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***Andrena (Suandrena) portosanctana* COCKERELL, 1922 and *A. (Suandrena) maderensis* COCKERELL, 1922 – new taxonomical and ecological data for two closely related endemic bee species of the Madeira Archipelago, Portugal**

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**A b s t r a c t :** *Andrena (Suandrena) portosanctana* COCKERELL, 1922, endemic to Porto Santo, Madeira Archipelago, Portugal, was described by Cockerell on the basis of three females collected in the year 1921. No further specimens were found until the year 2011, when two females of this species (collecting date 1995) were detected in a German private collection. In the year 2012 several females and, for the first time, some males were collected by two of the authors in Porto Santo (eight localities). A differential diagnosis of *A. portosanctana* compared to its probably closest relative *A. maderensis* COCKERELL, 1922 (endemic to Madeira Island) is given. Different morphological features could be demonstrated, e.g., for the following structures: length of body, wings, clypeus, pterostigma, basal area of propodeum, width of apical process of labrum basal area, puncturing of clypeus and mesoscutum, structure of apical process of labrum basal area and basal area of propodeum, colour of flagellomeres, pubescence colour of head, mesosoma, corbiculae and metasoma. It can be clearly shown that these morphological characteristics support the differentiation of two different species. Further data for *A. portosanctana* and *A. maderensis* regarding distribution ranges, habitats, flight times and specific flower-visiting behaviour as well as the role of former and recent human impact for the population size of *A. portosanctana* are presented. Both species are considered to be oligolectic in pollen foraging for Brassicaceae species. Aspects of the potential mainland ancestor as well as evolutionary and biogeographical aspects including other wild-bee species of the Madeira Archipelago are discussed. Given the limited pollen resources available in various Brassicaceae species, *A. portosanctana* is probably an endangered species with small population sizes; therefore a special conservation program should start to avoid extinction.

**K e y w o r d s :** Andrenidae, island biogeography, species diversification, flower-visiting behaviour.

### Introduction

COCKERELL (1922) described two *Suandrena* species for the Madeira Archipelago: *Andrena maderensis* COCKERELL, 1922 and *A. portosanctana* COCKERELL, 1922. In contrast to *A. maderensis*, which is morphologically well characterised and common on Madeira Island, until now the morphological analysis of *A. portosanctana* was based only on three females collected by Cockerell in January 1921 on Porto Santo Island.

No male of *A. portosanctana* was detected by Cockerell or anybody else, nor was there any evidence of the existence of further female individuals. Due to the unknown existence of syntypes and in absence of further specimens of this species the *Andrena* specialist Robert Wilhelm Grünwaldt, Munich, Germany (1909-2003), doubted the validity of *A. portosanctana* as distinct species (WARNCKE 1967). He argued that the short distance between Porto Santo Island and Madeira Island, only 45 km, should not serve as strong barrier for such large bee individuals. Grünwaldt had never seen the types of *A. portosanctana*. According to GUSENLEITNER & SCHWARZ (2002) *A. portosanctana* is a synonym for *A. maderensis*. This is also argued in the Fauna Europaea (DE JONG 2013).

In contrast, WARNCKE (1967) gave *A. portosanctana* the status of a subgenus (*A. m. portosanctana* COCKERELL, 1922), according to the oral contribution of Grünwaldt. WARNCKE (1968) defined *A. m. maderensis* COCKERELL 1922, endemic to Madeira Island, as nominate species. Besides *A. m. portosanctana* (Porto Santo), WARNCKE (1968) considered two other taxa as subspecies of *A. maderensis*: *A. m. notata* WARNCKE, 1968 (Canary Islands) and *A. m. fratella* WARNCKE, 1968 (Morocco); see also GUSENLEITNER & SCHWARZ (2002). DYLEWSKA (1983) objected in analogy to Grünwaldt, that types of *A. maderensis* do not exist; in her opinion a differentiation in the subspecies *A. m. maderensis* and *A. m. portosanctana* is not possible without analysing the types.

In the course of our studies we detected two of the three syntypes of *A. portosanctana*. Syntypes of females have been designated, because no holotype was dedicated in the species description. The first syntype is deposited in the California Academy of Science, California, San Francisco, USA (CAS TYPE 15373: syntype, female, adult), the second one in the Department of Entomology, NMNH, Smithsonian Institution, Washington DC, USA (USNM 24656, barcode number 00533697). Here we present both syntypes of *A. portosanctana* by photos in lateral view, dorsal view, head profile and by labels (Fig. 1-8). We were not able to discover where the third female is (was) deposited.

Madeira Island (728 km<sup>2</sup>) is inhabited by 16 wild-bee species (eight endemic, three native, five introduced or not permanently established) in contrast to Porto Santo Island (42 km<sup>2</sup>), where eight bee species (five endemic, three native, one introduced) were detected (KRATOCHWIL et al. 2008). Some species occur on both islands, e.g., *Amegilla quadrifasciata maderae* (SICHEL, 1868), *Bombus maderensis* ERLANDSSON, 1979, *Lasioglossum villosulum* (KIRBY, 1802), *Lasioglossum wollastoni* (COCKERELL, 1922).

But there are bee species with a remarkable allopatric distribution, if Madeira Island and Porto Santo are compared, although the distance of 45 km between these islands should usually not act as a strong dispersal barrier, especially for larger bee species (e.g. species with more than 10 mm body length). But the different age and colonization history of the two islands (Porto Santo 14 million years old, Madeira 4.6 million years old; GALOPIM DE CARVALHO & BRANDÃO 1991, GELDMACHER et al. 2000) and the trade winds blowing from the Northeast (preventing eastward dispersal), could be arguments for the occurrence of two different endemic *Suandrena* species.

