pa	g	2

- **Data from literature** (3♀♀, 1♂, 2 ind.): Alfken (1940): 3♀♀, 1♂, Rabaçal, 1,066 m *a.s.l.*, 32° 45′ 39.71″ N, 17° 08′ 4.78″ W, 17.07.-04.08.1935, leg. O. Lundblad; Costa (2019): 1 ind., Pico do Areeiro, 1,800 m *a.s.l.*, 32° 44′ N, 16° 55′ 47″ W, leg. R. Costa; 1 ind., Pico do Areeiro, 1,500 m *a.s.l.*, 32° 43′ 8″ N, 16° 54′ 31″ W, leg. R. Costa.

Osmia (Helicosmia) madeirensis Van der Zanden, 1991

- **Status**: Endemic to Madeira Island (Figs. 42 and 43).

- **Literature**: van der Zanden (1983), van der Zanden (1991), Fellendorf *et al*. (1999), Kratochwil *et al*. (2018).

- **Specimens analysed**: 87♀♀, 57♂♂.

- **Distribution, habitat characteristics, and flower-visiting behaviour** (Figs. 44 and 45, Tables 18 and 19): *Osmia madeirensis* shows an especially high presence in the lower subhumid vegetation series b). It is mainly the Mediterranean series [a) to d)] that is populated. Coastal rocks and ruderal sites, including fallows and road margins, are the main habitats. *Osmia madeirensis* shows a preference for Asteraceae (five plant families were recorded overall, but nearly only Asteraceae for females). Endemic (*Andryala glandulosa* subsp. *glandulosa*) and native plant species (*e.g.*, *Crepis vesicaria*, *Leontodon taraxacoides* subsp. *longirostris*) play an important role as pollen and nectar resources in the coastal-rock sites. Further species such as *Galactites tomentosa*, *Sonchus asper*, and *S. oleraceus* are used in ruderal sites.

- **Flight time**: Flight-activity data exist from February (first observation 5th February) to July (latest observation 16th July), with high abundances in May and April.

Fig. 42 – *Osmia madeirensis* (female), collecting pollen on the introduced plant species *Hypochoeris radicata* (above Porto Moniz, 28.03.2022; [vegetation series e)]. Photo A. Kratochwil.

Fig. 43 – *Osmia madeirensis* (female, sideview) with antlerlike structures on the broad plate of the insect's head ('clypeus'); same site and date as Fig. 42. Photo A. Kratochwil.

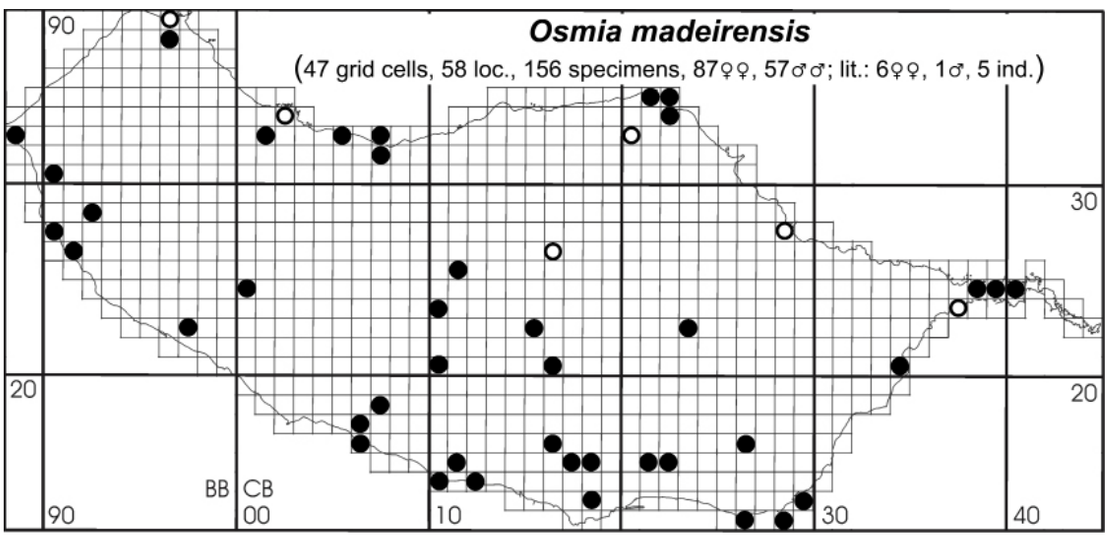

Fig. 44 – Detections of *Osmia madeirensis* (black dots: authors' data, checked specimens of collections; circles: literature data).

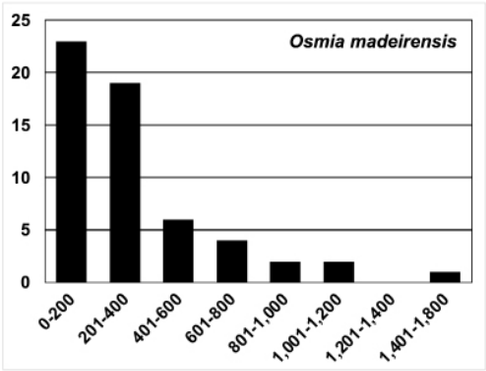

Fig. 45 – Number of localities with *Osmia madeirensis* detections per altitude level (m *a.s.l.*).

Table 18 – Presence of *Osmia madeirensis* in square-grid cells of different vegetation series.

Vegetation series		Presence %
May-Ol	a	29%
Hel-Si	b	**53%**
Sem-Ap 1	c	32%
Sem-Ap 2	d	20%
Cle-Oc	e	10%
Pol-Er	f	6%
Arm-Pa	g	-

Table 19 – Plant-species spectrum visited by *Osmia madeirensis*.

Plant species, plant families		Status	n
Andryala glandulosa subsp. *glandulosa*	Ast	end	8♀♀, 1♂
Argyranthemum pinnatifidum s.l.	Ast	end	1♂
Calendula arvensis	Ast	nat	1♂
Calendula maderensis	Ast	end	1♂
Calendula officinalis	Ast	intr	1♀
Crepis andryaloides	Ast	end	1♂
Crepis vesicaria	Ast	nat	6♀♀, 4♂♂
Galactites tomentosa	Ast	nat	11♀♀, 6♂♂
Gazzania sp.	Ast	intr	1♂
Helichrysum foetidum	Ast	intr	1♀
Helminthotheca echioides	Ast	nat?	2♀♀
Hypochoeris radicata	Ast	intr	1♀
Leontodon taraxacoides subsp. *longirostris*	Ast	nat	14♀♀, 10♂♂
Sonchus asper	Ast	nat?	1♀
Sonchus oleraceus	Ast	nat?	4♀♀, 2♂♂
Sonchus sp.	Ast	-	1♂
Urospermum picroides	Ast	nat?	3♀♀
Echium plantagineum	Bor	nat	1♂
Raphanus r. subsp. *raphanistrum*	Bra	nat	1♂
Bituminaria bituminosa	Fab	nat	1♀,♂
Rubus ulmifolius	Ros	nat	1♂

- **Data from the authors** (74♀♀, 47♂♂): ***cAK*** (46♀♀, 32♂♂): 1♀, 1♂, Ponta de São Lourenço, above Ponta do Buraco, 71 m *a.s.l.*, 32° 44′ 35.16″ N, 16° 42′ 01.06″ W, 10.04.1995, leg. K/S; 3♀♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 13.04.1995, leg. K/S; 1♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 24.03.2005, leg. K/S; 1♂, Ribeira Brava, Miradouro Pico da Cruz, 54 m *a.s.l.*, 32° 40′ 09.25′′ N, 17° 03′ 46.32′′ W, 25.03.2005, leg. K/S; 1♂, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 26.03.2005, leg. K/S; 1♀, 3♂♂, Serra de Água, lookout point, 465 m *a.s.l.*, 32° 43′ 50.79″ N, 17° 01′ 26.59″ W, 27.03.2005, leg. K/S; 1♂, Eirinha above Serra de Água, 506 m *a.s.l.*, 32° 43′ 54.22″ N, 17° 01′ 30.19″ W, 27.03.2005, leg. K/S; 3♂♂, Cabo Girão, S Quinta Grande, 603 m *a.s.l.*, 32° 39′ 27.08″ N, 17° 00′ 23.91″ W, 28.03.2005, leg. K/S; 1♂, Fajã dos Padres, W Quinta Grande, 325 m *a.s.l.*, 32° 39′ 21.12″ N, 17° 01′ 04.44″ W, 28.03.2005, leg. K/S; 1♀, 1♂, Câmara do Bispo, S Quinta Grande, 316 m *a.s.l.*, 32° 39′ 17.50″ N, 17° 01′ 02.02″ W, 28.03.2005, leg. K/S; 1♀, Fajã dos Padres, W Quinta Grande, 325 m *a.s.l.*, 32° 39′ 21.12″ N, 17° 01′ 04.44″ W, 28.03.2005, leg. K/S; 1♂, Ponta da Garajau, S Caniço, 112 m *a.s.l.*, 32° 38′ 18.33″ N, 16° 51′ 02.84″ W, 29.03.2005, leg. K/S; 1♂, W Ponta do Garajau, S Caniço, 82 m *a.s.l.*, 32° 38′ 23.20″ N, 16° 51′ 13.01″ W, 30.03.2005, leg. K/S; 1♂, Ponta da Garajau, S Caniço, 112 m *a.s.l.*, 32° 38′ 18.33″ N, 16° 51′ 02.84″ W, 01.04.2005, leg. K/S; 11♀♀, 3♂♂, Ribeira Brava in front of tunnel entrance, 44 m *a.s.l.*, 32° 40′ 29.71″ N, 17° 03′ 51.75″ W, 02.04.2005, leg. K/S; 2♂♂, Ponta do Pargo, near lighthouse, 345 m *a.s.l.*, 32° 48′ 50.16″ N, 17° 15′ 30.24″ W, 03.04.2005, leg. K/S; 2♀♀; E Ribeira da Janela, old road between Ribeira da Janela – Ribeiro Escuro, 17 m *a.s.l.*, 32° 48′ 59.01″ N, 17° 05′ 4.72″ W, 03.04.2005, leg. K/S; 1♂, W S. Vicente, old road between Ribeiro do Inferno – Ribeiro dos Caimbos, 10 m *a.s.l.*, 32° 48′ 33.51″ N, 17° 03′ 24.31″ W, 03.04.2005, leg. K/S; 1♂, E Seixal, old road between Ilhéu das Ceroulas – Ribeira de João Delgado, 51 m *a.s.l.*, 32° 48′ 37.15″ N, 17° 03′ 37.41″ W, 03.04.2005, leg. K/S; 9♂♂, W S. Vicente, ER 101, Fajã do Rente, 75 m *a.s.l.*, 32° 48′ 29.57″ N, 17° 03′ 05.00″ W, 03.04.2005, leg. K/S; 1♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 03.04.2005, leg. K/S; 15♀♀, Ponta de São Lourenço, 101 m *a.s.l.*, 32° 44′ 44.01″ N, 16°43′20.74″W, 04.04.2005, leg. K/S; 7♀♀, Ponta dos Reis Magos, SE Caniço, 14 m *a.s.l.*, 32° 38′ 55.50″ N, 16° 49′ 22.06″ W, 04.04.2005, leg. K/S; 1♂, Ponta S. Jorge, viewpoint above Barranco, 295 m *a.s.l.*, 32° 50′ 03.02″ N, 16° 54′ 41.05″ W, 06.04.2005, leg. K/S; 1♀, above P. Moniz, 379 m *a.s.l.*, 32° 51′ 40.5″ N, 17° 10′ 32.2″ W, 28.03.2022, leg. K/S; 1♀, Funchal, Jardim Botânico, 281 m *a.s.l.*, 32° 39′ 45.9′′ N, 16° 53′ 47.2′′ W, 29.03.2022, leg. K/S. ***cFA*** (3♀♀, 1♂): 2♀♀, Ribeira Brava, Miradouro Pico da Cruz, 54 m *a.s.l.*, 32° 40′ 09.25′′ N, 17° 03′ 46.32′′ W, 30.04.1989, leg. F. Aguiar; 1♂, Ribeira das Galinhas, Paúl do Mar, 50 m *a.s.l.*, 32° 45′ 58.86″ N, 17° 14′ 09.35″ W, 01.04.2004, leg. Aguiar / Jesus;

1♀, Farol, Ponta do Pargo, 248 m *a.s.l.*, 32° 48′ 39.26′′ N, 17° 15′ 34.01′′ W, 08.06.2004, leg. Aguiar / Jesus. ***cJS*** (21♀♀, 14♂♂): 1♀, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 10.07.1997, leg. J. Smit; 1♀, Fontes, 1,124 m *a.s.l.*, 32° 42′ 33.11“ N, 17° 00′ 57.13“ W, 16.07.1997, leg. J. Smit; 1♀, 1♂, Funchal, Pico das Romeiras, 423 m *a.s.l.*, 32° 39′ 47.94″ N, 16° 56′ 47.61″ W, 01.04.1998, leg. J. T. Smit; 2♂♂, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 03.04.1998, leg. J. T. Smit; 1♀, 1♂, Ponta de São Lourenço, 77 m *a.s.l.*, 32° 44′ 36.05″ N, 16° 42′ 01.91″ W, 17.04.1998, leg. J. T. Smit; 2♀♀, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32° 39′ 31.00″ N, 16° 56′ 22.00″ W, 25.04.1998, leg. J. T. Smit; 2♀♀, Água de Pena, 57 m *a.s.l.*, 32° 42′ 33.48″ N, 16° 45′ 44.40″ W, 03.05.1998, leg. J. Smit; 4♀♀, 3♂♂, Ponta do Pargo, 322 m *a.s.l.*, 32° 48′ 44.56″ N, 17° 15′ 38.36″ W, 05.05.1998, leg. J. Smit; 1♂, Lombada do Loreto, NE Arco de Calheta, 358 m *a.s.l.*, 32° 43′ 12.71″ N, 17° 09′ 35.85″ W, 05.05.1998, leg. J. T. Smit; 1♀, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32° 39′ 31.00″ N, 16° 56′ 22.00″ W, 12.05.1998, leg. J. T. Smit; 4♂♂, Ponta do Pargo, 322 m *a.s.l.*, 32° 48′ 44.56″ N, 17° 15′ 38.36″ W, 19.05.1998, leg. J. T. Smit; 1♂, Chão da Ribeira, Seixal, 433 m *a.s.l.*, 32° 48′ 33.25″ N, 17° 06′ 55.52″ W, 19.05.1998, leg. J. T. Smit; 5♀♀, Ribeira Brava, 125 m *a.s.l.*, 32° 40′ 32.04″ N, 17° 03′ 55.92″ W, 21.05.1998, leg. J. T. Smit; 3♀♀, Santa Quitéria, W São Martinho, 195 m *a.s.l.*, 32° 38′ 45.89″ N, 16° 56′ 24.79″ W, 31.05.1998, leg. J. T. Smit; 1♂, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 07.06.1998, leg. J. T. Smit. ***oFA*** (4♀♀): 1♀, Lombada dos Marinheiros, gravel road, 683 m *a.s.l.*, 32° 47′ 28.88′′ N, 17° 13′ 57.09′′ W, 08.06.2004, obs. F. Aguiar; 1♀, Ponta de São Lourenço, 500 m NW Prainha beach, 71 m *a.s.l.*, 32º 44′ 42.83′′ N, 16º 43′ 08.52′′ W, 19.04.2007, obs. F. Aguiar; 2♀♀, Farol to Cais de S. Jorge, 80 m *a.s.l.*, 32º 50′ 00.03′′ N, 16º 54′ 03.87′′ W, 21.06.2007, obs. F. Aguiar.

- **Data from collections** (13♀♀, 10♂♂): ***ICLAM*** (7♀♀, 4♂♂): 1♂, Ribeira das Galinhas, Paúl do Mar, 50 m *a.s.l.*, 32° 45′ 58.86′′ N, 17° 14′ 09.35′′ W, 01.04.2004, leg. J. Jesus; 2♀♀, Farol, Ponta do Pargo, 248 m *a.s.l.*, 32° 48′ 39.26′′ N, 17° 15′ 34.01′′ W, 08.06.2004, leg. Aguiar / Jesus; 1♀, Eira do Serrado, Pico do Serrado, 955 m *a.s.l.*, 32° 42′ 25.14′′ N, 16° 57′ 35.72′′ W, 17.06.2004, leg. Aguiar / Jesus; 1♀, Ribeirinha, Camacha, 649 m *a.s.l.*, 32° 40′ 20.95′′ N, 16° 50′ 50.97′′ W, 05.05.2005, leg. Aguiar / Jesus; 1♀, Prainha, Ponta de São Lourenço, Caniçal, 71 m *a.s.l.*, 32º 44′ 42.83′′ N, 16º 43′ 08.52′′ W, 26.04.2007, leg. Aguiar / Jesus; 1♂, Ribeiro Frio, garden, 1,166 m *a.s.l.*, 32º 43′ 47.70′′ N, 16º 53′ 01.23′′ W, 17.05.2007, leg. Aguiar / Jesus; 2♀♀, Farol to Cais de S. Jorge, 30 m *a.s.l.*, 32º 49′ 49.90′′ N, 16º 53′ 56.05′′ W, 21.06.2007, leg. J. Jesus; 1♂, Cabo Girão, 526 m *a.s.l.*, 32° 39′ 24.19″ N, 17° 0′ 10.58″ W, 16.04.2008, leg. C. Brazão; 1♂, Caminho de São Lourenço, 1.85 km NE Fajã da Ovelha church, 773 m *a.s.l.*, 32º 46′ 47.02′′ N, 17º 12′ 45.08′′ W, 19.05.2011, leg. F. Aguiar. ***OLML*** (3♀♀, 2♂♂): 1♀, Ribeira Brava, Miradouro Pico da Cruz, 54 m *a.s.l.*, 32° 40′ 09.25′′ N, 17° 03′ 46.32′ W, 02.05.??, leg. R. Storå; 2♀♀, 1♂, Ribeira Brava, Miradouro Pico da Cruz, 54 m *a.s.l.*, 32° 40′ 09.25′′ N, 17° 03′ 46.32′′ W, 15.03.1989, leg. J. A. W. Lucas; 1♂, Funchal, 310 m *a.s.l.*, 32° 40′ 0.96″ N, 16° 55′ 26.6″ W, 13.03.1989, leg. J. A. W. Lucas. ***UMB*** (2♀♀, 4♂♂): 1♂, Boca da Encumeada – Boca dos Corgos, 993 m *a.s.l.*, 32° 45′ 15.52″ N, 17° 01′ 7.80″ W, 30.05.1987, leg. W. Barkemeyer; 1♀, 2♂♂, Jardim do Mar, 50 m *a.s.l.*, 32° 44′ 18.64″ N, 17° 12′ 40.44″ W, 02.04.1994, leg. H. Hohmann; 1♂, Curral das Freiras, 600 m *a.s.l.*, 32° 43′ 11.82“ N, 16° 58′ 0.66“ W, 13.04.1994, leg. H. Hohmann; 2♀♀, Ribeira Brava, 50 m *a.s.l.*, 32° 41′ 6.29“ N, 17° 3′ 5.38“ W, 11.04.1994, leg. H. Hohmann.