KRATOCHWIL & SCHEUCHL (2013) documented recently that *A. wollastoni* COCKERELL, 1922 (Madeira Island) differs from *A. dourada* KRATOCHWIL & SCHEUCHL, 2013 (endemic to Porto Santo) in many morphological features (females: e.g. length of body, wings, clypeus, stigma, propodeum; facial fovea index; pubescence colour of, e.g.,

paraocular area, tibial scopa, tergites 5 and 6, labrum process structure, propodeum sculpture; males: e.g. length of body, wings, clypeus, stigma; width of labrum process; propodeum sculpture). *A. dourada* is a species of its own, formerly grouped to *A. wollastoni*. Another example is *Osmia madeirensis* VAN DER ZANDEN, 1991 (endemic to Madeira Island) and *O. latreillei iberoafricana* (PETERS, 1975) (native in Porto Santo, but also in mainland Europe and also in North-Africa). We hypothesise the occurrence of another species pair: *Andrena maderensis* COCKERELL, 1922 (endemic to Madeira Island) and *A. portosanctana* COCKERELL, 1922 (endemic to Porto Santo).

89 years after the first description by COCKERELL (1922) two females of *A. portosanctana* were detected in the year 2011 in the private collection of Christoph Saure (Berlin, Germany). The two females were collected by Gerhard Jaeschke (Berlin), a radiologist and ambitious hobby entomologist (KLIMA 1995). Both females were labelled by Fritz Gusenleitner (Linz, Austria) as *Andrena cyanomicans* PÉREZ, 1895, and this information was published by FELLENDORF et al. (1999). Erwin Scheuchl identified the specimens as *A. portosanctana* in November 2011; this is in total congruence with the species description by COCKERELL (1922). In view of these findings we increased our efforts to study *A. portosanctana* by searching for further females and the so far unknown male. We were successful in detecting 19 females and 5 males in the year 2012 and managed to study the flower-visiting behaviour of some of these individuals.

First we will characterise *A. portosanctana* concerning morphology of females and males, distribution, habitats, flight time and flower-visiting behaviour. According to the hypothesis of the close relationship between the two species, we will subsequently analyse *A. maderensis* in the same way. Additionally we will give ecological characterisations (habitats, flight times, flower-visiting behaviour). A differentiating diagnosis will follow for the two species. Thereafter we will discuss the relationship of both species to other *Suandrena* species, and furthermore add some biogeographical aspects and consider origin and relationship of *A. portosanctana* and *A. maderensis* in combination with the evolutionary background. The role of former and recent human impact regarding the population size of *A. portosanctana* and aspects of nature conservation will also be discussed.

## Material and methods

The Madeira Archipelago is situated above the Azores Ridge 32.30° N to 33.30° N and -16.30° E to -17.30° E in the Atlantic Ocean, all about 560 km away from Morocco and 978 km from Lisboa (Portugal). It includes Madeira Island (728 km<sup>2</sup>), Porto Santo Island (42 km<sup>2</sup>, 45 km northeast), Ilhas Desertas (three small islands, 24 km westward) and some other small islands.

According to GALOPIM DE CARVALHO & BRANDÃO (1991) and GELDMACHER et al. (2000) the age of the Madeira Archipelago ranges from 3.6 to 14 million years (Porto Santo: 14, Madeira: 4.6, Desertas: 3.6). During the last glacial period (optimum 18,000 years BP) Madeira and the Desertas were probably connected by a landbridge (BREHM et al. 2003) (today depth of the sea about 90 m). During the past millions of years the distance from the European continent was influenced by processes of continental drift, sea-level variations and geological processes of emergence and erosion of landbridge islands. In most of all cases sea-level variations represent the most important influencing factors.

Reconstructions of the glacial coast line during the last glacial optimum (18,000 years BC) demonstrate that the sea was 120 m deeper than today. Furthermore, many islands covered larger areas than today and were situated above sea-level (currently below sea-level); see GARCIA-TALAVERA (1999). MOORE et al. (2002) thus assume a minimal distance of 200 km from the European continent in former times.

Madeira Island is very mountainous and rich in barrancos; the highest elevation is the summit of 'Pico Ruivo de Santana' (1862 m a.s.l.). The coast lines are generally steep. In contrast the island of Porto Santo is much more flat; the highest peak 'Pico do Facho' reaches 517 m a.s.l. In contrast to Madeira Island Porto Santo has a band of sandy flat coastal line 10 km long. The highest point of Deserta Grande is unnamed (461 m a.s.l.); the coastal slopes are steep.

The Madeira Archipelago belongs to the Biogeographic Region 'Mediterranean', Subregion 'Madeiran'; RIVAS-MARTINEZ et al. (2004). The climate is oceanic, and mostly there are trade winds blowing from northeast. This is the reason why in the northern mountainous areas of Madeira Island the precipitation is higher than in the southern areas. On windward sides the annual precipitation amounts about 3000 mm per year; on lee sides, the precipitation is about 500 to 600 mm per year. The southern coastline and the eastern coastline areas (Ponta de S. Lourenço) are very dry. The mean temperature of Funchal in January is about 16 °C, in July (highest values) nearly 30 °C. The highest values of precipitation are obtained in Funchal from November to February (TAVARES 1965). The oceanic Mediterranean-Madeiran climate allows the existence of laurel forests (Laurisilva). Some of the plant species of Laurisilva are thought to be relicts from the flora of the tertiary period (POTT 2005). In the case of Porto Santo, the altitudes of the mountains mainly do not reach the trade wind zone, therefore for main parts of the island the humid clouds pass away.

In times of the discovery of Madeira Archipelago, Madeira was almost completely covered by forests or shrubs, which is documented by the florentine sea map of the year 1351 (Medici-Laurentian Atlas), where the Madeira island was named 'Isola di Legname' = 'woody island'. In the report of the discoverer João Gonçalves Zarco (\* about 1380; † about 1467) arboreous vegetation was mentioned for the coastal line to the mountain peaks (year 1419). Nowadays the natural vegetation is partly destroyed, fragmented or replaced by secondary vegetation.

The climate of Porto Santo is much drier compared to Madeira Island. The potential natural vegetation with *Dracaena draco* subsp. *draco* (extinct), *Juniperus turbinata* subsp. *canariensis* (rare), *Erica platycodon* subsp. *maderinicola* (rare), *Olea maderensis* (rare), probably with spotty former distribution of *Sideroxylon mirmulans* (rare) and *Apollonias barbujana* (extinct) had been destroyed over wide areas (rare/extinct data according to PRESS & SHORT 1994), in addition, the former soils eroded in a broad scale (FAUST-LICHTENBERGER 1988). In the 15<sup>th</sup> and 16<sup>th</sup> centuries Porto Santo was intensively cultivated after clearing (agriculture, e.g. crops, and livestock breeding) because the island served as one of the most important areas for supplies of food for ships. With the end of the 16<sup>th</sup> century many inhabitants left the island as consequence of the frequent attacks of buccaneers. The agricultural landscape was devastated and erosion and degradation processes started. This was the beginning of an immense loss of synanthropic vegetation types. In the 18<sup>th</sup> century only a few farmers lived there, in great misery. After reforms of the Portuguese government, coordinated by the Marquis of Pombal, Sebastião

José de Carvalho e Mello (1699-1782), the conditions became more favourable to settle as a farmer on Porto Santo Island. Today, ruins of old windmills, terraces and boundary stone walls for erosion shelter are documents of this time. But erosion is an insurmountable obstacle. Since the sixties of the last century agriculture was extremely reduced. Soil erosion control and recovery of endogenous biodiversity are among the main points for municipality, agricultural and environmental entities (DI BERARDINO 2010).

The specimens studied were collected by Anselm Kratochwil, Angelika Schwabe and Claudius Kratochwil (hand netting, pantraps white, yellow, blue) in the years 1995 (31.03.-13.04.), 2005 (24.03.-11.04.) and 2012 (15.03.-22.03.). Concerning *A. portosanctana* we were able to analyse 19 females (18 newly trapped in the year 2012 and one female from the collection of C. Saure) and 5 males (newly trapped in the year 2012), in the case of *A. maderensis* we collected 51 females and 10 males in the years 1995 and 2005 on Madeira Island; 3 further studied males come from the collection of Dr. Herbert Hohmann ('Übersee-Museum' Bremen, Germany).

We analysed various morphological features, e.g., colour and structure of different body parts including pubescence (head: e.g. clypeus, labrum process, antennae, paraocular area, fovea facialis, genae); mesosoma (e.g. mesothorax, mesoscutum, scutellum, basal propodeum, femur, tibia, basiotarsus, mediotarsi, propodeal corbiculae, trochanteral and femoral flocculus, tibial scopa, wings, pterostigma); metasoma.

The following morphometric features were analysed (terms according to MICHENER 2007, TADAUCHI & XU 1995, ARIANA et al. 2009, KRATOCHWIL & SCHEUCHL 2013): body length (BL): in mm from antennal base to tip of pygidium; wing length (WL): length of forewing excluding tegula; tergites 1-5 (T1-5); head length (HL): from top of vertex to lower margin of clypeus; head width (HW); mesosomal width (MsW): between outer rims of tegulae; metasomal width (MtW): maximum width of terga from dorsal view; ocellocular distance (OOD); postocular distance (POD); ocelloccipital distance (OCD), maximal length of facial fovea (FVL); maximal width of facial fovea (FVW); length of flagellomeres 1-3 (FL1-3): measured on ventral surfaces of flagellomeres when antenna stretched forward; puncture diameter (Pd); distance to a nearby puncture (IS); clypeal length (CPL); labrum process (apical process) width at the top (LBW); pterostigma length (PSI); propodeum basal area length (PBAI); SD = standard deviation.

According to MICHENER (2007), the terminology for parts of the labrum is often confused in the genus *Andrena* (especially the term 'process' for the 'basal elevated plate'). He wrote: 'The term process is misleading because this plate does not project, as one expects of a process. In other bees, e.g. the Panurginae (see RUZ 1986), the same structure is called the basal area of the labrum. Use of the word 'process' in the sense of basal area is further confusing because in some bees, especially the Halictidae, there is an entirely different process on the apex of the labrum, here called the apical process of the labrum.'

In the following we differentiate the labrum in a) basal area, b) apical (distal) process of the basal area, c) vertical area, d) margin of the basal area (Fig. 9).

If an apical process is absent, the basal area can be developed broadly as a semicircle (e.g. female of *A. rufizona* IMHOFF, 1834) or trapezoid (female of *A. bimaculata* [KIRBY, 1802]). In many cases the basal area is more or less narrow (female of *A. minutuloides* PERKINS, 1914; female of *A. barbilabris* KIRBY, 1802). The fact that there are many examples of such a narrower basal area had led to the synonymous use of the term 'pro-

cess'. In some cases an apical process is well developed and the basal area can be differentiated by a characteristic form of margins (e.g. female of *A. coitana* [KIRBY 1802]). If the margin has an irregular shape it is difficult to detect the apical process of the basal area (e.g. female of *A. lathyri* ALFKEN, 1899). The form of the apical process can be also characterised as e.g. square-based, trapezoid or ligular, as emarginated or not.

In *A. maderensis* the apical process is well developed. We measured the apical process width at the top. In *A. portosanctana* an apical process is missing or extremely fragmented. We measured the length of the apical part of the trapezoid labrum, which is as a rule the base of the apical process.

A special type is found e.g. in females of *A. labiata* (KIRBY, 1802) or females of *A. ovatula* (KIRBY, 1802) where the distal end of the basal area is emarginated but not exposed. This is effected by three separated hollows with hairs. Two 'bridges' of the basal area situated between the hollows reach into the vertical area and are more or less hairless. A similar situation is given in the case of the males of *A. maderensis* and parts of *A. portosanctana*. Here we measured the width of the emarginated area including the width of the both 'bridges'.

Boxplots were constructed by Excel 2010. The bottom and top of the box are the 25<sup>th</sup> and 75<sup>th</sup> percentile (lower quartile and upper quartile), and the band near the box is the median (50<sup>th</sup> percentile), the point is the arithmetic average. The ends of the vertical lines or 'whiskers' indicate the minimal and maximal data values.