- **Data from literature** (6♀♀, 1♂, 5 ind.): van der Zanden (1983): 1♀, 1♂, Funchal, 310 m *a.s.l.*, 32° 40′ 0.96“ N, 16° 55′ 26.6“ W, 10.04.1970, leg. G. van der Zanden; van der Zanden (1991): 4♀♀, Caniçal, 33 m *a.s.l.*, 32° 44′ 20.68“ N, 16° 44′ 17.61“ W, 28.05.1989, leg. H. G. Teunissen; 1♀, Funchal, 310 m *a.s.l.*, 32° 40′ 0.96“ N, 16° 55′ 26.6“ W, 10.04.1970, leg. W. Hoogenes; Fellendorf *et al.* (1999), 1 ind., Port Moniz, 40 m *a.s.l.*, 32° 52′ 0.06“ N, 17° 10′ 14.19“ W, leg. Fellendorf *et al.*; 1 ind., Seixal, 115 m *a.s.l.*, 32° 49′ 26.41“ N, 17° 6′ 33.53“ W, leg. Fellendorf *et al.*; 1 ind., Caniço, 164 m *a.s.l.*, 32° 38′ 53.92″ N, 16° 50′ 8.73″ W, leg. Fellendorf *et al.*; 1 ind., Porto da Cruz, 147 m *a.s.l.*, 32° 45′ 51.09″ N, 16° 49′ 41.74″ W, leg. Fellendorf *et al.*; 1 ind., João Frino, 1,589 m *a.s.l.*, 32° 45′ 38.56″ N, 16° 57′ 34.09″ W, leg. Fellendorf *et al.* Due to the lack of differentiation (number of individuals per locality, characterisation ‘female, male’), only one individual is counted per locality (n = 5 ind.).

Osmia (Helicosmia) niveata (Fabricius, 1804)

- **Status**: Native (Fig. 46).
- **Literature**: Fellendorf *et al.* (1999), Kratochwil *et al.* (2018).

Fig. 46 – *Osmia niveata* (male), taking nectar from the native plant species *Centranthus calcitrapae* (coast E S. Vicente near Fajã da Areia, 27.03.2022); vegetation series d). Photo A. Kratochwil.

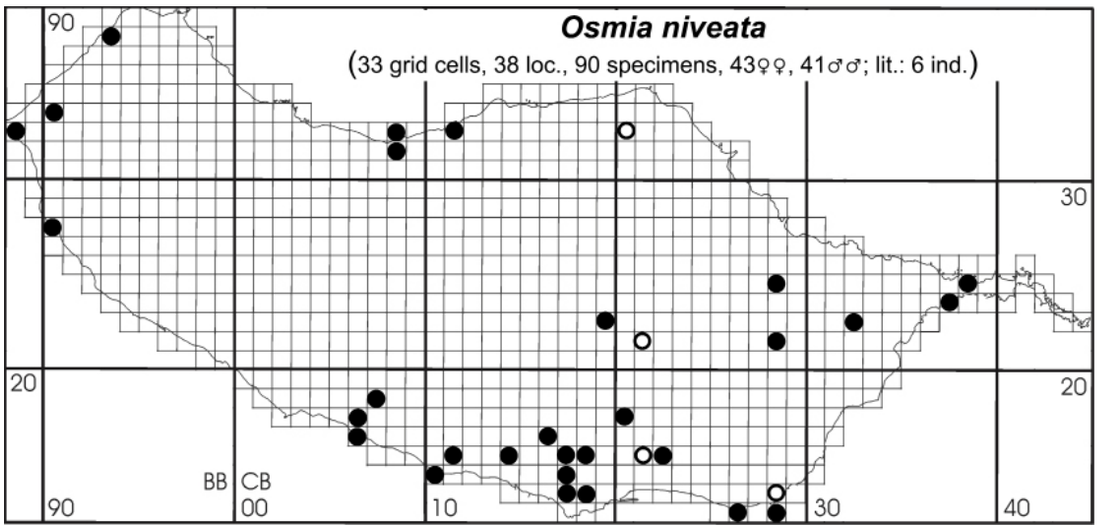

Fig. 47 – Detections of *Osmia niveata* (black dots: authors' data, checked specimens of collections; circles: literature data).

- **Specimens analysed**: 43♀♀, 41♂♂.

- **Distribution, habitat characteristics, and flower-visiting behaviour** (Figs. 47 and 48, Tables 20 and 21): *Osmia niveata* occurs mainly in the dry to subhumid vegetation series a), b), c). Ruderal sites are especially characteristic, as are, locally, coastal rocks. The flower resources are nearly exclusively Asteraceae, especially ruderal plant species (*e.g.*, *Galactites tomentosa*). We observed 11 females and 12 males (Table 21). Oligolectic behaviour has been documented in Central Europe (Scheuchl & Willner, 2016), especially for Carduoideae s.l.

- **Flight time**: Flight-activity data exist from February (first observation 7th February) to July (latest observation 9th July), with high abundances in March and April.

Table 20 – Presence of *Osmia niveata* in square-grid cells of different vegetation series.

Vegetation series		Presence %, absolute
May-Ol	a	24%
Hel-Si	b	**41%**
Sem-Ap 1	c	32%
Sem-Ap 2	d	13%
Cle-Oc	e	2%
Pol-Er	f	6%
Arm-Pa	g	1

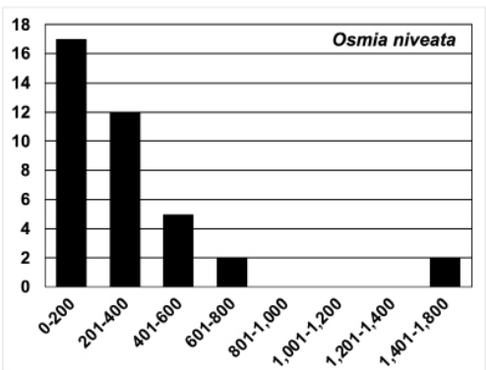

Fig. 48 – Number of localities with *Osmia niveata* detections per altitude level (m *a.s.l.*).

Table 21 – Plant-species spectrum visited by *Osmia niveata*.

Plant species, plant families		Status	n
Andryala sp.	Ast	-	1♂
Bidens pilosa	Ast	intr	1♂
Calendula officinalis	Ast	intr	1♂
Crepis andryaloides	Ast	end	1♂
Crepis vesicaria	Ast	nat	2♂♂
Galactites tomentosa	Ast	nat	9♀♀, 1♂
Leontodon taraxacoides subsp. *longirostris*	Ast	nat	2♀♀
Sonchus asper	Ast	nat?	2♂♂
Echium nervosum	Bor	end	2♂♂
Centhrantus calcitrapae	Val	nat	1♂

- **Data from the authors** (30♀♀, 31♂♂): ***cAK*** (11♀♀, 16♂♂): 2♀♀, Arco da Calheta, ER 101, 333 m *a.s.l.*, 32° 42′ 22.13″ N, 17° 08′ 22.47″ W, 08.04.1995, leg. K/S; 2♀♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 13.04.1995, leg. K/S; 1♂, Ribeira Brava, Miradouro Pico da Cruz, 54 m *a.s.l.*, 32° 40′ 09.25′′ N, 17° 03′ 46.32′′ W, 25.03.2005, leg. K/S; 2♂♂, Ponta de São Lourenço, 101 m *a.s.l.*, 32° 44′ 44.01″ N, 16° 43′ 20.74″ W, 26.03.2005, leg. K/S; 2♂♂, Ribeira Brava in front of tunnel entrance, 44 m *a.s.l.*, 32° 40′ 29.71″ N, 17° 03′ 51.75″ W, 27.03.2005, leg. K/S; 2♀♀, Cabo Girão, S Quinta Grande, 603 m *a.s.l.*, 32° 39′ 27.08″ N, 17° 00′ 23.91″ W, 28.03.2005, leg. K/S; 1♀, Câmara do Bispo, S Quinta Grande, 316 m *a.s.l.*, 32° 39′ 17.50″ N, 17° 01′ 02.02″ W, 28.03.2005, leg. K/S; 4♀♀, Funchal, in front of Jardim Botânico, 277 m *a.s.l.*, 32° 39′ 41.27″ N, 16° 53′ 41.25″ W, 30.03.2005, leg. K/S; 1♂, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 30.03.2005, leg. K/S; 1♂, Ponta do Garajau, S Caniço, 112 m *a.s.l.*, 32° 38′ 18.33″ N, 16° 51′ 02.84″ W, 02.04.2005, leg. K/S; 1♂, Archadas da Cruz, Miradouro Vereda do Calhau, 470 m *a.s.l.*, 32° 51′ 07.88″ N, 17° 12′ 36.20″ W, 03.04.2005, leg. K/S; 4♂♂, E S. Vicente, near Fajã da Areia, 21 m *a.s.l.*, 32° 48′ 40.3″ N, 17° 02′ 34.4″ W, 27.03.2022, leg. K/S; 1♂, below leftside valley of S. Vicente, 54 m *a.s.l.*, 32° 48′ 16.4″ N, 17° 02′ 51.4″ W, 27.03.2022, leg. K/S; 1♂, E S. Vicente, near Fajã da Areia, 22 m *a.s.l.*, 32° 48′ 40.3′′ N, 17° 02′ 34.4′′ W, 28.03.2022, leg. K/S; 1♂, Funchal, Jardim Botânico, 281 m *a.s.l.*, 32° 39′ 45.9′′ N, 16° 53′ 47.2′′ W, 29.03.2022, leg. K/S; 1♂, W Miradouro Quebradas, 33 m *a.s.l.*, 32° 49′ 02.1′′ N, 17° 00′ 45.3′′ W, 31.03.2022, leg. K/S. ***cFA***: 1♀, Preces, Câmara de Lobos, 179 m *a.s.l.*, 32° 39′ 37.11′′ N, 16° 58′ 49.56′′ W, 09.03.2000, leg. Aguiar / Jesus. ***cJS*** (18♀♀, 15♂♂): 2♀♀, Funchal, Jardim Botânico, 264 m *a.s.l.*, 32° 39′ 43.23″ N, 16° 53′ 48.10″ W, 09.07.1997, leg. J. Smit; 5♂♂, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32° 39′ 31.00″ N, 16° 56′ 22.00″ W, 07.02.1998, leg. J. T. Smit; 2♀♀, 1♂, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 16.02.1998, leg. J. T. Smit; 1♀, 1♂, Funchal, Pico das Romeiras, 423 m *a.s.l.*, 32° 39′ 47.94″ N, 16° 56′ 47.61″ W, 21.02.1998, leg. J. T. Smit; 1♀, 1♂, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 24.02.1998, leg. J. T. Smit; 3♀♀, 2♂♂, Funchal, Pico das Romeiras, 423 m *a.s.l.*, 32° 39′ 47.94″ N, 16° 56′ 47.61″ W, 01.03.1998, leg. J. T. Smit; 1♀, 1♂, Funchal, Pico das Romeiras, 423 m *a.s.l.*, 32° 39′ 47.94″ N, 16° 56′ 47.61″ W, 07.03.1998, leg. J. T. Smit; 1♀, Funchal, Pico das Romeiras, 423 m *a.s.l.*, 32° 39′ 47.94″ N, 16° 56′ 47.61″ W, 01.04.1998, leg. J. T. Smit; 4♀♀, 1♂, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 03.04.1998, leg. J. T. Smit; 1♂, Boa Morte, 483 m *a.s.l.*, 32° 49′ 08.83″ N, 17° 14′ 13.73″ W, 05.05.1998, leg. J. Smit; 1♀, Ponta do Pargo, 322 m *a.s.l.*, 32° 48′ 44.56″ N, 17° 15′ 38.36″ W, 05.05.1998, leg. J. Smit; 1♀, 2♂♂, Paúl do Mar, 150 m *a.s.l.*, 32° 45′ 59.16″ N, 17° 13′ 59.29″ W, 05.05.1998, leg. J. Smit; 1♀, Ponta do Pargo, 322 m *a.s.l.*, 32° 48′ 44.56″ N, 17° 15′ 38.36″ W, 19.05.1998, leg. J. T. Smit.

- **Data from collections** (13♀♀, 9♂♂): ***ICLAM***: 1♀, Cabo Girão, above car parking, 587 m *a.s.l.*, 32° 39′ 24.92′′ N, 17° 00′ 23.10′′ W, 09.05.2002, leg. Aguiar / Jesus. ***MZHF*** (9♀♀, 7♂♂): 1♂, Funchal, Santo Amaro – Fajã, 300 m *a.s.l.*, 32° 39′ 25.20″ N, 16° 56′ 38.40″ W, 19.04.1995, leg. M. Koponen; 1♂, São Martinho, 184 m *a.s.l.*, 32° 38′ 39.78″ N, 16° 56′ 29.68″ W, 12.03.1980, leg. M. Koponen; 9♀♀, 5♂♂, Funchal, Pico da Cruz, 224 m *a.s.l.*, 32° 38′ 31.20″ N, 16° 56′ 16.80″ W, 22.03.1980, leg. M. Koponen. ***UMB*** (3♀♀, 1♂): 1♀, 1♂, Corujeira, 550 m *a.s.l.*, 32° 40′ 36.74″ N, 16° 54′ 38.12″ W, 14.03.1989, leg. J. A. W. Lucas; 1♀, Machico, 230 m *a.s.l.*, 32° 43′ 54.41″ N, 16° 47′ 28.76″ W, 14.05.1989, leg. J. A. W. Lucas; 1♀, Ribeira Brava, Miradouro, 59 m *a.s.l.*, 32° 40′ 10.85″ N, 17° 03′ 45.66″ W, 10.04.1994, leg. H. Hohmann; 1♂, Ribeira Brava, 115 m *a.s.l.*, 32° 41′ 31.56″ N, 17° 02′ 54.60″ W, 31.03.1994, leg. H. Hohmann.

- **Data from literature** (6 ind.): Costa (2019): 1 ind., Pico do Areeiro, 1,800 m *a.s.l.*, 32° 44′ N, 16° 55′ 47″ W, leg. R. Costa; 1 ind., Pico do Areeiro, 1,500 m *a.s.l.*, 32° 43′ 8″ N, 16° 54′ 31″ W; Fellendorf *et al*. (1999): 1 ind., Caniço, 164 m *a.s.l.*, 32° 38′ 53.92″ N, 16° 50′ 8.73″ W, leg. Fellendorf *et al*.; 1 ind. Caniçal, 33 m *a.s.l.*, 32° 44′ 20.68″ N, 16° 44′ 17.61″ W, leg. Fellendorf *et al.;* 1 ind., Funchal, 310 m *a.s.l.*, 32° 40′ 0.96″ N, 16° 55′ 26.6″ W, leg. Fellendorf *et al*., 1 ind., Reis Magos, 20 m *a.s.l.*, 32° 38′ 50.17″ N, 16° 49′ 29.19″ W. leg. Fellendorf *et al*. Due to the lack of differentiation (number of individuals per locality, characterisation 'female, male'), only one individual is counted per locality (n = 4 ind.).

- **Further checked data**: Santos, R.: 1♂, Portela, 640 m *a.s.l.*, 32° 48′ 29.79″ N, 16° 51′ 56.77″ W, 03.07.2017, leg. R. Santos.

Stelis (Stelis) ornatula (Klug, 1807)

- **Status**: Introduced.

- **Literature**: Fellendorf *et al*. (1999), Kratochwil *et al*. (2018).

- **Specimens analysed**: 1♀.

- **Distribution, habitat characteristics, and flower-visiting behaviour** (Fig. 49): *Stelis ornatula* has so far been found only in one grid cell (1♀, Fontes, 1,200 m *a.s.l.*, 16.07.1997, leg. J. Smit); see comments on *Hoplites acuticornis*.

Anthophoridae

Amegilla (Amegilla) quadrifasciata maderae (Sichel 1868)

- **Status**: Subspecies endemic to the Madeira Archipelago. A differentiation as a subspecies seems

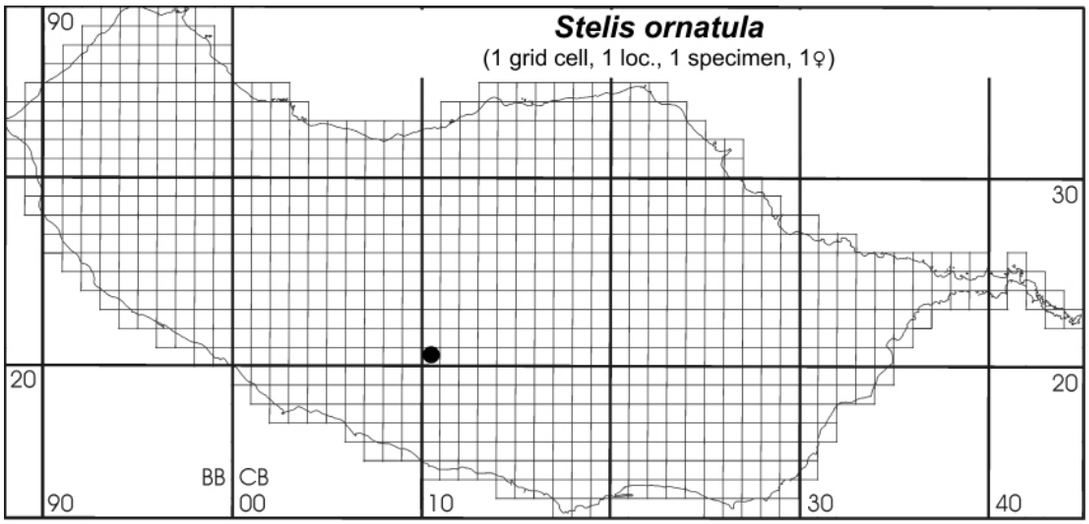

Fig. 49 – Detection of *Stelis ornatula* (black dot: data of J. Smit).

justified due to the characteristic morphological features; molecular investigations are in progress (Kratochwil, *in prep.*). Figs. 50-52.

- **Literature**: Sichel (1867), Fellendorf *et al*. (1999), Kratochwil *et al*. (2018).

- **Specimens analysed**: 102♀♀, 67♂♂.

- **Distribution, habitat characteristics, and flower-visiting behaviour** (Figs. 53 and 54, Tables 22 and 23): *Amegilla q. maderae* is a typical bee species mainly of the dry, lower subhumid vegetation series [a), b)]. Some observations were also made at higher altitudes. Intensive flower visits were observed on the two *Echium* species: *E. plantagineum* and especially *E. nervosum*. Coastal rocky sites with *E. nervosum* are very typical habitats. The same is true for *E. nervosum* planted in gardens or near roads. The endemic *E. nervosum* is an extraordinary important pollen and nectar resource for this polylectic species. On Porto Santo, *E. nervosum* is also a key species for *A. q. maderae*. In the higher mountains, the species has been detected visiting the endemic *E. candicans* (restoration site with microclimatic favourable conditions, Costa, 2019). All in all, the polylectic species visited flowers of nine plant families. Herrera (1990) found a flower visitation rate of 29.6 flowers per minute for *A. quadrifasciata* (*Lavandula latifolia* in southern Spain). The species' fast flight, regular approach to single flowering plants within a collecting home range, and its hovering in front of the flowers (Fig. 50) are remarkable. The males patrol the flowers and nesting sites in search of females.

In Central Europe (Scheuchl & Willner, 2016) as well as on the Canary Islands, *A. quadrifasciata* s.l. is a polylectic species. In the Canary Islands, Hohmann *et al*. (1993); Becerra (1992); García (2000) found 18 plant families visited by this wild bee species.

- **Flight time and nesting sites**: *A. q. maderae* flies year-round. We have detections from all months except October and November. These exceptions are probably due to a lack of collecting activity. Often, the endogeic colonies of *A. q. maderae* are found close to *E. nervosum* stands in the cliff areas. Near Ribeira Brava, particularly high flight activity was observed by the authors at nesting sites (05.04.1995, 29.12.2006). It was also observed in May and September (Fellendorf *et al*., 1999). Numerous nests were found on eroded paths (Fig. 52).

There is one observation of a sleeping aggregation (males) in Madeira Island (publication in preparation).

Fig. 50 – *Amegilla quadrifasciata maderae* (female), with a humming bird-like approach to *Echium nervosum* flowers. Ribeira Brava, Miradouro do Pico da Cruz, 25.03.2005; vegetation series a). Photo A. Kratochwil.

Fig. 51 – *Amegilla quadrifasciata maderae* (female): flower visit to *Echium nervosum*. Ponta de São Lourenço, coastal rocky site, 02.04.2022; vegetation series b). Photo A. Kratochwil.

Fig. 52 – Nesting site of *Amegilla quadrifasciata maderae* in December. Overlook (the line marks the micro area of nesting holes) and inset picture of one hole. Ribeira Brava, Miradouro do Pico da Cruz, 29.12.2006; vegetation series a). Photo: A. Schwabe.

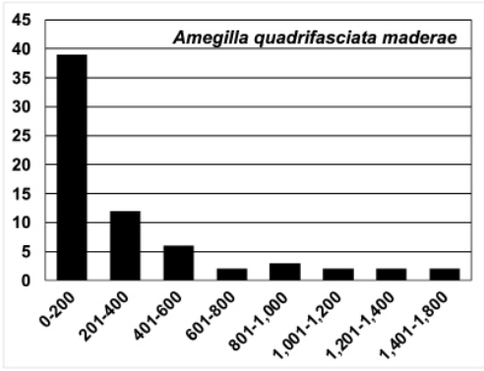

Fig. 54 – Number of localities with *Amegilla quadrifasciata maderae* detections per altitude level (m *a.s.l.*).

Table 22 – Presence of *Amegilla quadrifasciata maderae* in square-grid cells of different vegetation series.

Vegetation series		Presence %, absolute
May-Ol	a	**71%**
Hel-Si	b	59%
Sem-Ap 1	c	21%
Sem-Ap 2	d	30%
Cle-Oc	e	8%
Pol-Er	f	13%
Arm-Pa	g	1

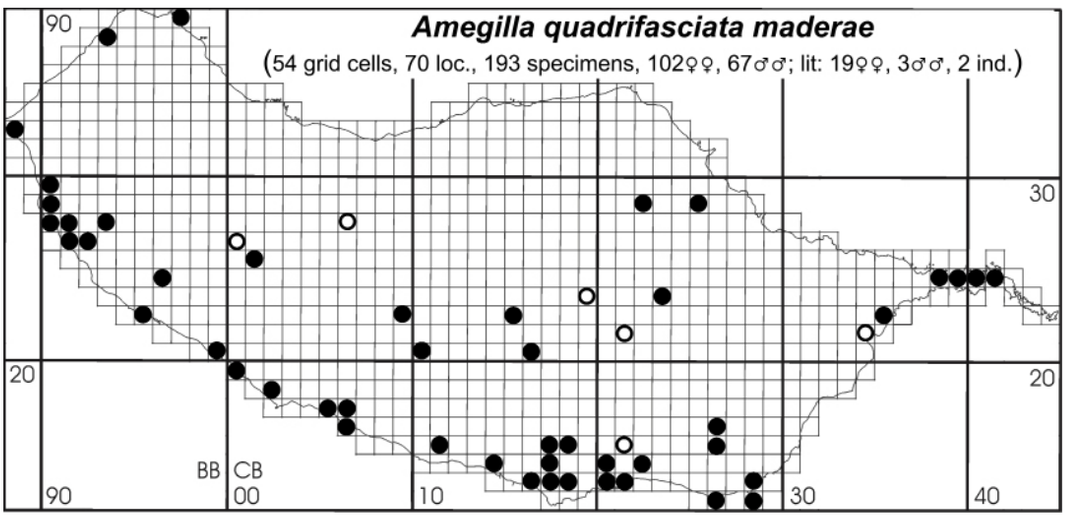

Fig. 53 – Detections of *Amegilla quadrifasciata maderae* (black dots: authors' data, checked specimens of collections; circles: literature data).

Table 23 – Plant-species spectrum visited by *Amegilla quadrifasciata maderae*.

Plant species, plant families		Status	n
Aptenia cordifolia	Aiz	nat	1♀
Carlina salicifolia	Ast	mac	1♀
Galactites tomentosa	Ast	nat	2♀♀, 7♂♂
Leontodon taraxacoides subsp. *longirostris*	Ast	nat	1♂
Tagetes sp.	Ast	intr	1♂
Echium candicans	Bor	end	3♂♂, 2 ind.
Echium nervosum	Bor	end	31♀♀, 5♂♂
Echium plantagineum	Bor	nat	6♀♀, 1♂
Rapistrum rugosum s.l.	Bra	nat	2♀♀
Sinapidendron angustifolium	Bra	end	2♀♀
Sechium edule	Cuc	int	2♀♀
Bituminaria bituminosa	Fab	nat	3♀♀, 1♂
Stachys ocymastrum	Lam	nat	4♀♀, 4♂♂
Misopates orontium	Scr	nat	1♀
Lantana camara	Ver	intr	1♂
Verbena bonariensis	Ver	intr	1♀, 4♂♂

- **Data from the authors** (87♀♀, 49♂♂): ***cAK*** (39♀♀, 17♂♂): 1♀, 1♂, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 02.04.1995, leg. K/S; 1♀, Ribeira Brava, Miradouro Pico da Cruz, 54 m *a.s.l.*, 32° 40′ 09.25′′ N, 17° 03′ 46.32′′ W, 05.04.1995, leg. K/S; 1♀, 2♂♂, Ribeira Brava, Miradouro Pico da Cruz, 54 m *a.s.l.*, 32° 40′ 09.25′′ N, 17° 03′ 46.32′′ W, 05.04.1995, leg. K/S; 1♀, Ponta do Garajau, S Caniço, 112 m *a.s.l.*, 32° 38′ 18.33″ N, 16° 51′ 02.84″ W, 07.04.1995, K/S; 2♂♂, Arco da Calheta, ER 101, 333 m *a.s.l.*, 32° 42′ 22.13″ N, 17° 08′ 22.47″ W, 08.04.1995, leg. K/S; 1♂, Pico do Facho, Machico, 266 m *a.s.l.*, 32° 43′ 22.49′′ N, 16° 45′ 30.60′′ W, 10.04.1995, leg. K/S; 2♂♂, Ponta de São Lourenço, above Ponta do Buraco, 71 m *a.s.l.*, 32° 44′ 35.16″ N, 16° 42′ 01.06″ W, 10.04.1995, leg. K/S; 2♀♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 11.04.1995, K/S; 1♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 13.04.1995, leg. K/S; 1♀, Ribeira Brava, Miradouro Pico da Cruz, 54 m *a.s.l.*, 32° 40′ 09.25′′ N, 17° 03′ 46.32′′ W, 25.03.2005, leg. K/S; 3♀♀, Cais, E Madalena do Mar, ER 213, 11 m *a.s.l.*, 32° 41′ 34.43″ N, 17° 07′ 29.24″ W, 25.03.2005, leg. K/S; 1♂, Cais, E Madalena do Mar, ER 213, 11 m *a.s.l.*, 32° 41′ 34.43″ N, 17° 07′ 29.24″ W, 25.03.2005, leg. K/S; 2♂♂, Câmara do Bispo, S Quinta Grande, 316 m *a.s.l.*, 32° 39′ 17.50″ N, 17° 01′ 02.02″ W, 28.03.2005, leg. K/S; 1♂, Fajã dos Padres, W Quinta Grande, 325 m *a.s.l.*, 32° 39′ 21.12″ N, 17° 01′ 04.44″ W, 28.03.2005, leg. K/S; 1♂, Cabo Girão, S Quinta Grande, 603 m *a.s.l.*, 32° 39′ 27.08″ N, 17° 00′ 23.91″ W, 28.03.2005, leg. K/S; 2♀♀, W Ponta do Garajau, S Caniço, 82 m *a.s.l.*, 32° 38′ 23.20″ N, 16° 51′ 13.01″ W, 30.03.2005, leg. K/S; 1♀, W Ribeira Brava, Ribeira da Caldeira, E 213, 37 m *a.s.l.*, 32° 40′ 25.21″ N, 17° 04′ 09.99″ W, 02.04.2005, leg. K/S; 2♀♀, Reservatório do Paúl do Mar, above Paúl do Mar, ER 212, 107 m *a.s.l.*, 32° 45′ 51.92″ N, 17° 13′ 50.32″ W, 28.12.2006, leg. K/S; 3♀♀, petrol station, E Ponta da Sol, 27 m *a.s.l.*, 32° 40′ 35.91″ N, 17° 04′ 36.98″ W, 29.12.2006, leg. K/S; 3♀♀, Calheta, 38 m *a.s.l.*, 32° 43′ 18.43″ N, 17° 10′ 43.70″ W, 03.01.2007, leg. K/S; 1♀, E Calheta, above Paúl do Mar, ER 212, 411 m *a.s.l.*, 32° 44′ 15.10″ N, 17° 10′ 15.91″ W, 03.01.2007, leg. K/S; 1♀, Ribeira das Galinhas, Paúl do Mar, 50 m *a.s.l.*, 32° 45′ 58.86″ N, 17° 14′ 09.35″ W, 03.01.2007, leg. K/S; 1♀, P. Moniz, 20 m *a.s.l.*, 32° 52′ 00.3″ N, 17° 09′ 58.7″ W, 28.03.2022, leg. K/S; 1♀, 4♂♂, Ribeira Brava, 60 m *a.s.l.*, 32° 40′ 11.8′′ N, 17° 03′ 45.5′′ W, 29.03.2022, leg. K/S; 3♀♀, Ribeira Brava, 60 m *a.s.l.*, 32° 40′ 11.8′′ N, 17° 03′ 45.5′′ W, 01.04.2022, leg. K/S; 10♀♀, São Lourenço, 54 m *a.s.l.*, 32° 44′ 36.5′′ N, 16° 43′ 21.8′′ W, 02.04.2022, leg. K/S. ***cFA*** (5♀♀, 4♂♂): 1♂, Pico das Pedras, garden of main house, 924 m *a.s.l.*, 32° 46′ 38.50′′ N, 16° 53′ 48.97′′ W, 14.08.1985, leg. F. Aguiar; 1♀, Ribeira Brava, Miradouro Pico da Cruz, 54 m *a.s.l.*, 32° 40′ 09.25′′ N, 17° 03′ 46.32′′ W, 30.04.1989, leg. F. Aguiar; 1♀, Achadas da Cruz, Porto Moniz, 514 m *a.s.l.*, 32° 51′ 03.74′′ N, 17° 12′ 33.69′′ W, 19.09.1989, leg. F. Aguiar; 1♂, Areeiro, São Martinho, 159 m *a.s.l.*, 32° 38′ 47.11′′ N, 16° 57′ 26.71′′ W, 30.03.1992, leg. F. Aguiar; 1♀, Areeiro, São Martinho, 159 m *a.s.l.*, 32° 38′ 47.11′′ N, 16° 57′ 26.71′′ W, 04.05.1992, leg. F. Aguiar; 1♀, Pico da Urze, Paúl da Serra, 1,334 m *a.s.l.*, 32° 44′ 57.40′′ N, 17° 07′ 16.04′′ W, 23.08.1997, leg. F. Aguiar; 1♂, Funchal, Lombo da Boa Vista, 176 m *a.s.l.*, 32° 39′ 18.97′′ N. 16° 53′ 38.56′′ W, 15.05.1999, leg. F. Aguiar; 1♂, Quebrada, Paúl do Mar, 50 m *a.s.l.*, 32° 45′ 11.85′′ N, 17° 13′ 28.74′′ W, 09.01.2000, leg. Aguiar / Jesus; 1♀, Amparo, Funchal, 162 m *a.s.l.*, 32° 38′ 44.74′′ N, 16° 56′ 37.06′′ W, 25.05.2004, leg. J. Jesus; ***cJS*** (16♀♀, 22♂♂): 1♂, Funchal, 24 m *a.s.l.*, 32° 38′ 42.72′′ N, 16° 54′ 49.93″ W, 23.02.1995, leg. H. H. Evenhuis; 1♀, 1♂, Funchal, 24 m *a.s.l.*, 32° 38′ 42.72′′ N, 16° 54′ 49.93″ W, 05.03.1995, leg. H. H. Evenhuis; 2♀♀, 5♂♂, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32° 39′ 31.00′′ N, 16° 56′ 22.00″ W, 07.07.1997, leg. J. Smit; 1♀, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32° 39′ 31.00′′ N, 16° 56′ 22.00″ W, 09.07.1997, leg. J. Smit; 1♂, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32° 39′ 31.00′′ N, 16° 56′ 22.00″ W, 13.07.1997, leg. J. Smit; 1♀, 1♂, Lombada dos Marinheiros, 578 m *a.s.l.*, 32° 47′ 16.13′′ N, 17° 14′ 18.83″ W, 15.07.1997, leg. J. Smit; 1♀, Fontes, 1,124 m *a.s.l.*, 32° 42′ 33.11′′ N, 17° 00′ 57.13″ W, 16.07.1997, leg. J. Smit; 1♀, 3♂♂, Ponta de São Lourenço, 77 m *a.s.l.*, 32° 44′ 36.05″ N, 16° 42′ 01.91″ W, 27.02.1998, leg. J. T. Smit; 3♀♀, Ponta de São Lourenço, 77 m *a.s.l.*, 32° 44′ 36.05′′ N, 16° 42′ 01.91″ W, 23.03.1998, leg. J. T. Smit; 1♀, Funchal, Pico das Romeiras, 423 m *a.s.l.*, 32° 39′ 47.94′′ N, 16° 56′ 47.61″ W, 23.04.1998, leg. J. T. Smit; 1♀, Ribeira Brava, 125 m *a.s.l.*, 32° 40′ 32.04′′ N, 17° 03′ 55.92″ W, 01.05.1998, leg. J. Smit; 1♀, Ponta de São Lourenço, 77 m *a.s.l.*, 32° 44′ 36.05′′ N, 16° 42′ 01.91″ W, 02.05.1998, leg. J. Smit; 1♂, Câmara de Lobos, 174 m *a.s.l.*, 32° 39′ 6.75′′ N, 16° 58′ 22.17″ W, 03.05.1998, leg. J. Smit; 1♀, 1♂, Faial, 191 m *a.s.l.*, 32° 46′ 58.10′′ N, 16° 51′ 35.00″

W, 04.05.1998, leg. J. Smit; 1♀, 1♂, Ponta do Pargo, 322 m *a.s.l.*, 32° 48′ 44.56′′ N, 17° 15′ 38.36″ W, 05.05.1998, leg. J. Smit; 1♀, 7♂♂, S Zimbreiros, SE Caniço, 105 m *a.s.l.*, 32° 38′ 58.26″ N; 16° 49′ 55.10″ W, 15.06.1998, leg. J. T. Smit. ***oFA*** (3♀♀, 6♂♂): 1♂, Preces, Agricultural Station, Câmara de Lobos, 124 m *a.s.l.*, 32° 39′ 20.53′′ N, 16° 58′ 35.57′′ W, 16.06.1998, obs. F. Aguiar; 1♂, Ponta de São Lourenço, track between Baia d'Abra and Casa do Sardinha, 54 m *a.s.l.*, 32° 44′ 45.29′ 'N, 16° 41′ 15.48′′ W, 30.5.1999, obs. F. Aguiar; 1♂, Ponta do Pargo, Miradouro do Fio, Terra Chã, 362 m *a.s.l.*, 32° 48′ 34.76′′ N, 17° 15′ 24.19′′ W, 08.06.2004, obs. F. Aguiar; 1♀, Ponta de São Lourenço, 500 m NW of Prainha beach, 72 m *a.s.l.*, 32º 44′ 43.40′′ N, 16º 43′ 09.07′′ W, 19.04.2007, obs. F. Aguiar; 1♀, 1♂, Funchal, Rua Lombo da Boa Vista, 175 m *a.s.l.*, 32° 39′ 19.25′′ N, 16° 53′ 38.04′′ W, 02.08.2008, obs. F. Aguiar; 1♂, Funchal, Rua Lombo da Boa Vista, 175 m *a.s.l.*, 32° 39′ 19.25′′ N, 16° 53′ 38.04′′ W, 30.08.2008, obs. F. Aguiar; 1♂, Funchal, Rua Lombo da Boa Vista, 175 m *a.s.l.*, 32° 39′ 19.25′′ N, 16° 53′ 37.92′′ W, 11.10.2008, obs. F. Aguiar; 1♀, Prazeres to Paúl do Mar, vereda near Jardim Atlântico Hotel, 427 m *a.s.l.*, 32° 45′ 15.70′′ N, 17° 13′ 05.29′′ W, 17.09.2009, obs. F. Aguiar. ***oKS*** (24♀♀): 1♀, W Ponta do Sol, between Livramento and Anjos, 38 m *a.s.l.*, 32° 40′ 56.30″ N, 17° 06′ 31.87″ W, 25.03.2005, obs. K/S; 1♀, Ponta de São Lourenço, 101 m *a.s.l.*, 32° 44′ 44.01″ N, 16° 43′ 20.74″ W, 26.03.2005, obs. K/S; 1♀, Cabo Girão, S Quinta Grande, 603 m *a.s.l.*, 32° 39′ 27.08″ N, 17° 00′ 23.91″ W, 28.03.2005, obs. K/S; 3♀♀, W Ribeira Brava, Ribeira da Caldeira, E 213, 37 m *a.s.l.*, 32° 40′ 25.21″ N, 17° 04′ 09.99″ W, 02.04.2005, obs. K/S; 12♀♀, Ribeira Brava, Miradouro Pico da Cruz, 54 m *a.s.l.*, 32° 40′ 09.25′′ N, 17° 03′ 46.32′′ W, 29.12.2006, obs. K/S; 1♀, Restaurante 'O Precipício', Fajã da Ovelha, 375 m *a.s.l.*, 32° 46′ 13.89″ N, 17° 14′ 05.42″ W, 28.12.2006, obs. K/S; 4♀♀, petrol station, E Ponta da Sol, 27 m *a.s.l.*, 32° 40′ 35.91″ N, 17° 04′ 36.98″ W, 29.12.2006, obs. K/S; 1♀, Ponta de São Lourenço, 56 m *a.s.l.*, 32° 44′ 36.74″ N, 16° 43′ 22.04″ W, 31.12.2006, obs. K/S.