The nomenclature for plant species names follows JARDIM & SEQUEIRA (2008). One plant species was newly described in the year 2010: *Echium portosanctensis* CARVALO, PONTES, BATISTA-MARQUES & JARDIM.

## Species descriptions

### 1. *Andrena (Suandrena) portosanctana* COCKERELL, 1922

*A. maderensis portosanctana* COCKERELL, 1922

**S t a t u s :** The first who discussed the question of the status of *A. portosanctana* after COCKERELL (1922) was WARNCKE (1967). He referred to an oral communication of Grünwaldt and noted that *A. portosanctana* is only a subspecies of *A. maderensis*. Neither Warncke nor Grünwaldt, ever saw specimens of *A. portosanctana*.

### Former Descriptions

In the first description by COCKERELL (1922), females are only differentiated on the basis of some morphological features:

'Female. – Like *Andrena maderensis*, and differing similarly *A. bimaculata*, but the thin abdominal hair-bands are white, without any fulvous tint, the apical tuft is black; the wings are clearer, not so red; the hair of front and vertex (but not occiput) is black, and on face dull white, but there is a conspicuous reddish band from eye to eye at level of antennae; the discs of mesothorax and scutellum have pure black hair, that on pleura is long and white; the process of labrum is more rounded, without a distinct point or tubercle; the clypeus, though shining, lacks a distinct smooth median line. The greenish tint of the abdomen is very obscure.'

POPOV (1958) published an identification key for species of the subgenus *Plastandrena* and incorporated erroneously *A. maderensis* and *A. portosanctana* at the basis of Cockerell's description in this subgenus.

### Up-to-date description

**Female.** BL 12.27 mm (SD 0.42), WL 8.77 mm (SD 0.42).

**C o l o u r .** Head (Fig. 3, 7): black, part slightly greenish; flagellomeres 3-10: upper side brownish, lower side yellow; mandible black, as a general rule with a reddish tip. Mesosoma (Fig. 1, 2, 5, 6): black; femur and tibia 1 and 2 black, tibia 3 sometimes pars parte reddish brown; metatarsi 1 and 2 brown, metatarsus 3 pars parte reddish-brown, mediotarsi black, pars parte reddish brown; wings hyalin, veins brown (reddish/black), pterostigma orange (yellowish) with a dark margin. Metasoma (Fig. 2, 6): T1-4 black partly greenish (see description by COCKERELL 1922), with black to dark reddish brown depression zones; pygidium black.

**P u b e s c e n c e .** Head (Fig. 3, 7): white hairs in front, yellowish hairs beside and between the antennal sockets (see description by COCKERELL 1922: 'there is a conspicuous reddish band from eye to eye at level of antennae'; Fig. 7); upper part of paraocular area with brownish hairs; clypeus as a general rule only with laterally denser yellowish-white hairs; scapus with yellowish hairs and some brownish hairs; genal area with dense whitish hairs (in many cases brighter than the paraocular hairs), Fig. 5; lower part of facial fovea with whitish hairs, upper part with brownish hairs; vertex with some dark brownish (black) hairs. Mesosoma: mesoscutum and scutellum with lateral yellowish-white hairs (Fig. 2, 6), in the centre only some brownish hairs (only in some cases black hairs; compare the description by COCKERELL 1922); mesepisternum with longer yellowish-white hairs (Fig. 1, 5); propodeal corbicula with dense white marginal hairs, no hairs in the centre; trochanteral and femoral flocculus well developed with long white hairs (Fig. 1, 5); dorsal tibial scopa with reddish-brown hairs and brownish tips, dorsobasal tibial scopa with brownish hairs (Fig. 5); ventral tibial scopa with yellowish whitish hairs (Fig. 5). Metasoma (Fig. 1, 2, 5, 6): T1-4 with white partly closed thin hair bands, T5 in the centre with dark brownish hairs, lateral with long white hairs, T6 with dense dark brownish hairs reaching to pygidium, centre of T1 and T2 with longer, T3-4 with shorter whitish hairs.

**S t r u c t u r e .** Head (Fig. 3, 7): HL/HW = 0.83 (SD 0.02); HW:MsW:MtW = 1.1:1.1:1.0; vertex narrow, as wide as ocellar diameter, surface structure not rugose; face above antennal fossae with longitudinal rugulae, interrugal space slightly shiny; OOD:POD:OCD = 3.5:2.7:1.0; FL1:FL2:FL3 = 2.4:1.1:1.0; inner margin of eyes not converging; FVL = 1.36 mm (SD 0.08), FVW = 0.31 mm (SD 0.03), FVL/FVW = 4.39 (SD 0.30); facial fovea at the base narrower; clypeus convex, front very shiny without punctures, other area also shiny and smooth, as a general rule without impunctate median line (see the description of COCKERELL 1922), punctured, from the centre to the base shagreened; shallow punctures (Pd = [14] 28-42  $\mu$ m, IS = 14-56 [70]  $\mu$ m); CPL = 1.26 mm (SD 0.07); labrum with basal area margin rounded, as a general rule slightly trapezoid (sometimes undulated or curled) contrary to the description of COCKERELL 1922: 'the process of labrum is more rounded, without a distinct point or tubercle') mostly with a fragmented apical process (sometimes asymmetric and/or emarginated), vertical area with long yellowish/reddish hairs; LBW = 1.26 mm (SD 0.02). Mesosoma

(Fig. 2, 6): shagreened, shallow punctured (Pd = 28 µm); PSI = 1.25 mm (SD 0.07); rugose, as a general rule some longitudinal lamina, small central lateral boundary line, PBAI = 0.50 mm (SD 0.03). Metasoma (Fig. 2, 6): smooth and shiny, scattered punctured (Pd = 14-28 µm), posterior depression of T1-T5.