- **Data from collections** (15♀♀, 18♂♂): ***ICLAM*** (3♀♀, 7♂♂): 1♂, Curral das Freiras, land belonging to Comissão de levadas, 525 m *a.s.l.*, 32° 43′ 33.47′′ N, 16° 58′ 05.17′′ W, 27.05.1999, leg. Aguiar / Jesus; 1♀, Ribeirinha, Camacha, 649 m *a.s.l.*, 32° 40′ 20.95′′ N, 16° 50′ 50.97′′ W, 21.06.1999, leg. Aguiar / Jesus; 2♀♀, Ribeira Brava, Miradouro Pico da Cruz, 54 m *a.s.l.*, 32° 40′ 09.25′′ N, 17° 03′ 46.32′′ W, 10.02.2000, leg. Aguiar / Jesus; 1♂, Ribeira das Galinhas, Paúl do Mar, 50 m *a.s.l.*, 32° 45′ 58.86′′ N, 17° 14′ 09.35′′ W, 01.04.2004, leg. J. Jesus; 3♂♂, Eira do Serrado, Pico do Serrado, 955 m *a.s.l.*, 32° 42′ 25.14′′ N, 16° 57′ 35.72′′ W, 17.06.2004, leg. Aguiar / Jesus; 2♂♂, lighthouse (Farol), Ponta do Pargo, 185 m *a.s.l.*, 32º 48′ 37.34′′ N, 17º 15′ 33.43′′ W, 10.07.2008, leg. C. Brazão. ***MZHF*** (12♀♀, 11♂♂): 2♀♀, 1♂, Serra d'Água, 325 m *a.s.l.*, 32° 43′ 33.60′′ N, 17° 01′ 37.20′′ W, 16.07.-19.07.1957, leg. H. Lindberg; 1♀, 1♂, Terrenos de Santa Luzia. 61 m *a.s.l.*, 32° 39′ 13.36′ ,N, 16° 54′ 42.34′′ W, 21.07.1957, leg. H. Lindberg; 1♂, Ribeiro Frio, 926 m *a.s.l.*, 32° 44′ 02.40′′ N, 16° 53′ 09.60′′ W, 14.05.1959, leg. H. Lindberg; 2♀♀, 1♂, Funchal, Pico da Cruz, 224 m *a.s.l.*, 32° 38′ 16.71′′ N, 16° 55′ 50.85′′ W, 18.03.1980, leg. M. Koponen; 1♀, Funchal, Pico da Cruz, 224 m *a.s.l.*, 32° 38′ 16.71′′ N, 16° 55′ 50.85′′ W, 20.03.1980, leg. M. Koponen; 1♂, Funchal, 10 m *a.s.l.*, 32° 38′ 31.20′′ N, 16° 56′ 16.80′′ W, 15.04.1990, leg. M. Koponen; 1♂, Ribeira Brava, 30 m *a.s.l.*, 32° 40′ 12.00′′ N, 17° 03′ 50.40′′ W, 19.04.1990, leg. M. Koponen; 1♀, Funchal, Lido, 17 m *a.s.l.*, 32° 38′ 9.49″ N, 16° 55′ 58.77″ W, 18.12.1994, M. Koponen; 4♀♀, 4♂♂, Funchal, Amparo – Quebradas, 150 m *a.s.l.*, 32° 38′ 45.78′′ N, 16° 56′ 58.13′′ W, 16.04.1995, leg. M. Koponen; 1♀, 1♂, Funchal, Santo Amaro – Fajã, 300 m *a.s.l.*, 32° 39′ 35.20′′ N, 16° 56′ 38.40′′ W, 19.04.1995, leg. M. Koponen.

- **Data from literature** (19♀♀, 3♂♂, 2 ind.): Alfken (1940): 1♀, 2♂♂, Machico, 10 m *a.s.l.*, 32° 43′ 05.58″ N, 16° 45′ 48.59″ W, 12.07.1935, leg. O. Lundblad; 1♀, Caramujo, 1,273 m *a.s.l.*, 32° 46′ 20.49″ N, 17° 03′ 46.44″ W, 06.-14.08.1935, leg. O. Lundblad; 8♀♀, Funchal, 310 m *a.s.l.*, 32° 40′ 0.96″ N, 16° 55′ 26.6″ W, 11.07.-15.07.1935, leg. O. Lundblad; 9♀♀, 1♂, Rabaçal, 1,069 m *a.s.l.*, 32° 45′ 39.71″ N, 17° 08′ 4.78″ W, 17.07.-04.08.1935, leg. O. Lundblad; Costa (2019): 1 ind. Pico do Areeiro, 1, 500 m *a.s.l.*, 32° 43′ 8″ N, 16° 54′ 31″ W, leg. R. Costa; 1 ind., area Pico do Areeiro, 1,800 m *a.s.l.*, 32° 44′ N, 16° 55′ 47″ W, leg. R. Costa.

Apidae

Bombus (Megabombus) r. ruderatus (Fabricius, 1775)

- **Status**: Introduced?, Fig. 55.

- **Literature**: Fabricius (1775), Fellendorf *et al.* (1999), Kratochwil *et al.* (2018).

Fig. 55 – *Bombus r. ruderatus* (queen), visiting the native *Bituminaria bituminosa* in ruderal vegetation. Ponta de São Lourenço, roadside, 02.04.2022; vegetation series b). Photo. A. Kratochwil.

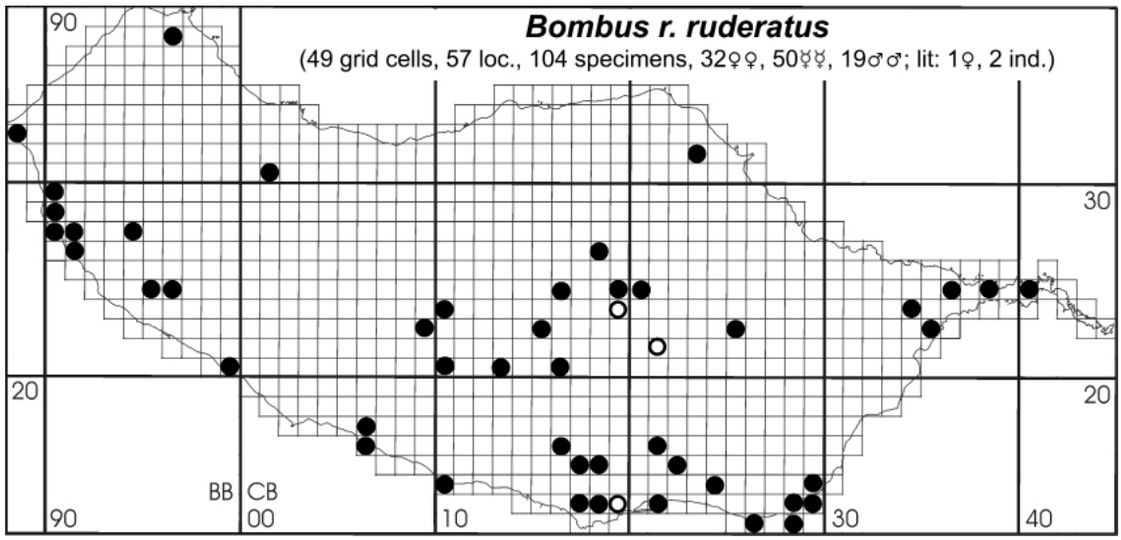

Fig. 56 – Detections of *Bombus r. ruderatus* (black dots: authors' data, checked specimens of collections; circles: literature data).

- **Specimens analysed**: 32♀♀, 50☿☿, 19♂♂.

- **Distribution, habitat characteristics, and flower-visiting behaviour** (Figs. 56 and 57, Tables 24 and 25): *Bombus r. ruderatus* shows main occurrences in the Mediterranean dry to subhumid vegetation series a), b), c). *Bombus r. ruderatus* was detected in half of all grid cells in series a). Coastal rocks, ruderal sites, and gardens are among the habitat types. The polylectic species (detection of 14 plant families) with a long proboscis was observed on many different plant species, as well as on ornamental species in gardens with deep flower tubes (*e.g.* 'Azalea' *Rhododendron* sp.).

- **Flight time**: *Bombus r. ruderatus* flies year-around. We have detections from all months with the exceptions of February, October, and November.

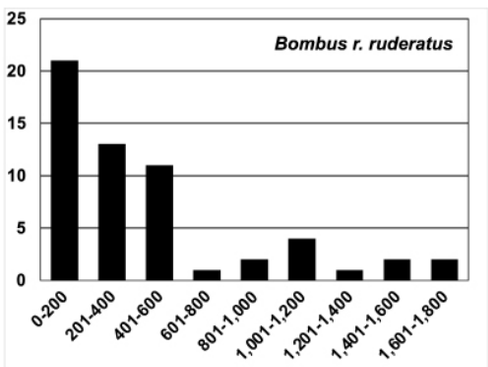

Fig. 57 – Number of localities with *Bombus r. ruderatus* detections per altitude level.

Table 24 – Presence of *Bombus r. ruderatus* in square-grid cells of different vegetation series.

Vegetation series		Presence %, absolute
May-Ol	a	**48%**
Hel-Si	b	35%
Sem-Ap 1	c	38%
Sem-Ap 2	d	15%
Cle-Oc	e	10%
Pol-Er	f	6%
Arm-Pa	g	2

Table 25 – Plant-species spectrum visited by *Bombus r. ruderatus*.

Plant species, plant families		Status	n
Arctium minus	Ast	nat	1 ind.
Galactites tomentosa	Ast	nat	1♀, 1☿
Borago officinalis	Bor	intr	1 ind.
Echium candicans	Bor	end	2 ind.
Echium nervosum	Bor	end	1♀, 4☿☿, 2♂♂
Echium plantagineum	Bor	nat	1♀, 2☿☿
Opuntia tuna	Cac	intr	1♀
Cucurbita pepo	Cuc	cult	1☿
Ipomoea purpurea	Cuc	intr	1♀, 1☿
Rhododendron sp. ('Azalea')	Eri	cult	1♀
Bituminaria bituminosa	Fab	nat	5♀♀, 8☿☿
Lathyrus clymenum	Fab	nat	1♀
Trifolium sp.	Fab	-	1 ind.
Vicia benghalensis	Fab	nat	1☿
Vicia lutea	Fab	nat	1♀
Stachys ocymastrum	Lam	nat	1♀, 1☿
Agapanthus praecox	Lil	cult	1 ind.
Hibiscus sp.	Mal	cult	6♀♀
Bougainvillea majus	Nyc	cult	1 ind.
Papaver rhoeas	Pap	nat	2☿☿
Rubus ulmifolius	Ros	nat	1♂, 1☿
Tropaeolum majus	Tro	intr	1 ind.
Digitalis purpurea	Scr	nat	2♀♀

- **Data from the authors** (26♀♀, 39☿☿, 12♂♂): ***cAK*** (18♀♀, 9☿☿, 1♂♂): 1♀, Arco da Calheta, ER 101, 333 m *a.s.l.*, 32° 42′ 22.13″ N, 17° 08′ 22.47″ W, 08.04.1995, leg. K/S; 1♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 11.04.1995, leg. K/S; 1♀, 2☿☿, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 13.04.1995, leg. K/S; 1♀, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 24.03.2005, leg. K/S; 1☿, Ribeira Brava, Miradouro Pico da Cruz, 54 m *a.s.l.*, 32° 40′ 09.25′′ N, 17° 03′ 46.32′′ W, 25.03.2005, leg. K/S; 1☿, Ponta de São Lourenço, above Rochinha, 78 m *a.s.l.*, 32° 44′ 40.19″ N, 16° 43′ 22.21″ W, 26.03.2005, leg. K/S; 1♀, Ponta de São Lourenço, 101 m *a.s.l.*, 32° 44′ 44.01″ N, 16° 43′ 20.74″ W, 26.03.2005, leg. K/S; 1♀, Fajã dos Padres, W. Quinta Grande, 325 m *a.s.l.*, 32° 39′ 21.12″ N, 17° 01′ 04.44″ W, 28.03.2005, leg. K/S; 1☿, Funchal, in front of Jardim Botânico, 277 m *a.s.l.*, 32° 39′ 41.27″ N, 16° 53′ 41.25″ W, 30.03.2005, leg. K/S; 1♀, Ribeira Brava, in front of tunnel entrance, 44 m *a.s.l.*, 32° 40′ 29.71″ N, 17° 03′ 51.75″ W, 02.04.2005, leg. K/S; 2♀♀, Serra de Água, lookout point, 465 m *a.s.l.*, 32° 43′ 50.79″ N, 17° 01′ 26.59″ W, 02.04.2005, leg. K/S; 2☿☿, Ponta dos Reis Magos, SE Caniço, 14 m *a.s.l.*, 32° 38′ 55.50″ N, 16° 49′ 22.06″ W, 04.04.2005, leg. K/S; 1♀, Restaurante 'O Precipício', Fajã da Ovelha, 375 m *a.s.l.*, 32° 46′ 13.89″ N, 17° 14′ 05.42″ W, 28.12.2006, leg. K/S; 1♀, above Paúl do Mar, ER 212, Reservatório do Paúl do Mar, 67 m *a.s.l.*, 32° 45′ 49.96″ N, 17° 13′ 51.95″ W, 31.12.2006, leg. K/S; 3♀♀, Paúl do Mar, near Aparthotel, 35 m *a.s.l.*, 32° 45′ 57.20″ N, 17° 14′ 8.47″ W, 01.01.2007, leg. K/S; 2☿☿, Este de Calheta, above Paúl do Mar, ER 212, 411 m *a.s.l.*, 32° 44′ 15.10″ N, 17° 10′ 15.91″ W, 03.01.2007, leg. K/S; 3♀♀, Paúl do Mar, near Aparthotel, 35 m *a.s.l.*, 32° 45′ 57.20″ N, 17° 14′ 8.47″ W, 03.01.2007, leg. K/S; 1♂, Ribeira Brava, near the river mouth, 60 m a.s.l., 32° 40′ 11.8′′ N, 17° 03′ 45.5′′ W, 29.03.2022, leg. K/S; 1♀, São Lourenço, 66 m *a.s.l.*, 32° 44′ 38.0′′ M, 16° 43′ 32.6′′ W, 02.04.2022, leg. K/S. ***cFA*** (1♀, 3♂♂): 1♂, Posto Agrário do Pico, Santana, 419 m *a.s.l.*, 32° 48′ 27.67′′ N, 16° 53′ 11.23′′ W, 20.07.1998, leg. F. Aguiar; 1♂, Jardim da Serra, 500 m before Boca da Corrida, 1,079 m *a.s.l.*, 32° 42′ 17.68′′ N, 16° 59′ 12.68′′ W, 10.09.1998, leg. Aguiar / Jesus; 1♂, Fajã dos Cardos, Curral das Freiras, 762 m *a.s.l.*, 32° 44′ 36.72′′ N, 16° 57′ 49.62′′ W, 07.9.2001, leg. Aguiar / Jesus; 1♀, Boca da Corrida, above forest services post, 1,216 m *a.s.l.*, 32° 42′ 36.75′′ N, 16° 59′ 13.65′′ W, 17.09.2001, leg. D. Erber. ***cJS*** (2♀♀, 18☿☿, 6♂♂): 2♂♂, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32° 39′ 31.00″ N, 16° 56′ 22.00″ W, 07.07.1997, leg. J. Smit; 1☿, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32° 39′ 31.00″ N, 16° 56′ 22.00″ W, 09.07.1997, leg. J. Smit; 1☿, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32° 39′ 31.00″ N, 16° 56′ 22.00″ W, 13.07.1997, leg. J. Smit; 1☿, Lombada dos Marinheiros, 578 m *a.s.l.*, 32° 47′ 16.13″ N, 17° 14′ 18.83″ W, 15.07.1997. leg. J. Smit; 1♀, Fontes, 1,124 m *a.s.l.*, 32° 42′ 33.11″ N, 17° 00′ 57.13″ W, 16.07.1997, leg. J. Smit; 2☿☿, Funchal, Pico das Romeiras, 423 m *a.s.l.*, 32° 39′ 47.94″ N, 16° 56′ 47.61″ W, 01.03.1998, leg. J. T. Smit; 1♂, Funchal, Pico das Romeiras, 423 m *a.s.l.*, 32° 39′ 47.94″ N, 16° 56′ 47.61″ W, 28.03.1998, leg. J. T. Smit; 1♀, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 03.04.1998, leg. J. T. Smit; 1☿, Funchal, Pico das Romeiras, 423 m *a.s.l.*, 32° 39′ 47.94″ N, 16° 56′ 47.61″ W, 22.04.1998, leg. J. T. Smit; 1☿, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32° 39′ 31.00″ N, 16° 56′ 22.00″ W, 25.04.1998, leg. J. T. Smit; 1☿, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32° 39′ 31.00″ N, 16° 56′ 22.00″ W, 30.04.1998, leg. J. T. Smit; 2♂♂, Caniçal, 86 m *a.s.l.*, 32° 44′ 31.98″ N, 16° 44′ 39.84″ W, 02.05.1998, leg. J. Smit; 1☿, Palheiro Ferreiro, NW São Gonçalo, 505 m *a.s.l.*, 32° 39′ 15.75″ N, 16° 52′ 17.22″ W, 06.05.1998. leg. J. Smit; 2☿☿, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32° 39′ 31.00″ N, 16° 56′ 22.00″ W, 12.05.1998, leg. J. T. Smit; 7☿☿, 1♂, S Zimbreiros, SE Caniço, 105 m *a.s.l.*, 32° 38′ 58.26″ N, 16° 49′ 55.10″ W, 15.06.1998, leg. J. T. Smit. ***oFA*** (5♀♀, 2♂♂, 2 ind.): 1 ind., Chão da Ribeira, Seixal, 517 m *a.s.l.*, 32° 47′ 44.24′ 'N, 17° 06′ 52.97′′ W, 20.06.1996, obs. F. Aguiar; 1 ind., Curral das Freiras, land belonging to Comissão de levadas, 525 m *a.s.l.*, 32° 43′ 33.47′′ N, 16° 58′ 05.17′′ W, 16.04.1998, obs. F. Aguiar; 1♀, Pico do Facho, Machico, 266 m *a.s.l.*, 32° 43′ 22.49′′ N, 16° 45′ 30.60′′ W, 12.06.2003, obs. F. Aguiar; 1♀, Caniço, near Pico da Atalaia, 17 m *a.s.l.*, 32° 39′ 02.76′ 'N, 16° 49′ 04.85′′ W, 29.05.2005, obs. F. Aguiar; 1♂, Reis Magos, near Atalaia peak, 31 m *a.s.l.*, 32° 39′ 04.50′′ N, 16° 49′ 03.06′′ W, 29.05.2005, obs. F. Aguiar; 1♀, Santo da Serra, dirt road to Pico do Suna, 1,118 m *a.s.l.*, 32° 43′ 44.51′′ N, 16° 51′ 25.34′′ W, 20.09.2007, obs. F. Aguiar; 1♂, Caniçal, 135 m *a.s.l.*, 32° 44′ 55.44′′ N, 16° 42′ 24.15′′ W, 05.6.2008, obs. F. Aguiar; 1♀, road from Paúl da Serra to Prazeres, 860 m *a.s.l.*, 32° 46′ 04.08′′ N, 17° 11′ 24.81′′ W, 24.06.2010, obs. F. Aguiar; 1♀, Caniçal, dirt road, 390 m *a.s.l.*, 32° 44′ 25.01′′ N, 16° 45′ 43.11′′ W, 12.01.2012, obs. F. Aguiar. ***oKS*** (12☿☿): 1☿, Ponta do Garajau, S Caniço, 112 m *a.s.l.*, 32° 38′ 18.33″ N, 16° 51′ 02.84″ W, 28.03.2005, obs. K/S; 2☿☿, Ponta do Pargo, near lighthouse, 345 m *a.s.l.*, 32° 48′ 50.16″ N, 17° 15′ 30.24″ W, 03.04.2005, obs. K/S; 1☿, above Porto Moniz, 407 m *a.s.l.*, 32° 51′ 35.12″ N, 17° 10′ 26.56″ W, 03.04.2005, obs. K/S; 8☿☿, Ponta dos Reis Magos, SE Caniço, 14 m *a.s.l.*, 32° 38′ 55.50″ N, 16° 49′ 22.06″ W, 04.04.2005, obs. K/S.

- **Data from collections** (6♀♀, 11☿☿, 7♂♂): ***ICLAM*** (2♀♀, 1☿, 1♂): 1☿, Jardim da Serra, 500 m before Boca da Corrida, 1,079 m *a.s.l.*, 32° 42′ 17.68′ N, 16° 59′ 12.68′′ W, 27.08.1998, leg. Aguiar / Jesus; 1♀, Montado do Sabugal, above Fajã da Nogueira, 825 m *a.s.l.*, 32° 44′ 47.39′′ N, 16° 54′ 43.99′′ W, 17.07.2003, leg. Aguiar / Jesus; 1♂ Boca da Corrida, below miradouro, 1,152 m *a.s.l.*, 32° 42′ 39.43′′ N, 16° 59′ 07.37′′ W, 16.08.2004, leg. Aguiar / Jesus; 1♀, Vereda Pico do Areeiro to Pico Ruivo, 1,568 m *a.s.l.*, 32º 44′ 44.69′′ N, 16º 56′ 01.80′′ W, 02.06.2005, leg. Aguiar / Jesus. ***MZHF*** (3♀♀, 8☿☿, 5♂♂): 1☿, Funchal, Pico da Cruz, 224 m *a.s.l.*, 32° 38′ 31.20″ N, 16° 56′ 16.80′′ W, 10.03.1980. leg. M. Koponen; 1☿,

Monte, 559 m *a.s.l.*, 32° 40′ 30.46″ N, 16° 54′ 04.94″ W, 12.06.1957, leg. H. Lindberg; 1♂, Funchal, 10 m *a.s.l.*, 32° 38′ 49.90″ N, 16° 54′ 18.00″ W, 15.04.1990, leg. M. Koponen; 1☿, Funchal, Amparo – Quebradas, 150 m *a.s.l.*, 32° 38′ 45.78′′ N, 16° 56′ 58.13′′ W, 16.04.1995, leg. M. Koponen; 1☿, 4♂♂, Serra d'Água, 325 m *a.s.l.*, 32° 43′ 33.60′′ W, 17° 01′ 37.20′′ N, 16.07.-19.07.1957, leg. H. Lindberg; 1♀, Funchal, Pico da Cruz, 224 m *a.s.l.*, 32° 38′ 21.20′′ N, 16° 56′ 16.80′′ W, 18.03.1980, leg. M. Koponen; 1♀, Ribeira Brava, 30 m *a.s.l.*, 32° 40′ 12.00′′ N, 17° 03′ 50.40′′ W, 19.04.1990, leg. M. Koponen; 1☿, Funchal, Pico da Cruz, 224 m *a.s.l.*, 32° 38′ 31.20′′ N, 16° 56′ 16.80′′ W, 20.03.1980, leg. M. Koponen; 1☿, Pico Ruivo, 1,797 m *a.s.l.*, 32° 45′ 41.60′′ N, 16° 56′ 17.58′′ W, 27.6.-29.06.1957, leg. H. Lindberg; 1♀,1☿, Funchal, Pico da Cruz, 224 m *a.s.l.*, 32° 38′ 45.06′′ N, 16° 56′ 10.03′′ W, 08.03.1980, leg. M. Koponen; 1☿, Funchal, 10 m *a.s.l.*, 32° 38′ 49.20′′ N, 16° 56′ 16.80′′ W, 9.6.-10.06.1957, leg. H. Lindberg. ***UMB*** (1♀, 2☿☿, 1♂): 1☿, Fajã de Ovelha, 483 m *a.s.l.*, 32° 46′ 27.43′′ N 17° 14′ 2.88″ W, 02.04.1994, leg. H Hohmann; 1♀, Paúl do Mar, 15 m *a.s.l.*, 32° 45′ 32.65″ N, 17° 13′ 49.58″ W, 02.04.1994, leg. H. Hohmann; 1☿, 1♂, Calheta, 374 m *a.s.l.*, 32° 44′ 16.83″ N, 17° 10′ 51.57″ W, 10.04.1994, leg. H. Hohmann.

- **Data from literature** (1♀, 2 ind.): Costa (2019): 1 ind., Pico do Areeiro, 1,500 m *a.s.l.*, 32° 43′ 8″ N, 16° 54′ 31″ W, leg. R. Costa; 1 ind., area Pico do Areeiro 1,800 m *a.s.l.*, 32° 44′ N, 16° 55′ 47″ W, leg. R. Costa; Saunders (1903): 1♀, Funchal, 54 m *a.s.l.*, 32° 38′ 26.00″ N, 16° 55′ 26.66′′ W, leg. A. E. Eaton.

Bombus (Bombus) terrestris lusitanicus Krüger, 1956

- **Status**: Native (Figs. 58-60).

Fig. 58 – *Bombus terrestris lusitanicus* (worker), collecting pollen on the endemic plant species *Echium nervosum*. Coast E S. Vicente near Fajã da Areia, 27.03.2022; vegetation series d). Photo A. Schwabe.

Fig. 59 – *Bombus terrestris lusitanicus* (worker) with subspecies-characteristic red hairs on the third (hind) metatarsus (Corbiculae) and on the second metatarsus, visiting *Vicia faba* in a traditional garden of the northern slopes. Because of the short proboscis, nectar is gained by biting holes ('nectar robbing'). Ribeira Funda near São Jorge, 30.03.2022; vegetation series e). Photo A. Schwabe.

Fig. 60 – *Bombus terrestris lusitanicus* (male), visiting the native species *Galactites tomentosa*; many wild bee species visit this species frequently. Arco de S. Jorge, ruderal habitat near the coast, 04.04.2022; vegetation series d). Photo A. Schwabe.

- **Literature**: Bischoff (1937), Erlandsson (1979), Widmer *et al.* (1998), Fellendorf *et al.* (1999), Rasmont *et al.* (2008), Kratochwil *et al.* (2018).

- **Specimens analysed**: 36♀♀, 352☿; 13♂♂, 1 ind.

- **Distribution, habitat characteristics, and flower-visiting behaviour** (Figs. 61 and 62, Tables 26 and 27): *Bombus terrestris lusitanicus* has an especially high presence in the vegetation series of the temperate climate [e), f)] and the transition zone d). The species is a typical element of the cultural landscape, with small vegetable gardens and different types of anthropogenic vegetation on the northern slopes. Gardens with ornamental plants are frequently visited in many areas. Further coastal rocks, fallows, and the pasture landscapes in the potential tree-heath series f) are populated.

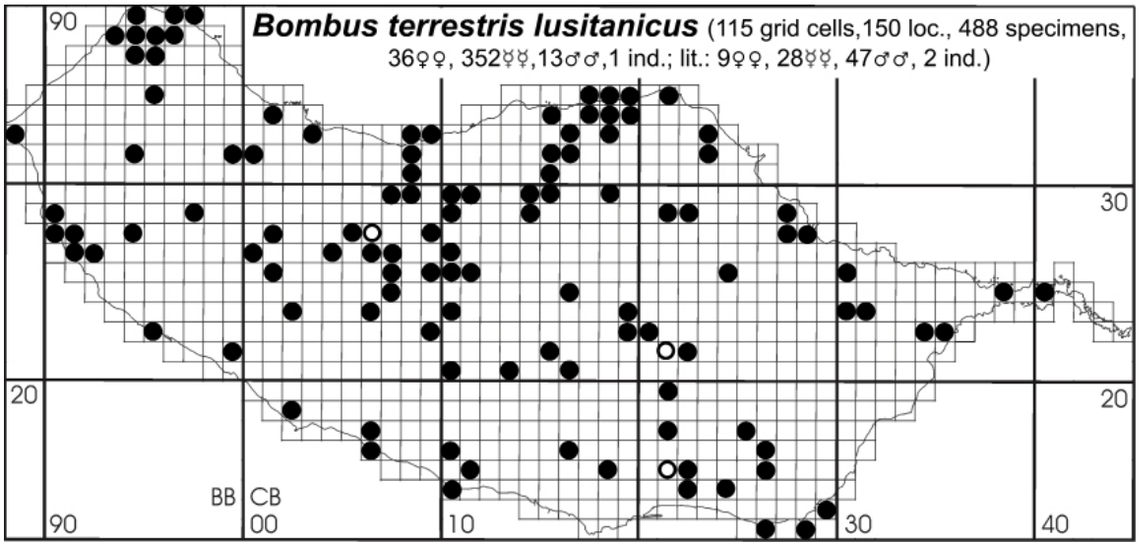

Fig. 61 – Detections of *Bombus terrestris lusitanicus* (black dots: authors' data, checked specimens of collections; circles: literature data).

In near-natural sites on Madeira Island, the endemic *Echium nervosum* on coastal rocks plays a role as a pollen and nectar resource. In the case of stormy weather, *B. t. lusitanicus* forages there 'by feet' from flower to flower. Ruderal plants such as *Bituminaria bituminosa* and *Galactites tomentosa* and many others play a role. In the small vegetable gardens especially in the northern part of Madeira, flowering *Brassica oleracea* and *Tropaeolum majus* are regularly visited. In the intensively grazed hyperhumid vegetation series f), there is often only the introduced *Ulex europaeus* left as a pollen and nectar resource, which is intensively used by *B. t. lusitanicus*. All in all, in our observations, 30 plant families were visited by this polylectic species. In the case of *Rhododendron* sp. ('Azalea') and *Vicia faba*, *Bombus t. lusitanicus* was only able to get nectar by biting holes ('nectar robbing').

- **Flight time**: *Bombus t. lusitanicus* flies year-around. We have detections from all months.

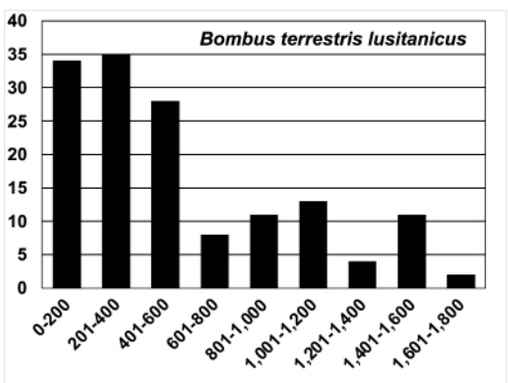

Fig. 62 – Number of localities with *Bombus terrestris lusitanicus* detections per altitude level.

Table 26 – Presence of *Bombus terrestris lusitanicus* in square-grid cells of different vegetation series.

Vegetation series		Presence %, absolute
May-Ol	a	38%
Hel-Si	b	35%
Sem-Ap 1	c	36%
Sem-Ap 2	d	43%
Cle-Oc	e	**54%**
Pol-Er	f	**56%**
Arm-Pa	g	2

- **Data of the authors** (27♀♀, 345☿☿, 7♂♂, 1 ind.): ***cAK*** (2♀♀, 39☿☿): 2☿☿, Ponta do Garajau, S Caniço; 112 m *a.s.l.*, 32° 38′ 18.33″ N, 16° 51′ 02.84″ W, 07.04.1995, leg. K/S; 2☿☿, Poiso, 1,175 m *a.s.l.*, 32° 43′ 13.28″ N, 16° 53′ 27.21″ W, 07.04.1995, leg. K/S; 1♀, Cabo do Castelo, S Camacha, 488 m *a.s.l.*, 32° 39′ 51.20″ N, 16° 50′ 46.06″ W, 09.04.1995, leg. K/S; 1☿, Ponta da Oliveira, Caniço de Baixo, 22 m *a.s.l.*, 32° 38′ 28.16″ N, 16° 49′ 53.02″ W, 13.04.1995, leg. K/S; 3☿☿, E Arco da Calheta, ER 101, 322 m *a.s.l.*, 32° 42′ 31.99″ N, 17° 08′ 14.93″ W, 25.03.2005, leg. K/S; 1☿, Ribeira Brava, in front of tunnel entrance, 44 m *a.s.l.*, 32° 40′ 29.71″ N, 17° 03′ 51.75″ W, 27.03.2005, leg. K/S; 1☿, Serra de Água, lookout point, 465 m *a.s.l.*, 32° 43′ 50.79″ N, 17° 01′ 26.59″ W, 27.03.2005, leg. K/S; 4☿☿, Cabo Girão, S Quinta Grande, 603 m *a.s.l.*, 32° 39′ 27.08″ N, 17° 00′ 23.91″ W, 28.03.2005, leg. K/S; 1☿, Funchal, in front of Jardim Botânico, 277 m *a.s.l.*, 32° 39′ 41.27″ N, 16° 53′ 41.25″ W, 30.03.2005, leg. K/S; 1☿, Ribeira Brava, in front of tunnel entrance, 44 m *a.s.l.*, 32° 40′ 29.71″ N, 17° 03′ 51.75″ W, 02.04.2005, leg. K/S; 1☿, Cova do Negro, W Rabaçal, 1,130 m *a.s.l.*, 32° 48′ 23.66″ N, 17° 11′ 50.04″ W, 02.04.2005, leg. K/S; 1☿, Ponta dos Reis Magos, SE

Table 27 – Plant-species spectrum visited by *Bombus terrestris lusitanicus*. * = 'nectar robbing'.

Plant species, plant families		Status	n
Justitia adhatoda	Aca	cult	2☿☿
Carpobrotus edulis	Aiz	intr	1 ind.
Melanoselinum decipiens	Api	end	2☿☿
Asteraceae yellow	Ast	-	1♀
Bidens pilosa	Ast	intr	12☿☿, 3♂♂, 1 ind.
Calendula officinalis	Ast	intr	1☿
Carlina salicifolia	Ast	mac	1♀
Cirsium vulgare	Ast	intr	1♀
Crepis capillaris	Ast	intr	2☿☿
Crepis vesicaria	Ast	nat	2☿☿
Galactites tomentosa	Ast	nat	3♀♀, 18☿☿
Sonchus asper	Ast	nat?	4☿☿
Taraxacum hamatum	Ast	intr	2☿☿
Tacoma capensis	Big	intr	2☿☿
Echium candicans	Bor	end	4 ind.
Echium nervosum	Bor	end	1♀, 37☿☿
Echium plantagineum	Bor	nat	2☿☿
Brassica oleracea	Bra	cult	2♀♀, 52☿☿
Erysimum bicolor	Bra	mac	1☿
Raphanus r. subsp. *raphanistrum*	Bra	nat	1☿
Sinapidendron angustifolium	Bra	end	2☿☿
Cercis siliquastrum	Cae	cult	1 ind.
Ipomoea purpurea	Con	intr	1☿
Crassula ovata	Cra	intr	1♀
Sechium edule	Cuc	intr	1☿
Rhododendron sp. ('Azalea')*	Eri	cult	6☿☿
Vaccinium padifolium	Eri	end	1☿
Euphorbia pulchemima	Eup	cult	1☿
Bituminaria bituminosa	Fab	nat	15☿☿
Cytisus scoparius	Fab	intr	1♀
Trifolium pratense	Fab	intr	1☿
Trifolium repens	Fab	nat	4☿☿
Ulex europaeus	Fab	intr	4♀♀, 46☿☿
Vicia angustifolia	Fab	nat	3☿☿
*Vicia faba**	Fab	cult	3☿☿
Wisteria sinensis	Fab	cult	17☿☿
Geranium maderense	Ger	end	3☿☿
Geranium robertianum	Ger	nat	7☿☿
Pelargonium sp.	Ger	intr	3☿☿
Rosmarinum officinale	Lam	cult	6☿☿
Salvia leucantha	Lam	intr	1☿
Teucrium betonicum	Lam	end	2☿☿
Agapanthus praecox	Lil	intr	1♀
Allium triquetrum	Lil	intr?	2☿☿
Lilium sp.	Lil	cult	1☿
Bougainvillea spectabilis	Nyc	cult	1 ind.
Callianthe picta (*Abutilon pictum*)	Mal	intr	4☿☿
Fuchsia magellanica	Ona	intr	1♀, 9☿☿
Oxalis pes-caprae	Oxa	intr	14☿☿
Fumana muralis	Pap	nat	3☿☿
Passiflora caerulea	Pas	intr	4☿☿
Plantago sp.	Pla	-	1♀
Hakea sericea	Pro	intr	1♀
Rubus ulmifolius	Ros	nat	1♀
Bergenia crassifolia (= *cordifolia*)	Sax	cult	3☿☿
Salpichroa origanifolia	Sol	intr	1♀, 2☿☿
Strelitzia reginae	Str	cult	2☿☿
Tropaeolum majus	Tro	intr	19☿☿