**Male.** BL 9.99 mm (SD 0.58), WL 7.77 mm (SD 0.33).

**Colour.** Head: black, part slightly greenish; flagellomeres 3-10: lower side brownish, upper side black/dark brownish; mandible black with a reddish tip. Mesosoma: black; femur and tibia 1 and 2 black, tibia 3 pars parte reddish brown; metatarsi 1 and 2 brown, metatarsus 3 pars parte reddish-brown, mediotarsi black, pars parte reddish brown; wings hyalin, veins brown (reddish/black), pterostigma orange (yellowish) with a dark margin. Metasoma: T1-4 black partly greenish, with black to dark reddish brown depression zones; pygidium black/reddish.

**Pubescence.** Head (Fig. 12): white hairs in front, yellowish hairs beside and between the antennal sockets, upper part of paraocular area with brownish hairs; clypeus with whitish lateral hairs, hair free line in the centre; scapus with whitish hairs, brownish hairs behind antennal socket; dense whitish hairs, brighter than paraocular hairs, upper area with brownish hairs; vertex with dark brownish (black) hairs. Mesosoma (Fig. 12): mesoscutum and scutellum with whitish hairs lateral, in the centre only few hairs, some brownish; mesepisternum with long whitish hairs. Metasoma (Fig. 12): T2-4 with whitish thin hair bands, in the centre slightly open, T6 central with reddish, lateral whitish hairs, T7 with reddish hairs, in the centre T1 and T2 with long, T3-4 shorter whitish hairs; T8 narrow with white hairs.

**Structure.** Head: HL/HW = 0.81 (SD 0.04); HW:MsW:MtW = 1.2:1.1:1.0; vertex and face above antennal fossae similar to female; OOD:POD:OCD = 3.5:2.6:1.0; FL1:FL2:FL3 = 1.5:1.1:1.0; inner margin of eyes not converging; vertex narrow, as wide as ocellar diameter; clypeus structure similar to female (Pd = 28-42 µm, IS = 14-42 µm), CPL = 1.05 mm (SD 0.04); labrum basal area flat and rounded, without exposed apical process, beneath in the centre a hollow with whitish/yellowish hairs, left and right with a hairless area, followed by an area with long yellowish hairs; width of the emarginated area including the width of the two 'bridges' = 0.21 mm. Mesosoma: mesoscutum and scutellum shagreened, scattered shallow punctured (Pd = 28 µm); PSI = 1.07 mm; propodeum rugose in the centre, no lateral boundary line; PBAI = 0.42 mm (SD 0.04). Metasoma: smooth and shiny, very scattered punctures (Pd = 14-28 µm), slightly shagreened, posterior depression of T1-T5.

**Genitals:** Fig. 13, 14.

**Specimens examined** (identity number, sex, locality, altitude above sea level, latitude and longitude coordinates, flower-visiting behaviour, date of collection; PS: private collection A. Kratochwil, CS: private collection C. Saure): Females: PS12/29-PS12/34: 6 ♀♀, Porto Santo, east of Campo de Baixo, south of restaurant 'Mare Sol', dune area, 5 m, 33°02'53.33"N, -16°20'50.46"E, *Cakile maritima* subsp. *maritima*, 17.03.2012; PS12/53, PS12/60, PS12/65, PS12/69, PS12/70, PS12/72, PS12/73: 7 ♀♀, Porto Santo, Campo de Baixo, Estrada dos Carreiros, dune area, 5 m, 33° 02'45.58"N, -16°21'0.22"E, *Cakile maritima* subsp. *maritima*, 18.03.2012; PS12/82: 1 ♀, Porto Santo, Vereda do Pico Branco, fallow land, 310 m, 33°05'31.84"N, -16°18'17.16"E, *Calendula arvensis*, 19.03.2012; PS12/142: 1 ♀, Porto Santo, Vila Baleira, near sports field, ruderal site, 25 m, 33°02'35.16"N, -16°21'38.48"E, *Asphodelus fistulosus*, 20.03.2012; PS12/150, PS12/151, PS12/153: 3 ♀♀, Porto Santo, Campo de Baixo, near tennis court, ruderal, fallow land, 20 m, 33°02'50.07"N, -16°21'23.35"E, *Sinapis arvensis*, 20.03.2012; PS12/154: 1 ♀, Porto Santo, Capela de S. Pedro, ruderal site, 50 m, 33°02'44.85"N, -16°21'43.82", *Rapistrum*



*rugosum*, 20.03.2012; CS1: 1♀, surrounding Hotel Luamar, dune area, 5 m, 33°02'12.80"N, 16°21'36.86"E, 18.03.1994, leg. G. Jaeschke. Males: PS12/35: 1♂, Porto Santo, east of Campo de Baixo, south of restaurant 'Mare Sol', dune area, 5 m, 33°02'53.33"N, -16°20'50.46"E, *Cakile maritima* subsp. *maritima*, 17.03.2012; PS12/41M: 1♂, near Pico da Cabrita, fallow land, 230 m, 33°05'42.18"N, -16°19'04.49"E, 18.03.2012; PS12/66-PS12/68, PS12/74: 4♂♂, Campo de Baixo, Estrada dos Carreiros, dune area, 5 m, 33°02'45.58"N, -16°21'0.22"E, *Cakile maritima* subsp. *maritima*, 18.03.2012.

### Historical records

- COCKERELL (1922): 3♀♀ collected in January 1921, Porto Santo, in the south of Pico do Castelo on flowers of *Oxalis pes-caprae* and *Calendula*.
- FELLENDORF et al. (1999): 2♀♀ (collection of C. Saure, Berlin) were collected by G. Jaeschke (Berlin) in the surrounding of Hotel Luamar (18.03.1994) determined by F. Gusenleitner (Linz) as *Andrena cyanomicans*. Both were identified as *A. portosanctana* (see Introduction).
- FELLENDORF et al. (1999): 3♀♀, visiting flowers of the Brassicaceae taxa *Cakile maritima* and *Raphanus* sp. (18.03.-30.03.1997), were identified by the authors as *A. cyanomicans*. According to FELLENDORF et al. (1999) 1♀ had been deposited in the Bavarian State Collection of Zoology (Munich). Unfortunately the specimen sent to the Bavarian State Collection was lost before deposition by the courier (Schönitzer, Bavarian State Collection of Zoology Munich, pers. communication). It is quite evident that FELLENDORF et al. (1999) had not taken the original description of COCKERELL (1922) as a basis for the identification of *A. portosanctana*. They wrote: 'We were unable to collect the species [*A. portosanctana*] on the island, despite careful search.'