Caniço, 14 m *a.s.l.*, 32° 38′ 55.50″ N, 16° 49′ 22.06″ W, 04.04.2005, leg. K/S; 1☿, N Fonte da Pedra, 874 m *a.s.l.*, 32° 49′ 54.26″ N, 17° 11′ 16.03″ W, 28.12.2006, leg. K/S; 1♀, 1☿, above Paúl do Mar, ER 212, Reservatório do Paúl do Mar, 67 m *a.s.l.*, 32° 45′ 49.96″ N, 17° 13′ 51.95″ W, 29.12.2006, leg. K/S; 1☿, Falca de Cima, near Boaventura, 396 m *a.s.l.*, 32° 47′ 27.0″ N, 16° 58′ 29.4″ W, 25.03.2022, leg. K/S; 3☿☿, Fajã do Penedo, near Boaventura, 238 m *a.s.l.*, 32° 48′ 17.8″ N, 16° 57′ 49.2″ W, 25.03.2022, leg. K/S; 4☿☿, Arco de S. Jorge, 109 m *a.s.l.*, 32° 49′ 36.1″ N, 16° 56′ 52.8″ W, 25.03.2022, leg. K/S; 1☿, Fanal, above Ribeira Janela, 1,134 m *a.s.l.*, 32° 48′ 27.2″ N, 17° 08′ 30.0″ W, 26.03.2022, leg. K/S; 1☿, W P. Moniz, 417 m *a.s.l.*, 32° 51′ 38.2″ N, 17° 12′ 04.1″ W, 26.03.2022, leg. K/S; 1☿, P. Moniz, 20 m *a.s.l.*, 32° 52′ 00.3″ N, 17° 09′ 58.7″ W, 28.03.2022, leg. K/S; 1☿; road Encumeada to Paúl da Serra, 1,220 m *a.s.l.*, 32° 44′ 55.3′′ N, 17° 02′ 04.2′′ W, 01.04.2022, leg. K/S; 1☿, Encumeada Pass, 996 m *a.s.l.*, 32° 45′ 16.5′′ N, 17° 01′ 10.6′′ W, 01.04.2022, leg. K/S; 1☿, above Rosário, S. Vicente, 707 m *a.s.l.*, 32° 45′ 48.5′′ N, 17° 01′ 19.6′′ W, 01.04.2022, leg. K/S; 5☿☿, Arco São Jorge, 109 m *a.s.l.*, 32° 49′ 36.1′′ N, 16° 56′ 52.8′′ W, 01.04.2022, leg. K/S. ***cFA*** (2♀♀, 1☿, 1♂): 1♀, Funchal, Lombo da Boa Vista, 174 m *a.s.l.*, 32° 39′ 18.68′′ N, 16° 53′ 38.36′′ W, 18.10.89, leg. F. Aguiar; 1☿, Ribeirinha, Camacha, 649 m *a.s.l.*, 32° 40′ 20.95′′ N, 16° 50′ 50.97′′ W, 26.02.1999, leg. Aguiar / Jesus; 1♂, Eira do Serrado, between miradouro and peak, 1,025 m *a.s.l.*, 32° 42′ 37.29′′ N, 16° 57′ 55.05′′ W, 17.06.2004, leg. Aguiar / Jesus; 1♀, Fajã dos Cardos, Curral das Freiras, 762 m *a.s.l.*, 32° 44′ 36.72′′ N, 16° 57′ 49.62′′ W, 07.09.2004, leg. Aguiar / Jesus. ***cJS*** (3♀♀, 6☿☿, 3♂♂): 1☿, Funchal, Ribeira dos Socorridos, 315 m *a.s.l.*, 32° 40′ 27.17″ N, 16° 57′ 22.11″ W, 10.07.1997, leg. J. Smit; 1♂, Parque Ecológico, near Poço da Neve, 1,633 m *a.s.l.*, 32° 43′ 32.87″ N, 16° 55′ 29.69″ W, 11.07.1997, leg. J. Smit; 1☿, 1♂, Fontes, 1,124 m *a.s.l.*, 32° 42′ 33.11″ N, 17° 00′ 57.13″ W, 16.07.1997, leg. J. Smit; 2♀♀, Rabaçal, 1064 m *a.s.l.*, 32° 45′ 43.45″ N, 17° 08′ 03.01″ W, 20.07.1997, leg. J. Smit; 1☿, Ponta de São Lourenço, 77 m *a.s.l.*, 32° 44′ 36.05″ N, 16° 42′ 01.91″ W, 27.02.98, leg. J. T. Smit; 1♀, Rabaçal, 1,064 m *a.s.l.*, 32° 45′ 43.45″ N, 17° 08′ 03.01″ W, 03.03.1998, leg. J. T. Smit; 1☿, Funchal, Pico dos Barcelos, 338 m *a.s.l.*, 32°39′31.00″N, 16° 56′ 22.00″ W, 08.03.1998, leg. J. T. Smit; 1☿, Ponta do Pargo, 322 m *a.s.l.*, 32° 48′ 44.56″ N, 17° 15′ 38.36″ W, 05.05.1998, leg. J. Smit; 1☿, Palheiro Ferreiro, NW São Gonçalo, 505 m *a.s.l.*, 32° 39′ 15.75″ N, 16° 52′ 17.22″ W, 06.05.1998, leg. J. Smit; 1♂, Terreiro da Luta, N Monte, 886 m *a.s.l.*, 32° 41′ 05.47″ N, 16° 53′56.59″ W, 06.05.1998, leg. J. Smit. ***oFA*** (13♀♀, 6☿☿, 3♂♂, 1 ind.): 1♀, Encumeada, road to S. Vicente, 989 m *a.s.l.*, 32° 45′ 15.42′′ N, 17° 01′ 01.27′′ W, 12.09.1996, obs. F. Aguiar; 1♀, Tranqual, Campanário, 570 m *a.s.l.*, 32° 39′ 56.73′′ N, 17° 01′ 07.18′′ W, 30.03.2000, obs. F. Aguiar; 1♀, Paúl da Serra, 2 km SW Estanquinhos, 1,458 m *a.s.l.*, 32º 45′ 20.26′′ N, 17º 05′ 21.70′′ W, 16.04.2003, obs. F. Aguiar; 1 ind., Pinheiro, Serra de Água, 381 m *a.s.l.*, 32° 43′ 19.20′′ N, 17° 02′ 02.28′′ W, 11.01.2007,

obs. F. Aguiar; 3♂♂, Pinheiro, Serra de Água, 1 km SW Serra de Água church, 373 m *a.s.l.*, 32º 43′ 17.42′′ N, 17º 02′ 01.88′′ W, 11.01.2007, obs. F. Aguiar; 1♀, Pinheiro, 1 km SW Serra de Água church, 379 m *a.s.l.*, 32º 43′ 17.28′′ N, 17º 02′ 02.72′′ W, 22.02.2007, obs. F. Aguiar; 1♀, Pinheiro, 1 km SW Serra de Água church, 379 m *a.s.l.*, 32º 43′ 17.28′′ N, 17º 02′ 02.72′′ W, 22.02.2007, obs. F. Aguiar; 6☿☿, Levada da Fajã do Rodrigues, Rosário, S. Vicente, 605 m *a.s.l.*, 32º 46′ 00.08′′ N, 17º 02′ 09.61′′ W, 15.03.2007, obs. F. Aguiar; 1♀; Paúl da Serra, dirt road from Estanquinhos to Ginjas, 1,585 m *a.s.l.*, 32º 46′ 11.84′′ N, 17º 04′ 28.12′′ W, 05.07.2007, obs. F. Aguiar; 1♀, Portela, dirt road from Portela to Ribeira de Machico, 573 m *a.s.l.*, 32º 45′ 23.69′′ N, 16º 48′ 28.42′′ W, 08.05.2008, obs. F. Aguiar; 1♀, near Poço da Neve, road to Pico do Areeiro, 1,566 m *a.s.l.*, 32º 43′ 36.71′′ N, 16º 55′ 09.78′′ W, 18.09.2008, obs. F. Aguiar; 1♀, Poiso, vereda from Poiso to Chão das Feiteiras, 1,199 m *a.s.l.*, 32º 41′ 59.16′′ N, 16º 53′ 58.70′′ W, 23.04.2009, obs. F. Aguiar; 1♀, Canhas to Paúl da Serra, dirt road, 1,162 m *a.s.l.*, 32º 44′ 06.76′′ N, 17º 06′ 23.10′′ W, 29.04.2010, obs. F. Aguiar; 1♀, road from Paúl da Serra to Prazeres, 851 m *a.s.l.*, 32º 46′ 02.65′′ N, 17º 11′ 26.96′′ W, 24.06.2010, F. Aguiar; 1♀, Prazeres to Paúl do Mar, vereda near Jardim Atlantico Hotel, 501 m *a.s.l.*, 32º 45′ 09.24′′ N, 17º 13′ 04.90′′ W, 28.04.2011, obs. F. Aguiar; 1♀, Encumeada, Serra de Água, near Forest Service house, 937 m *a.s.l.*, 32º 45′ 26.71′′ N, 17º 01′ 14.85′′ W, 16.06.2011, obs. F. Aguiar. ***oKS*** (7♀♀, 293☿☿): 1☿, W Ponta do Sol, between Livramento and Anjos, 38 m *a.s.l.*, 32° 40′ 56.30″ N, 17° 06′ 31.87″ W, 25.03.2005, obs. K/S; 2☿☿, Boca da Encumeada, 999 m *a.s.l.*, 32° 45′ 16.43″ N, 17° 01′ 11.22″ W, 27.03.2005, obs. K/S; 7☿☿, Câmara do Bispo, S Quinta Grande, 316 m *a.s.l.*, 32° 39′ 17.50″ N, 17° 01′ 02.02″ W, 28.03.2005, obs. K/S; 4☿☿, Fajã dos Padres, W Quinta Grande, 325 m *a.s.l.*, 32° 39′ 21.12″ N 17° 01′ 04.44″ W, 28.03.2005, obs. K/S; 1☿, Cabo Girão, S Quinta Grande, 603 m *a.s.l.*, 32° 39′ 27.08″ N, 17° 00′ 23.91″ W, 28.03.2005, obs. K/S; 2☿☿, Funchal, in front of Jardim Botânico, 277 m *a.s.l.*, 32° 39′ 41.27″ N, 16° 53′ 41.25″ W, 30.03.2005, obs. K/S; 5☿☿, Cova da Negro, W Rabaçal, 1,130 m *a.s.l.*, 32° 48′ 23.66″ N, 17° 11′ 50.04″ W, 02.04.2005, obs. K/S; 1☿, above Porto Moniz, 407 m *a.s.l.*, 32° 51′ 35.12″ N, 17° 10′ 26.56″ W, 03.04.2005, obs. K/S; 1☿, Casa das Queimadas, SW Santana, 896 m *a.s.l.*, 32° 47′ 01.27′′ N, 16° 54′ 23.56″ W, 05.04.2005, obs. K/S; 1☿, above Paúl do Mar, ER 212, Reservatório do Paúl do Mar, 67 m *a.s.l.*, 32° 45′ 49.96″ N, 17° 13′ 51.95″ W, 28.12.2006, obs. K/S; 1♀, Restaurante 'O Precipício', Fajã da Ovelha, 375 m *a.s.l.*, 32° 46′ 13.89″ N, 17° 14′ 05.42″ W, 28.12.2006, obs. K/S; 2☿☿, N Fonte da Pedra, 874 m *a.s.l.*, 32° 49′ 54.26″ N, 17° 11′ 16.03″ W, 28.12.2006, obs. K/S; 1☿, Eirinha above Serra de Água, 506 m *a.s.l.*, 32° 43′ 54.22″ N, 17° 01′ 30.19″ W, 01.01.2007, obs. K/S; 1♀, Estanquinhos, 1,559 m *a.s.l.*, 32° 46′ 12.81″ N, 17° 04′ 40.56″ W, 01.01.2007, obs. K/S; 1♀, Pico da Fajã da Lenha, 1,331 m *a.s.l.*, 32° 46′ 13.48″ N, 17° 07′ 05.60″ W, 01.01.2007, obs. K/S; 1☿, above Calheta, 88 m *a.s.l.*, 32° 43′ 23.97″ N, 17° 10′ 39.73″ W, 03.04.2007, obs. K/S; 12☿☿, Lombo do Urzal, near Boaventura, 472 m *a.s.l.*, 32° 46′ 54.3″ N, 16° 58′ 45.5″ W, 25.03.2022, obs. K/S; 1☿, Lombo do Urzal, Boaventura, 456 m *a.s.l.*, 32° 47′ 04.4″ N, 16° 58′ 37.4″ W, 25.03.2022, obs. K/S; 2☿☿, Falca de Cima, Boaventura, 396 m *a.s.l.*, 32° 47′ 27.0″ N, 16° 58′ 29.4″ W, 25.03.2022, obs. K/S; 1☿, Fajã do Penedo, Boaventura, 264 m *a.s.l.*, 32° 47′ 53.6″ N, 16° 58′ 05.5″ W, 25.03.2022, obs. K/S; 1☿, Fajã do Penedo, Boaventura, 220 m *a.s.l.*, 32° 48′ 12.1″ N, 16° 57′ 59.8″ W, 25.03.2022, obs. K/S; 6☿☿, Fajã do Penedo, Boaventura, 238 m *a.s.l.*, 32° 48′ 17.8″ N, 16° 57′ 49.2″ W, 25.03.2022, obs. K/S; 3☿☿, Fajã do Penedo, Boaventura, 211 m *a.s.l.*, 32° 48′ 20.6″ N, 16° 57′ 51.7″ W, 25.03.2022, obs. K/S; 1☿, Arco de S. Jorge, 262 m *a.s.l.*, 32° 49′ 36.9″ N, 16° 56′ 30.9″ W, 25.03.2022, obs. K/S; 1☿, below Paúl da Serra da Lamoirinha, 1,217 m *a.s.l.*, 32° 46′ 24.9″ N, 17° 09′ 42.5″ W, 26.03.2022, obs. K/S; 1☿, Fanal, above Ribeira da Janela, 1,187 m *a.s.l.*, 32° 47′ 56.9″ N, 17° 07′ 57.3″ W, 26.03.2022; obs. K/S; 1☿, Passada Vermelha, 1,180 m *a.s.l.*, 32° 48′ 19.3″ N, 17° 11′ 29.8″ W, 26.03.22, obs. K/S; 1♀, 3☿☿, Fanal, above Ribeira Janela, 1,134 m *a.s.l.*, 32° 48′ 27.2″ N, 17° 08′ 30.0″ W, 26.03.2022, obs. K/S; 6☿☿, above P. Moniz, 644 m *a.s.l.*, 32° 50′ 54.9″ N, 17° 11′ 42.1″ W, 26.03.2022, obs. K/S; 10☿☿, Pombais, above P. Moniz, 590 m *a.s.l.*, 32° 51′ 08.1″ N, 17° 11′ 46.0″ W, 26.03.2022, obs. K/S; 4☿☿, Pombais, above P. Moniz, 427 m *a.s.l.*, 32° 51′ 33.6″ N, 17° 12′ 06.1″ W, 26.03.2022, obs. K/S; 6☿☿, Miradouro Pombais, above P. Moniz, 378 m *a.s.l.*, 32° 51′ 34.6″ N, 17° 12′ 12.6″ W, 26.03.2022, obs. K/S; 2☿☿, W P. Moniz, 417 m *a.s.l.*, 32° 51′ 38.2″ N, 17° 12′ 04.1″ W, 26.03.2022, obs. K/S; 8☿☿, S. Vicente, 364 m *a.s.l.*, 32° 47′ 05.8″ N, 17° 01′ 13.1″ W, 27.03.2022, obs. K/S; 1♀, 8☿☿, S. Vicente, 414 m *a.s.l.*, 32° 47′ 18.2″ N, 17° 01′ 03.4″ W, 27.03.2022, obs. K/S; 2☿☿, S. Vicente, 243 m *a.s.l.*, 32° 47′ 19.1″ N, 17° 01′ 38.5″ W, 27.03.2022, obs. K/S; 1☿, S. Vicente, 269 m *a.s.l.*, 32° 47′ 20.6″ N, 17° 03′ 00.5″ W, 27.03.2022, obs. K/S; 3☿☿, S. Vicente, 252 m *a.s.l.*, 32° 47′ 20.9″ N, 17° 01′ 37.0″ W, 27.03.2022, obs. K/S; 2☿☿, S. Vicente, 272 m *a.s.l.*, 32° 47′ 27.6″ N, 17° 03′ 04.8″ W, 27.03.2022, obs. K/S; 3☿☿, S. Vicente, 200 m *a.s.l.*, 32° 47′ 47.1″ N, 17° 02′ 44.5″ W, 27.03.2022, obs. K/S; 3☿☿, S. Vicente, 54 m *a.s.l.*, 32° 48′ 16.4″ N, 17° 02′ 51.4″ W, 27.03.2022, obs. K/S; 1♀, 2☿☿, E S. Vicente, near Fajã Areia, 21 m *a.s.l.*, 32° 48′ 40.3″ N, 17° 02′ 34.4″ W, 27.03.2022, obs. K/S; 2☿☿, E S. Vicente, near Fajã Areia, 19 m *a.s.l.*, 32° 48′ 49.1″ N, 17° 01′ 52.1″ W, 27.03.2022, obs. K/S; 5☿☿, above P. Moniz, 379 m *a.s.l.*, 32° 51′ 40.5″ N, 17° 10′ 32.2″ W, 28.03.2022, obs. K/S; 2☿☿, P. Moniz, 30 m *a.s.l.*, 32° 52′ 0.2″ N, 17° 10′ 09.9″ W, 28.03.2022, obs. K/S; 6☿☿, P. Moniz, 28 m *a.s.l.*, 32° 52′ 00.1″ W, 17° 10′ 03.7″ N, 28.03.2022, obs. K/S; 1☿, P. Moniz, 20 m *a.s.l.*, 32° 52′ 00.3″ N, 17° 09′ 58.7″ W, 28.03.2022, obs. K/S; 1☿, P. Moniz, 10 m *a.s.l.*, 32° 52′ 01.4″ N, 17° 09′ 54.6″ W, 28. 03. 2022, obs. K/S; 5☿☿, Fajã da Parreira, 45 m *a.s.l.*, 32° 49′ 33.3′′ N, 17° 07′ 14.5′′ W, 28.03.2022, obs. K/S; 2☿☿, above P. Moniz, 622 m *a.s.l.*,

32° 51′ 0.76″ N, 17° 11′ 36.47″ W, 28.03.2022, obs. K/S; 1☿, above P. Moniz, 618 m *a.s.l.*, 32° 51′ 04.3″ N, 17° 11′ 22.5″ W, 28.03.2022, obs. K/S; 1☿, above P. Moniz, 565 m *a.s.l.*, 32° 51′ 07.9″ N, 17° 11′ 05.0″ W, 28.03.2022, obs. K/S; 2☿☿, above P. Moniz, 565 m *a.s.l.*, 32° 51′ 07.9″ N, 17° 11′ 05.0″ W, 28.03.2022, obs. K/S; 8☿☿, Santa, above P. Moniz, 483 m *a.s.l.*, 32° 51′ 33.0″ N, 17° 11′ 15.8″ W, 28.03.2022, obs. K/S; 3☿☿, Funchal Botanical Garden, 281 m *a.s.l.*, 32° 39′ 45.9″ N, 16° 53′ 47.2″ W, 29.03.2022, obs. K/S; 10☿☿, Ribeira Brava, near the river mouth, 60 m *a.s.l.*, 32° 40′ 11.8″ N, 17° 03′ 45.5″ W, 29.03.2022, obs. K/S; 5☿☿, below Ribeiro Frio, 544 m *a.s.l.*, 32° 45′ 20.6′ 'N, 16° 52′ 05.8″ W, 30.03.2022, obs. K/S; 3☿☿, Penha D'Aguia, Porto da Cruz, 83 m *a.s.l.*, 32° 46′ 43.8″ N, 16° 50′ 48.6″ W, 30.03.2022, obs. K/S; 1☿, Santana, 348 m *a.s.l.*, 32° 48′ 53.6″ N, 16° 53′ 13.2″ W, 30.03.2022, obs. K/S; 8☿☿, Ribeira Funda, near São Jorge, 585 m *a.s.l.*, 32° 49′ 08.6″ N, 16° 56′ 25.0″ W, 30.03.2022, obs. K/S; 1☿, Lapa Negra, near São Jorge, 480 m *a.s.l.*, 32° 49′ 22.7″ N, 16° 55′ 40.6″ W, 30.03.2022, obs. K/S; 9☿☿, Cabanas, near São Jorge, 492 m *a.s.l.*, 32° 49′ 34.0″ N, 16° 56′ 18.9″ W, 30.03.2022, obs. K/S; 2☿☿, Lapa Negra, near São Jorge, 409 m *a.s.l.*, 32° 49′ 45.3″ N, 16° 55′ 26.1″ W, 30.03.2022, obs. K/S; 3☿☿, Arco de S. Jorge, 40 m *a.s.l.*, 32° 49′ 46.8″ N, 16° 56′ 58.7″ W, 30.03.2022, obs. K/S; 8☿☿, Miradouro da Vigia, near São Jorge, 303 m *a.s.l.*, 32° 50′ 01.9″ N, 16° 54′ 42.4″ W, 30.03.2022, obs. K/S; 12☿☿, Farol, near São Jorge, 258 m *a.s.l.*, 32° 50′ 03.5″ N, 16° 54′ 22.0″ W, 30.03.2022, obs. K/S; 1☿, São Cristovão, 89 m *a.s.l.*, 32° 49′ 37.25″ N, 16° 58′ 25.32″ W, 31.03.2022, obs. K/S; 1☿, São Cristovão, 89 m *a.s.l.*, 32° 49′ 37.25″ N, 16° 58′ 25.32″ W, 31.03.2022, obs. K/S; 1☿, São Cristovão, 89 m *a.s.l.*, 32° 49′ 37.25″ N, 16° 58′ 25.32″ W, 31.03.2022, obs. K/S; 1☿, São Cristovão, 89 m *a.s.l.*, 32° 49′ 37.25″ N, 16° 58′ 25.32″ W, 31.03.2022, obs. K/S; 1☿, São Cristovão, coastal rock, 89 m *a.s.l.*, 32° 49′ 37.25″ N, 16° 58′ 25.32″ W, 31.03.2022, obs. K/S; 1♀, 8☿☿, São Cristovão, 89 m *a.s.l.*, 32° 49′ 37.25″ N, 16° 58′ 25.32″ W, 31.03.2022, obs. K/S; 13☿☿, Ribeira Brava, 60 m *a.s.l.*, 32° 40′ 11.8″ N, 17° 03′ 45.5″ W, 01.04.2022, obs. K/S; 1☿, Ribeira Brava, 18 m *a.s.l.*, 32° 40′ 21.0″ N, 17° 04′ 07.7″ W, 01.04.2022, obs. K/S; 5☿☿, Paúl da Serra, 1,471 m *a.s.l.*, 32° 44′ 03.1″ N, 17° 03′ 41.3″ W, 01.04.2022, obs. K/S; 1☿, road Encumeada to Paúl da Serra, 1,220 m *a.s.l.*, 32° 44′ 55.3″ N, 17° 02′ 04.2″ W, 01.04.2022, obs. K/S; 1☿, Paúl da Serra, 1,575 m *a.s.l.*, 32° 44′ 57.0″ N, 17° 03′ 30.3″ W, 01.04.2022, obs. K/S; 7☿☿, Encumeada Pass, 996 m *a.s.l.*, 32° 45′ 16.5″ N, 17° 01′ 10.6″ W, 01.04.2022, obs. K/S; 2☿, Paúl da Serra, Bica da Cana, 1,568 m *a.s.l.*, 32° 45′ 25.0″ N, 17° 03′ 30.4″ W, 01.04.2022, obs. K/S; 2☿☿, Paúl da Serra, 1,578 m *a.s.l.*, 32° 45′ 44.3″ N, 17° 04′ 12.8″ W, 01.04.2022, obs. K/S; 1☿, above Rosário, S. Vicente, 707 m *a.s.l.*, 32° 45′ 48.5″ N, 17° 01′ 19.6″ W, 01.04.2022, obs. K/S; 1☿, Rosário, above S. Vicente, 321 m *a.s.l.*, 32° 46′ 37.2″ N, 17° 01′ 30.0″ W, 01.04.2022, obs. K/S; 1☿, Pico do Facho, summit, 273 m *a.s.l.*, 32° 43′ 26.1″ N, 16° 45′ 31.5″ W, 02.04.2022, obs. K/S; 2☿☿, below Pico do Facho, 248 m *a.s.l.*, 32° 43′ 41.2″ N, 16° 45′ 41.5″ W, 02.04.2022, obs. K/S; 2☿☿, São Lourenço, 54 m *a.s.l.*, 32° 44′ 36.5″ N, 16° 43′ 21.8″ W, 02.04.2022, obs. K/S; 2☿☿, W Santa Cruz, 170 m *a.s.l.*, 32° 46′ 21.7″ N, 16° 50′ 22.3″ W, 02.04.2022, obs. K/S; 2☿☿, near Santa Cruz, 57 m *a.s.l.*, 32° 46′ 28.6″ N, 16° 49′ 49.3″ W, 02.04.2022, obs. K/S; 1☿, Arco de S. Jorge, 109 m *a.s.l.*, 32° 49′ 36.1″ N, 16° 56′ 52.8″ W, 02.04.2022, obs. K/S; 1☿, E Porto do Seixal, old coastal road, 111 m *a.s.l.*, 32° 49′ 01.6″ N, 17° 06′ 00.0″ W, 03.04.2022, obs. K/S; 1☿, below Pico do Facho, 259 m *a.s.l.*, 32° 43′ 42.0″ N, 16° 45′ 40.8″ W, 04.04.2022, obs. K/S; 2☿☿, near Maroços, 276 m *a.s.l.*, 32° 44′ 05.3″ N, 16° 48′ 18.9″ W, 04.04.2022, obs. K/S; 9☿☿, Arco de S. Jorge, 109 m *a.s.l.*, 32° 49′ 36.1″ N, 16° 56′ 52.8″ W, 04.04.2022, obs. K/S.

- **Data from collections** (9♀♀, 7☿☿, 6♂♂): ***ICLAM*** (8♀♀, 5☿☿, 4♂♂): 1♀, Posto Agrário do Pico, Santana, 419 m *a.s.l.*, 32° 48′ 27.67″ N, 16° 53′ 11.23″ W, 28.11.1996, leg. Aguiar / Jesus; 2☿, Ribeira Brava, Miradouro Pico da Cruz, 54 m *a.s.l.*, 32° 40′ 09.25″ N, 17° 03′ 46.32″ W, 06.05.1997, leg. J. Jesus; 1♀, Queimadas, Santana, 877 m *a.s.l.*, 32° 47′ 10.52″ N, 16° 54′ 23.26″ W, 29.07.1997, leg. Aguiar / Jesus; 1♀, Ribeira do Lageado, Paúl da Serra, 1,354 m *a.s.l.*, 32° 45′ 21.32″ N, 17° 06′ 57.80″ W, 23.08.1997, leg. Aguiar / Jesus; 1♀, Serra de Água, N Terra Grande, 484 m *a.s.l.*, 32° 43′ 52.88″ N, 17° 01′ 26.21″ W, 22.10.1998, leg. Aguiar / Jesus; 2☿☿, Ribeirinha, Camacha, 649 m *a.s.l.*, 32° 40′ 20.95″ N, 16° 50′ 50.97″ W, 26.02.1999, leg. J. Jesus; 1♀, 1☿, 2♂♂, Tranqual, Campanário, 543 m *a.s.l.*, 32° 40′ 03.41″ N, 17° 01′ 13.41″ W, 26.03.1999, leg. Aguiar / Jesus; 1♂, Boca da Corrida, below miradouro, 1,152 m *a.s.l.*, 32° 42′ 39.43″ N, 16° 59′ 07.37″ W, 27.05.1999, leg. Aguiar / Jesus; 1♀, Farol, Ponta do Pargo, 248 m *a.s.l.*, 32° 48′ 39.26″ N, 17° 15′ 34.01″ W, 28.11.2002, leg. Aguiar / Jesus; 1♀, Fajã da Ovelha, 246 m *a.s.l.*, 32º 46′ 02.17″ N, 17º 13′ 54.68″ W, 27.11.2003, leg. Aguiar / Jesus; 1♂, Eira do Serrado, Pico do Serrado, 955 m *a.s.l.*, 32° 42′ 25.14″ N, 16° 57′ 35.72″ W, 17.06.2004, leg. Aguiar / Jesus; 1♀, Canhas to Paúl da Serra, dirt road, 1,163 m *a.s.l.*, 32º 44′ 01.40″ N, 17º 06′ 25.87″ W, 29.03.2007, leg. Aguiar / Jesus. ***MZHF*** (1♀, 2♂♂): 2♂♂, Vale Paraíso, 775 m *a.s.l.*, 32° 40′ 41.02″ N, 16° 51′ 41.45″ W, 13.6.1957, leg. H. Lindberg; 1♀, Queimadas, 882 m *a.s.l.*, 32° 47′ 00.72″ N, 16° 54′ 21.65″ W, 24.6.-26.06.1957, leg. H. Lindberg. ***UMB*** (2☿☿): 1☿, Paúl do Mar, 15 m *a.s.l.*, 32° 45′ 32.65″ N, 17° 13′ 49.58″ W, 02.04.1994, leg. H. Hohmann; 1☿, Paúl do Mar, 15 m *a.s.l.*, 32° 45′ 32.65″ N, 17° 13′ 49.58″ W, 02.04.1994, leg. H. Hohmann.

- **Data from literature** (9♀♀, 28☿☿, 47♂♂, 2 ind.): Costa (2019): 1 ind., Pico do Areeiro, 1,500 m *a.s.l.*, 32° 43′ 8″ N, 16° 54′ 31″ W, leg. R. Costa; 1 ind. area Pico do Areeiro, 1,800 m *a.s.l.*, 32° 44′ N, 16° 55′ 47″ W, leg. R. Costa; Erlandson (1979): 8♀♀, 5☿☿, Funchal, 310 m *a.s.l.*, 32° 40′ 0.96″ N, 16° 55′ 26.6″ W, 03.07.72, leg. S. Erlandson; 19☿☿, 37♂♂, Rabaçal, 1,066 m *a.s.l.*, 32° 45′ 39.71″ N, 17° 08′ 4.78″ W, 01.07.-04.08.1935, leg. O. Lundblad; 1♀, 4☿☿, 10♂♂, Caramujo, 1,273 m *a.s.l.*, 32° 46′ 20.49″ N, 17° 03′ 46.44″ W, 06.-14.08.1935, leg. O. Lundblad.

***Xylocopa violacea* (Linnaeus, 1758)**

- **Status**: Introduced (Fig. 63).

- **Distribution**: There are three observations of a *Xylocopa* species on Madeira Island without collection and one record with collection. All of them come from the Municipality of Funchal. The first observation was recorded by P. Wirtz (Quinta Magnólia, 76 m *a.s.l.*, 32° 38′ 36.75″ N, 16° 55′ 29.88″ W, June 1994). H. Schaefer documented a flower visit of *X.* cf. *violacea* on *Wisteria sinensis* in nine photos (Miradouro da Igreja de São Roque, 340 m *a.s.l.*, 32° 40′ 06.02″ N, 16° 55′ 23.48″ W, 03.09.2012). Another flower visit on *Wisteria sinensis* was reported by F. Rocha (Funchal, Madeira) (Travessa do Lombo da Quinta, 412 m *a.s.l.*, 32° 39′ 33.87″ N, 16° 52′ 33.77″ W, 29.03.2018). One specimen was collected by I. Silva (Jardim Bôtanico, 301 m *a.s.l.*, 32° 39′ 44.58″ N, 16° 53′ 42.77″ W, 30.06.2020). The determination by A. Aguiar revealed that it is a female of *Xylocopa violacea*. We suppose that all previous observations can also be assigned to this species. An introduction of specimens in wood or bamboo (*e.g.* via shipping) is easily possible for this species, as it nests in dead wood or culms (for dispersal and range expansion, see Banaszak *et al.*, 2019).

Major occurrences of wild bee species in vegetation series of Madeira Island

All wild bee data in Table 28 (without and with flower-visiting data) were assigned to the grid-cell system and the specific vegetation series. In columns a to f, the percentages of qualitative occurrences in specific grid cells are counted. These refer to the number of studied grid cells per vegetation series (= 100%). In the case of column g (only three grid cells), absolute numbers are given. The table summarises the data of the single bee species (Tables 4, 6, 8, 10, 12, 14, 16, 17, 18, 20, 22, 24, 26) in a synoptic presence table.

Table 28 shows that there is a pronounced community of bee species with main occurrence in the Mediterranean zones a), b), c). The two endemic species and one endemic subspecies (*Amegilla quadrifasciata maderae*, *Andrena maderensis*, and *Osmia madeirensis*) are characteristic of the dry to subhumid, warm environments. Further, *Bombus r. ruderatus* (intr?), *Lasioglossum v. villosulum* (nat?), and *Osmia niveata* (nat) occur mainly in this zone. The temperate humid to hyperhumid zone is generally not a very favourable habitat for wild bee species worldwide (Michener, 2007). Exceptions are species of the genus *Bombus*, here *B. terrestris lusitanicus*, which is also present with about 30% in zones a) to c). The occurrence of the endemic species *Halictus frontalis* (with a large body size of 11 mm), mainly in the temperate zone, is remarkable. Obviously, there are microhabitats with shelter (by rocks) for successful breeding in these very humid zones (see the 'Biogeographic Characteristics and Potential Natural Vegetation' section).

The two small endemic species *Andrena wollastoni* (7.6 mm) and *Lasioglossum wollastoni* (5.5 mm) are widely distributed, but there are only few occurrences, which are found in the very dry vegetation series a). Compared to the relatively sparse occurrences of the near relatives (Kratochwil *et al.*, 2021), *e.g.* in Tenerife or Gran Canaria with a lot of other competing small wild bee species, *A. wollastoni* obviously occupies a broad spectrum of habitats.

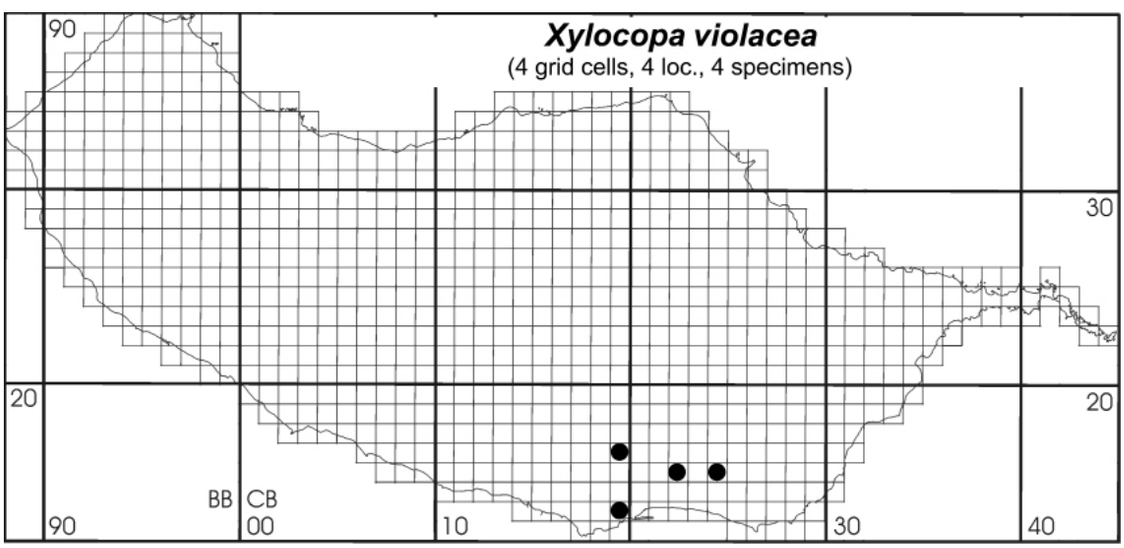

Fig. 63 – Detections of *Xylocopa violacea*.

In general, the rare species cannot be assigned to vegetation series. The endemic species *Hylaeus maderensis* has two small peaks in series a) and in series f), but it may be undersampled. All other rare species are introduced or probably introduced, and obviously have not established larger populations yet.

Flower resources for wild bee species in different vegetation series

All in all, 112 plant taxa, belonging to 39 plant families, had been recorded as pollen / nectar resources for wild bee species in our data base (816 females including in the case of *Bombus* workers and queens; 193 males; and 29 individuals without assignment).

In the **dry Mayteno umbellatae – Oleetum maderensis vegetation series a)** (southern coast, Table 1, Figs. 1, 2, and 11), there is one endemic plant species, which plays an extraordinary role as a pollen and nectar resource for wild bee species: *Echium nervosum* (Bor). There are also occurrences of this plant species upwards to series d), including coastal areas on the northern slope, but in the a) series and the favourable microclimatic habitats of the b) series (see below), it is a key species. *Sinapidendron angustifolium* (Bra, Fig. 2) and *Aeonium glutinosum* (Cra) are also visited (all rocky coastal habitats). In ruderal sites

Table 28 – Wild bee species assigned to the grid-cell system and to the specific vegetation series (columns a) to f): the percentages of qualitative occurrences in specific grid cells per vegetation series). In column g) (three grid cells) the absolute numbers are given.

		Mediterranean dry to subhumid vegetation series			Transition zone	Temperate humid to hyper-humid vegetation series			
	Dominant vegetation series/grid cell (Abbr., see Table 1)	May-Ol	Hel-Si	Sem-Ap 1	Sem-Ap 2	Cle-Oc	Pol-Er	Arm-Pa	
	Designation to vegetation series (Table 1)	a	b	c	d	e	f	g	
	number of all square grids (n = 826)	53	44	90	170	410	53	6	
Status	number of representative square-grid cells with bee data (n = 251)	21	17	29	61	104	16	3	
	presence in square-grid cells	%	%	%	%	%	%	absolute	
	Species with main occurences in the Mediterranean veg.series:								sum cells
end	Amegilla quadrifasciata maderae	71	59	21	30	8	13	1	54
intr?	Bombus ruderatus	48	35	38	15	10	6	2	49
nat?	Lasioglossum v. villosulum	52	18	46	35	21	13	1	72
end	Andrena maderensis	29	35	18	17	13	.	.	39
end	Osmia madeirensis	29	53	32	20	10	6	.	47
nat	Osmia niveata	24	41	32	13	2	6	1	33
	Species with main occurences in transitions/temperate veg.series:								
nat	Bombus terrestris lusitanicus	38	35	36	43	54	56	2	115
end	Halictus frontalis	5	6	21	18	15	31	2	42
	Species with broad amplitudes in veg.series:								
end	Andrena wollastoni	14	35	54	37	38	38	1	92
end	Lasioglossum wollastoni	15	35	38	42	15	31	2	73
	Rare species, no assignment to veg.series								
end	Hylaeus maderensis	10	.	7	2	3	13	1	11
intr	Hoplitis acuticornis	.	.	.	2	2	13	2	7
intr	Xylocopa cf. violacea	5	.	7	2	.	.	.	4
intr?	Megachile versicolor	.	.	.	.	1	6	2	4
intr	Anthidium manicatum	5	.	.	.	.	.	.	1
intr	Megachile pusilla	5	.	.	.	.	.	.	1
intr	Hylaeus s. signatus	.	.	4		.	.	.	1
intr	Stelis ornatula	.	.	.	.	1	.	.	1
	number of detected bee species/veg.series	***14***	***10***	***13***	***13***	***14***	***12***	***11***	
	percentages	highest		2nd highest		3rd highest			

especially, the native plant species *Bituminaria bituminosa* (Fab), *Crepis vesicaria*, *Galactites tomentosa*, and *Leontodon taraxacoides* subsp. *longirostris* (all Ast) are important pollen and nectar plants.