### Distribution and habitat characteristics

25 individuals of *A. portosanctana* were detected on more than one-third of all investigated localities (eight from 21 localities, distributed all over the island). Therefore we can assume that *A. portosanctana* is widely distributed on Porto Santo. The range of altitudes reaches from sea level (drift line) up to 310 m a.s.l. Individuals of *A. portosanctana* were found primarily in the infra-Mediterranean-Madeiran and lower thermo-Mediterranean-Madeiran thermotypes (terminology according to CAPELO et al. 2004).

Most individuals (n = 18) were detected in the dune zone with occurrence of *Cakile maritima* subsp. *maritima* (Fig. 15, 16), but also on dry rocky grassland at the base of Pico da Cabrita (230 m a.s.l.) (Fig. 17), on formerly cultivated sites (Pico Branco, Fig. 18); ruderal sites or cultivated field margins near Vila Baleira and Campo de Baixo (Fig. 19, 20).

### Flight time records

As yet flight activity has been detected from January (observation of Cockerell) to the end of March.

### Flower-visiting behaviour

Flower visits by females and males have been observed by A. Kratochwil and A.

Schwabe on individuals of five plant taxa belonging to four plant families: Brassicaceae: *Cakile maritima* subsp. *maritima* (Fig. 11): 13 ♀ ♀, 6 ♂ ♂ patrouillant on flowers; *Sinapis arvensis*: 3 ♀ ♀; *Rapistrum rugosum*: 1 ♀, Asphodelaceae (Liliaceae s.l.): *Asphodelus fistulosus*: 1 ♀; Asteraceae: *Calendula arvensis*: 1 ♀. Additionally there is the observation of 3 ♀ ♀ made by COCKERELL (1922): Oxalidaceae: *Oxalis pes-caprae*: 1 ♀; Asteraceae: *Calendula arvensis*: 1 ♀; 1 ♀ not assigned.

The Brassicaceae-dominated flower visits of pollen-collecting females is consistent with the hypothesis, that the species of the subgenus *Suandrena* prefer this family (DYLEWSKA 1983, KRATOCHWIL 1991).

### **Flower-visiting behaviour in an evolutionary, historical and biogeographical context**

The currently known pollen resource spectrum of *A. portosanctana* is dominated by flower visits on *Cakile maritima* subsp. *maritima*. This annual species grows in sandy driftline habitats. The fruits (distal segments) can float even for longer distances and periods in seawater. The seeds from the proximal segments are dispersed by wind (DAVY et al. 2006). Within the Madeira Archipelago sandy coastal habitats exist only in Porto Santo; *Cakile maritima* subsp. *maritima* is restricted to Porto Santo (PRESS & SHORT 1994). These sediments are of quarternary origin, where the sand was blown out from the large shelf of the island, which had become dry during glacial times. Eolianites (dunes of crossbedded marine bioclastic calcarenite, age: 21.570 and 13.480 B.P., main Würm), reach up to a thickness of 50 m. Eolianites are rich in fossil land snails (LIETZ & SCHWARZBACH 1971). The colonization by the ancestor of *A. portosanctana* probably took place much earlier than the development of the dunes and the sandy coast (including the habitat of *Cakile maritima* subsp. *maritima*). Therefore the question arises of potential pollen resources within the Brassicaceae especially in former times (probably since Miocene).

There are three endemic plant species of Brassicaceae which occurred in Porto Santo Island before human settlement and still exist now, but today mostly in very reduced individual numbers.

- *Erysimum arbuscula*. The habitats of this endemic species are rock crevices on the peaks and higher slopes from 300-450 m a.s.l. *E. arbuscula* is a member of the Siderito multiflorae-Echietum portosanctensis, a nanophanerophytic community characterised by further endemic species (e.g. *Echium portosanctensis*). The community occurs in the vertical cliffs of the Pico Branco in the northern slopes of the island (Mediterranean xeric-oceanic, infra-Mediterranean dry climate) (CARVALHO et al. 2010, COSTA et al 2012). According to PRESS & SHORT (1994) *E. arbuscula* was formerly locally abundant but now reduced by overgrazing in places accessible for sheep and goats.

This species is also an element of the Erysimo arbusculae-Artemisietum argenteae (CAPELO et al. 1999), but only in primary habitats (CAPELO et al. 2003).

- *Matthiola maderensis*. The habitats are costal rocks and cliffs, 'fairly frequent in Porto Santo and sometimes found inland, recorded growing at altitudes of up to 200 m on Pico do Castelo' (PRESS & SHORT 1994). *M. maderensis* is an element of

the *Limonietum pyramidati*, a chasmophytic phytocoenosis found under the impact of sea salt spray in Porto Santo's northern arenitic cliffs (JARDIM et al. 2003). Another plant community in which *M. maderensis* occurs is the *Euphorbio paraliae-Lotetum glauci*, a chamaephytic community of elder dunes of southern Porto Santo (JARDIM et al. 2003).

- *Crambe fruticosa* is only locally common in the areas of Ana Ferreira, Branco and Castelo (PRESS & SHORT 1994). According to COSTA et al. (2012) *C. fruticosa* occurs in the Gennario *diphyllae-Euphorbietum piscatoriae*, a nanophanerophytic community on basaltic substrate of Porto Santo. In the Table of COSTA et al. (2012) the altitude of the relevés with *Crambe fruticosa* is between 330 and 390 m a.s.l. Additionally there are occurrences on basaltic leptosols at low altitudes (120-300 m a.s.l.) in the *Loto macranthi-Phagnaletum lowei* (COSTA et al. 2012).

We observed *A. portosanctana* collecting pollen on flowers of two other Brassicaceae species: *Rapistrum rugosum* and *Sinapis arvensis*. In the last centuries the abundance of both species was probably much higher than today, because they were favoured by the agricultural impact.

*Andrena portosanctana* prefers Brassicaceae species, but species of other plant families were also visited. It is not clear if the reason was a severe lack of Brassicaceae, as we observed in March 2012 after a dry winter.

The following ruderal plant species were visited by *A. portosanctana*:

- *Asphodelus fistulosus* (Liliaceae) is an annual or short-lived perennial; habitats are roadsides, cultivated ground, and dry sandy places; common in Porto Santo (PRESS & SHORT 1994).
- *Calendula arvensis* (Asteraceae) is a common annual weed of waste and cultivated ground, margins of pastures and roadsides mainly throughout the upper regions of Porto Santo.
- *Oxalis pes-caprae* (Oxalidaceae): The polyploid *O. pes-caprae* is an invasive species, native to the Cape Region of South Africa. *O. pes-caprae* was introduced by cultivation in Great Britain in 1757. The first record from the wild was in 1901 (Guernsey). *O. pes-caprae* was imported in the Mediterranean area in the beginning of the nineteenth century, probably by an Italian monk, and first introduced in a botanical garden at Floriana (Malta), from which it escaped (PIGNATTI 1982, BRANDES 1991). According to PRESS & SHORT (1994) 'commonly cultivated as an ornamental and widespread as an escape by waysides and on waste ground around houses'. Large areas are dominated by this weedy species (Fig. 18). The observations of COCKERELL (1922) support that already 100 years ago there were high population sizes of *Oxalis pes-caprae*.

## 2. *Andrena (Suandrena) maderensis* COCKERELL, 1922

*Andrena bimaculata* KIRBY? var.

*Andrena maderensis maderensis* COCKERELL, 1922

**S t a t u s :** The types of *A. maderensis* (four females and two males) are not deposited in the University Museum, Hope Entomological Collections, Oxford as mentioned by FELLENDORF et al. 1999 (confirmed by James E. Hogan; Oxford), but are in the British Museum of Natural History, London; see GUSENLEITNER & SCHWARZ (2002). In the

Entomology Collection Data Base (<http://www.nhm.ac.uk/research-curation/scientific-resources/collections>) only four syntypes and one possible syntype (primary type number 17a.2820) are listed. The sixth possible syntype seems to be lost.

WARNCKE (1968) defines the nominate species *Andrena m. maderensis* COCKERELL, 1922 (Madeira) based on one male and one female (Cotypes of *A. maderensis* Cockerell, 1922, Museum of Natural History, London) and one male collected on 13.06.1957 by Lindberg (Vale Paraíso west of Camacha, Madeira), which was deposited in the collection of Grünwaldt. Today, this specimen is not part of the collection of Grünwaldt (Bavarian State Collection of Zoology, Munich) but the accompanying female exists (Fig. 21). In the nineties, E. Scheuchl analysed the male and made drawings. Today this specimen seems to be lost.

### Former Descriptions

In the first description by COCKERELL (1922) females and males were differentiated only on the basis of some morphological features:

‘Female. – Length about 12 mm.; very close to *Andrena bimaculata* KIRBY, but differing thus: clypeus shining, with well separated punctures, smooth down the middle; labrum fringed with shining red hair, and its process pointed; mesothorax posteriorly not distinctly punctate, and without a shining area; stigma with a strong dark margin; nervures fuscous; second submarginal cell very broad; area of metathorax less distinctly defined and less coarsely sculptured; abdomen distinctly greenish, and first two segments without distinct punctures; hair at apex of abdomen dark reddish; scope of hind tibiae redder, blackened posteriorly. The dark chocolate facial foveae are like those of *bimaculata*.’

‘Male. – similar to *Andrena bimaculata*, but easily separated by the shining clypeus, dark marginated stigma, and other characters as in the female.’

‘Madeira, 4 ♀ ♀, 2 ♂ ♂, in British Museum (T.V. Wollaston). This was recorded by E. Saunders as *Andrena bimaculata* var?’

POPOV (1958) published an identification key for species of the subgenus *Plastandrena* erroneously incorporating *A. maderensis* and *A. portosanctana*. The characterisation is identical with COCKERELL (1922). WARNCKE (1968) published a drawing characterising the genital of *A. maderensis*.

GUSENLEITNER & SCHWARZ (2002) give a more detailed description (translated from German):

‘Taxonomy: ♀ length 14 mm, pubescence brownish yellow, abdomen slightly hairy, hairs stood on end, hair bands only developed as in the centre open, dense hair fringes. The last fringe with brownish hairs, legs reddish-brown; clypeus smooth, not shagreened, moderately scattered punctured, distance about one puncture diameter; labrum process broad and triangular, in front slightly exposed and emarginated in the centre; fovea facialis in the upper part broadened, not deepened or marginated, the width of fovea facialis corresponds to the half of the width of the face; the second flagellar segment corresponds in length to the segments three to five; the third segment is slightly subquadratic, the fourth quadratic, following segments something longer than broad; genae broader than compound eye; lower side of mandibles with a long, broad lamellar appendix; mesoscutum slightly but dense shagreened, slightly/modestly but dense punctured;

basal area propodeum flat but clearly rugose, well developed central lateral boundary line; tergites slightly shagreened, scattered punctate with a distance of two to three diameters; well developed posterior depressions reddish brown more fine and dense punctate; vein black brown, nervulus ends slightly antefurcal; within the subgenus *Suandrena*, *A. maderensis* is characterised by a not 'cutted' pygidium.'

'The ♂ less with longer and more dense yellowish brown hairs; mesoscutum and tergites with dark brown hairs; the second flagellar segment one and a half time longer than the third segment, following segments somewhat longer than broad; clypeus and the other sculpture similar to ♀; colour of tergites black with slightly bluish shine; depressions reddish brown.'