The **lower subhumid type Helichryso melaleuci – Sideroxyletum marmulanae series b)** (Table 1, Figs. 3, 4, and 11), is especially developed in the southeastern coastal parts of Madeira Island, including 'Ponta de São Lourenço'. In this vegetation series, two endemic plant species, *Echium nervosum* (Bor) as well as *Sinapidendron angustifolium* (Bra), are present as pollen and nectar resources. *Argyranthemum pinnatifidum* subsp. *succulentum* (Ast), amoung others, is also important. Native ruderal and other species such as *Bituminaria bituminosa* (Fab), *Crepis vesicaria*, *Galeopsis tomentosa*, *Leontodon taraxacoides* subsp. *longirostris* (all Ast), *Raphanus r.* subsp. *raphanistrum* and *Rapistrum rugosum* s.l. (both Bra) also play a role.

The **higher subhumid type Semele androgynae – Apollonietum barbujanae 1 series c)** (Table 1, Fig. 11), mainly found at south-facing lower altitudes (above type a), shows the importance of the two endemic plant species *Sinapidendron angustifolium* (Bra) and *Aeonium glutinosum* (Cra), and of the species *Crepis vesicaria*, *Galactites tomentosa* (both Ast), and *Reseda luteola* (Res).

The transition form from the Mediterranean to the temperate zone, **the lower humid type Semele androgynae – Apollonietum barbujanae 2 series d)** (Table 1, Figs. 5, 6, and 11) shows the importance of the two endemic *taxa Andryala glandulosa* subsp. *glandulosa* (Ast) and *Aeonium glandulosum* (Cra) on rocky sites as pollen and nectar resources. The native plant species *Bituminaria bituminosa* (Fab), *Crepis vesicaria* s.l. (partly the endemic *C. andryaloides*), *Galactites tomentosa*, and *Leontodon taraxacoides* subsp. *longirostris* (all Ast) are also important pollen and nectar plants.

In the **humid to lower hyperhumid type of potential Laurisilva vegetation: Clethro arboreae – Ocoteetum foetentis series e)** (Table 1, Figs. 7, 8, and 11) there are some elements of the Laurisilva vegetation complex that are important as pollen and nectar resources for wild bee species, especially the endemic species *Melanoselinum decipiens* (Api), *Clethra arborea* (Cle), *Echium candicans* (Bor), *Geranium maderense* (Ger), *Vaccinium padifolium* (Eri), *Andryala glandulosa* subsp. *glandulosa* (Ast), and the Macaronesian *Erysimum bicolor* (Bra). Parts of this series have been transferred in intensively grazed areas, rich in the introduced *Ulex europaeus* (Fab, see also type f), visited by *Bombus terrestris lusitanicus*. Parts of the series are also characterised by ruderal vegetation (especially *Galactites tomentosa* and *Leontodon taraxacoides* subsp. *longirostris*; both Ast). Further, a lot of traditional vegetable gardens exist in this humid area, with flowering *Brassica oleracea* (Bra) as a very important pollen and nectar resource. Flowering cabbage plants are grown for seed production and traditional Madeiran food. *Bombus terrestris lusitanicus*, and to a lesser extent *Andrena maderensis*, are the main pollinators of. *B. oleracea*, which depends on cross-pollination (Kitashiba & Nasrallah, 2014). The introduced *Oxalis pes-caprae* (Oxa) and *Tropaeolum majus* (Tro) are characteristic in this humid series too, they are used by *Bombus terrestris lusitanicus* especially.

There are not many data from the temperate hyperhumid vegetation series **Polysticho falcinelli – Ericetum arboreae f)** and **Armerio maderensis – Parafestucetum albidae g)** (Table 1, Fig. 11). In both cases, there are observations on the endemic plant species *Echium candicans* (Bor, often also planted, *e.g.* in the case of restoration projects). The introduced and invading shrub in heavily grazed pastures *Ulex europaeus* (Fab, Fig. 9) is a pollen and nectar resource for *Bombus terrestris lusitanicus*. Tiny *Taraxacum* taxa in the grazed areas (*e.g.* the introduced *T. hamatum*) play a role as pollen and nectar resources for *Halictus frontalis* and *Lasioglossum v. villosulum*. Large areas show monodominant stands of *Ulex europaeu*s, but there are efforts to enlarge and restore the typical high-altitude tree-heath series with the endemic *Vaccinium padifolium* (visited by *Bombus terrestris lusitanicus* and *Andrena wollastoni*) and other species of the tree-heath community (Fig. 10), *e.g.* in Paúl da Serra.

Remarkably, there was not a single flower visit of *Erica arborea* (Eri) which offers millions of flowers in the early year in different vegetation series [a) to f)], recorded in the whole data base.

Females of the occurring wild bee species and their plant-family spectrum

The flower-visiting and pollinating females (including in the case of *Bombus* queens and workers) are presented separately in Fig. 64 to demonstrate relationships between specific plant families and bee species. We present only bee females with higher numbers of interactions. The oligolectic behaviour or preference of certain plant families of *Andrena maderensis* (Bra), *Halictus frontalis*, *Lasioglosssum v. villosulum*, *Osmia madeirensis*, and *O. niveata* (all Ast) on Madeira Island is now shown with empirical data. All other bee species are polylectic, but in the case of *Andrena wollastoni* and *Lasioglossum wollastoni*

two families (firstly Ast, secondly Bra) predominate. In the whole *Andrena wollastoni* group (six species on Madeira Island, Porto Santo, Tenerife, Gran Canaria, La Palma, La Gomera) only two species show this behaviour; all others prefer Brassicaceae (Kratochwil & Schwabe, 2020). The key species *Echium nervosum* (Bor), with simple foraging availability of large pollen and nectar quantities, is especially frequently used by the supergeneralists in the sense the term is used by Valido & Olesen (2010): *Amegilla q. maderae*, *Bombus terrestris lusitanicus*, and *B. r. ruderatus*. In our study, the latter three species visited a very broad range of nine to 27 plant families (see also Tables 23, 25, and 27).

Threats to the endemic and native bee fauna of Madeira Island

Knowledge about the wild bee fauna of Madeira Island was very incomplete until yet now, as is shown, *e.g.*, by the treatment of the endemic species in the 'IUCN Red List of Threatened Species'. *E.g.*, for the endemic bee *Halictus frontalis*, only the occurrences in clearings of the Laurel Forest are named (Michez *et al.*, 2013), and not the considerable populations in the tree-heath zone f). Although this study resolves some data deficits, there are still gaps in knowledge, *e.g.* those concerning *Hylaeus maderensis*, as already stated by Dathe (2013).

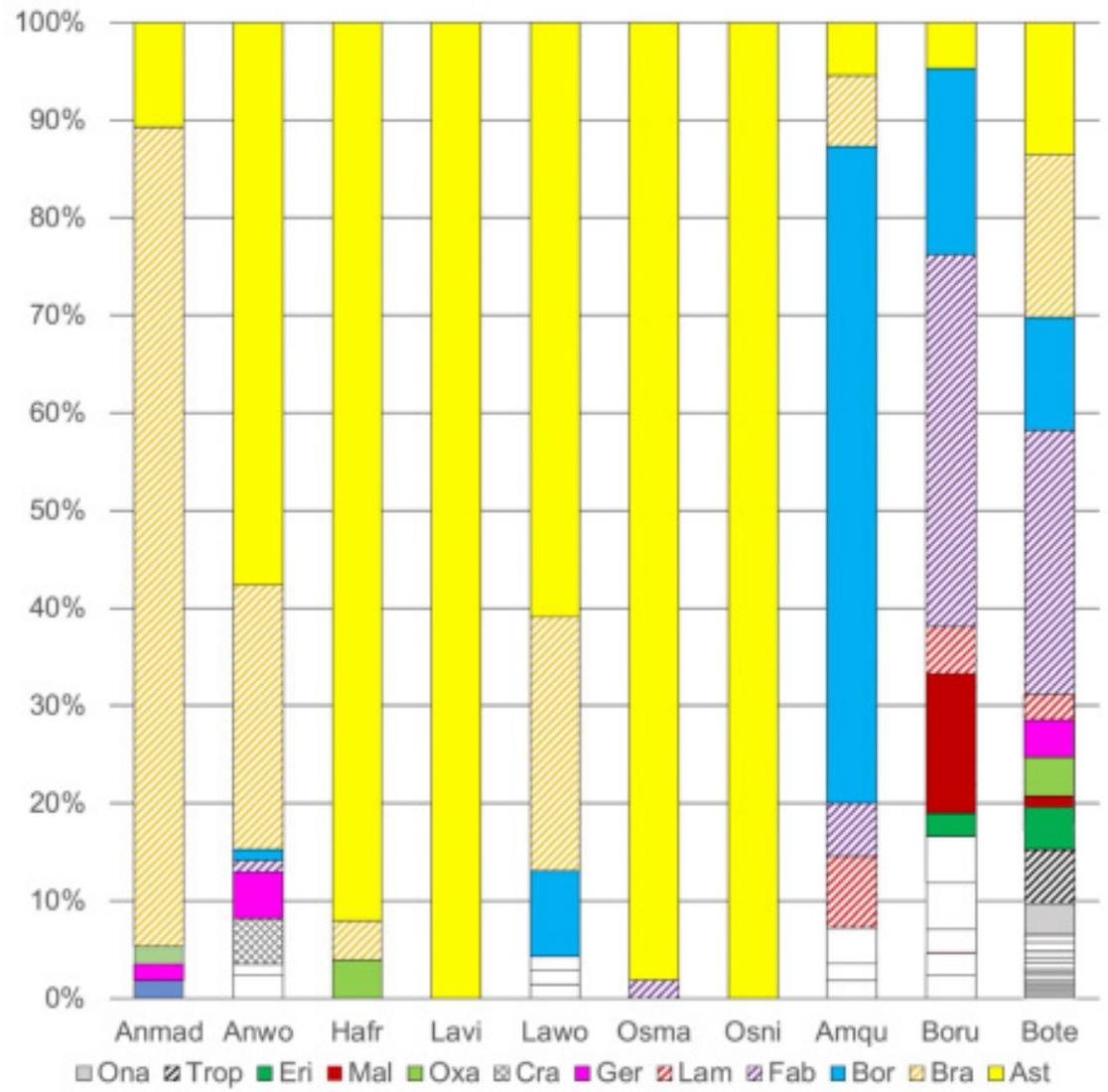

Fig. 64 – Plant-family spectrum visited by females (incl. *Bombus*: workers and queens) of the 10 most common wild bee species (n = 803 flower visits). White crossbars are not differentiated by colours (original values of interactions in brackets): Anwo = Api (1), Poa (2); Lawo = Api (1), Hyp (1), Pap (1), Scr (1); Boru = Cac (1), Co (1), Cuc (2), Pap (2), Ros (1), Scr (2); Amqu = Aiz (1), Cuc (2), Scr (1), Ver (1); Bote = Aca (2), Api (2), Big (2), Con (1), Cra (1), Cuc (1), Eup (1), Lil (4), Pap (3), Pas (4), Pla (1), Sax (3), Sol (3), Str (2).

According to the 'European Red List of Bees' (Nieto *et al*., 2014) the major threats to bees in Europe are (1) agricultural expansion / intensification; (2) livestock farming and ranching; (3) pollution, especially from neonicotinoid pesticides; and (4) residential / commercial development. On Madeira Island, (4) is relevant mainly for the southern slopes and (2) mainly for the potential tree-heath zone f (Paúl da Serra and vicinity, northern slopes in the northwestern region, and others). Additionally, the plantations, especially of *Eucalyptus*, lead to understorey vegetation that offers no pollen and nectar resources for wild bees or to a lack of any field-layer vegetation at all because of the nearly undecomposable litter; only the flowers of *Eucalyptus* are used by honeybees.

Due to the strong relief and the construction of a large-area nature protection system there are still considerable sites of valuable coastal vegetation as well as large areas of Laurisilva forest and the typical vegetation complex. The whole island has diverse ruderal sites with rich pollen and nectar resources for wild bees, and especially on the northern slopes, where there is still traditional farming, and house gardens are rich in flowering vegetables (*e.g*. the self-incompatible *Brassica oleracea*) as well as ruderal plant species. The ornamental gardens are used by wild bee species (*e.g*. *Wisteria sinensis* by *Bombus terrestris lusitanicus*). Some of the introduced plant species, *e.g*. *Carpobrotus edulis* (Aiz), Gazzania sp. (Ast), *Ageratina adenophora* (Ast.) have limited or no importance as resources for wild bee species. A very important and dangerous threat is, that in the context of tomato crop cultivation in greenhouses, *Bombus* species or subspecies may be imported as pollinators and escape (Dafni *et al*., 2010) [2].

Other wild bee species may also be introduced (as had already taken place; see Table 3) and compete with the endemic and native taxa, which should be prevented by strict controls, *e.g*. of introduced plant material.

Among the endemic bee species of Madeira Island, the females of *Halictus frontalis* are not able to find plenty of pollen in the intensively grazed pasture areas of vegetation series f) (Pol-Er). This vegetation series was newly detected in this study as an important habitat type for *H. frontalis*. High nature-value (HNF) farming (Caballero, 2007) would enhance the necessary flower resources of Asteraceae (*e.g*. of the *Taraxacum* group as *T. hamatum*) and further restoration measures to create tree-heath stands (already in progress) that can serve as 'islands' with different flowering resources for different bee species. All other endemic and native bee species obviously have plenty of pollen and nectar resources.

Outlook

The wild bee fauna of Madeira Island is composed of a very limited number of species. These wild bee taxa are endemic or native species; a possible exception is *L. v. villosulum* (probably native). Many of them are widespread. None of the endemic species has undergone further evolutionary inter-island radiations on the island of Madeira, as was the case, *e.g*. with *Hylaeus* in Hawaii (Magnacca & King, 2013), and also to a lesser extent on the subspecies level in the *Andrena acuta* – group (Tenerife, near relative to *A. wollastoni*) (Kratochwil, 2020). In Tenerife, a colonisation after the connection of the former palaeo-islands is supposed. There were then 'inland islands' covered with vegetation and surrounded by lava flows (the 'kipuka scenario' presented by Machado, 1976, Machado *et al*., 2017). 'Kipukas' are the remnants of the original habitats in the area surrounded by lava flows (Vandergast & Gillespie, 2004).

There was only a splitting of species (*Andrena dourada* versus *A. wollastoni*, *Andrena portosantana* versus *A. maderensis*) between the much older island of Porto Santo and Madeira Island (Kratochwil, 2020). The origin

[2] Prŷs-Jones *et al*. (2018) assume that *Bombus terrestris* in the Azores is a more recently introduced species related to introduction for crop pollination (*e.g*. tomatoes). They cite its low genetic differentiation (barcoding analyses by Weissmann *et al*., 2017) and current presence on all nine islands of the Azores as justification for this position. The companies that manage breeding and shipping of *Bombus* individuals for crop pollination are Koppert (Straelen, Germany) and Biobest (Westerlo, Belgium). These introduced bumblebees belong to the central European subspecies *B. t. terrestris*. However, an evaluation of a larger series of bumblebees from S. Miguel (Azores), collected by A. Kratochwil and A. Schwabe in May 2022, has shown (n.p.) by morphological analysis that the populations correspond to *B. t. lusitanicus* Krüger, 1956 (Rasmont *et al*., 2008). The barcoding results of Weissman *et al*. (2017) cannot be used, as only few specimens were analysed and in general the subspecies level can hardly be distinguished by this method. COI sequences of specimens of H. Schaefer (Technical University, Munich, Germany) from the Azores B65-B67, acc. no. KX824773-75, were identical on the one side to a a sequence of *B. terrestris* sequence from Denmark and on the other side to a sequence of *B. maderensis* Erlandsson, 1979 (= *B. terrestris lusitanicus*) from Madeira in GenBank. The queens and workers from Madeira Island can also be clearly morphologically assigned to the subspecies '*lusitanicus*'. However, introgression with the Central European populations is always possible, and it is a gradual process that ultimately dissolves the subspecies boundaries.

of these species that evolved into endemic ones was demonstrated in the case of *Andrena wollastoni* and *A. maderensis* (Kratochwil, 2020, Kratochwil *et al*., 2021). Their ancestors originated from North Africa. Other species, such as *Bombus terrestris lusitanicus*, *B. r. ruderatus*, or *Amegilla quadrifasciata* s.l. originated from southern Europe. Introduced species usually have a Central European origin. Among the endemic species, *Andrena wollastoni*, which is only 7.6 mm in female body size (males 6.4 mm), plays a major role as a generalist. Considering the differences in the climatic-hygric conditions of the vegetation series, this is astonishing. The ancestors of *A. wollastoni* from the Canary Islands (Kratochwil et al., 2021) have much smaller niche widths (Kratochwil & Schwabe, 2020). The endemic species *Lasioglossum wollastoni* shows a similar habitat amplitude as *A. wollastoni*.

Four species with larger body sizes occur, mainly in the temperate zone of the island, as well as in zones a) to c): *B. terrestris lusitanicus* (queen: body size: 20-25 mm, worker: 12-18 mm) and the endemic *Halictus frontalis* (body size: 11 mm, preference for Asteraceae), along with *Amegilla q. maderae* (14-15 mm) and the probably introduced *B. r. ruderatus* (queen: body size 21-24 mm, worker: 11-18 mm).

The few wild bee species of Madeira Island cover a considerable number of plant species and plant family spectra in their flower-visiting behaviour, and ensure pollination for most of them. Whether the wild bee community of Madeira Island is saturated or not is difficult to answer. It appears that the introduced wild bee species currently do not have a large dispersal potential. However, long-term monitoring is absolutely necessary, as discussed in the example of introduced *Bombus terrestris* colonies (Dafni *et al*., 2010).

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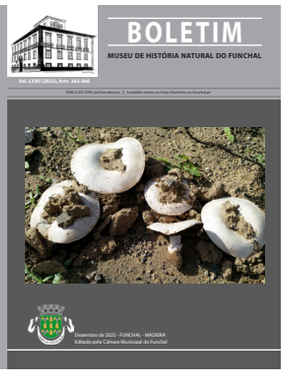

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CORRECTIONS & AMENDMENTS

Author correction: Birds of the archipelagos of Madeira and the Selvagens III – New records and checklist update (2010-2020)

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In the version of this article initially published, the original reference given for *Passer hispaniolensis* (Table 3, p. 20) is not correct. The correct reference should be Sarmento, 1936.

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