### Up-to-date description

**Female.** BL 14.24 mm (SD 0.55), WL 6.31 mm (SD 0.21).

**C o l o u r .** Head: black, part slightly greenish, flagellum black, flagellomeres brownish (Fig. 24); mandible mostly with a red tip. Mesosoma: black (Fig. 23); femur, tibia 1 and 2 black, tibia 3 pars parte reddish brown; mediotarsi black, pars parte reddish brown (Fig. 22); subhyalin, veins (reddish-black) brown (Fig. 22), pterostigma (orange) yellow with a dark margin. Metasoma: T1-4 black (Fig. 23), with black to dark reddish brown depression zone, depression zone (T4) T5 translucent, reddish brown. T1-4 black partly greenish (see description by COCKERELL 1922), with black to dark reddish brown depression zone; Fig: 23).

**P u b e s c e n c e .** Head: yellowish, sometimes yellowish-reddish hairs in front, longer yellowish-reddish hairs beside/between the antennal socket, upper part of paraocular area with brownish hairs (Fig. 24); scapus and antennal socket longer yellowish-brownish hairs, genal area dense long yellowish hairs; facial fovea lower part yellowish, upper part brownish hairs; vertex with longer brownish, dark brown hairs. Mesosoma: mesoscutum with yellowish-reddish hairs (Fig. 22), sometimes in the centre brownish, scutellum with yellowish-reddish hairs (Fig. 22, 23), mesepisternum with yellowish-reddish, sometimes yellowish hairs (Fig. 22), propodeal corbicula with some yellowish-reddish (yellowish) hairs (Fig. 22), some shorter hairs in the centre, trochanteral flocculus well developed and with yellowish hairs, femoral flocculus with yellowish hairs, tibial scopa dorsal with yellowish-reddish hairs and with brownish hair tips, at the base with brown hairs, ventral with yellowish-reddish hairs (Fig. 22). Metasoma: tergites: T1: with (whitish-yellowish) yellowish hair row and lateral fragmented bands, T2-4 with yellowish hair bands (T4 reduced) (Fig. 23), T2/T3 in the centre open, T5 with dense brownish hairs central, lateral with yellowish hairs (Fig. 22), T6 with dense brownish hairs reaching to the pygidium, in the centre of T1 and T2 with long, T3-4 with shorter brownish hairs.

**S t r u c t u r e .** Head: HL/HW = 0.82 (SD 0.02); HW:MsW:MtW = 1.0:1.0:1.0; vertex narrow, as wide as ocellar diameter; face above antennal fossae with longitudinal rugulae; OOD:POD:OCD = 3.0:2.1:1.0; FL1:FL2:FL3 = 2.5:1.0:1.2; facial fovea FVL = 1.67 mm (SD 0.08), FVW = 0.36 mm (SD 0.03), FVL/FVW = 4.76 (SD 0.53); clypeus convex, front very shiny without punctures, other area also shiny and smooth, usually fragmented median line (Fig. 24), punctured, base shagreened (Pd = [14]28-56[70] µm), IS = 14-70 µm, CPL = 1.44 mm (SD 0.06); apical process of the basal area short trapezoid, usually (slightly) asymmetric and emarginated, sometimes left and right side

thickened, in some cases margin of basal area undulated, beneath with long reddish hairs, LBW = 0.14 mm (SD 0.02). Mesosoma: mesoscutum smooth and shiny, shallow punctured (Pd = 14-28  $\mu$ m), posterior depression of T1-T5; PSI = 1.48 mm (SD 0.06); basal area of propodeum rugose in the centre, only some longitudinal lamina or lamina missing, small central lateral boundary line, PBA1 = 0.61 mm (SD 0.07). Metasoma: smooth and shiny, shallow punctured (Pd = 14-28  $\mu$ m), posterior depression of T1-T5.

**Male.** BL 11.36 mm (SD 0.59), WL 9.17 mm (SD 0.29).

**C o l o u r .** Head: black, part slightly greenish; flagellomeres 3-10: lower brownish, upper side dark brownish (Fig. 27); mandible black with reddened tip. Mesosoma: black; femur and tibia 1 and 2 black, tibia 3 pars parte reddish brown; metatarsi 1 and 2 brown, metatarsus 3 pars parte reddish-brown, mediotarsi black, pars parte reddish brown; wings subhyalin (Fig. 25, 26), veins (reddish-black) brown (Fig. 26), pterostigma (orange) yellow with a dark margin (Fig. 26). Metasoma: T1-4 black partly greenish, with black to dark reddish brown depression zone (Fig. 26), pygidium black/reddish.

**P u b e s c e n c e .** Head: yellowish-reddish hairs in front, longer yellowish-reddish hairs beside/between the antennal socket, upper part of paraocular area with brownish hairs (Fig. 25, 27); clypeus with yellowish lateral hairs, mostly with a hairless line in the centre; scapus with yellowish-brownish hairs and brownish hairs behind antennal socket (Fig. 27); vertex with some longer dark hairs lateral (Fig. 25). Mesosoma: mesoscutum with yellowish-reddish hairs (Fig. 25); scutellum in many cases with lateral (yellowish) reddish-brown hairs (Fig. 26), in the centre with brownish hairs; mesepisternum longer yellowish-whitish hairs (Fig. 25). Metasoma: T1 with a yellowish-whitish hair row, T2-4 with yellowish-whitish hair bands, in the centre mostly open (Fig. 26), T5 with yellowish (reddish) hairs central and lateral whitish (yellowish) hairs, T6 with reddish hairs reaching to the pygidium, in the centre of T1 and T2 (T3) with long whitish, (T3) T4 with shorter reddish hairs. T8 narrow with reddish hairs.

**S t r u c t u r e .** Head: HL/HW = 0.83 (SD 0.02); HW:MsW:MtW = 1.1:1.1:1.0; vertex and face above antennal fossae similar to female; OOD:POD:OCD = 3.3:2.1:1.0; FL1:FL2:FL3 = 1.3:1.0:1.1; clypeus convex, front very shiny as a general rule with some punctures, remaining area punctured, base shagreened, as a general rule without unpunctured fragmented central line (Pd = [14]28-42[52]  $\mu$ m), IS = 14-56[70]  $\mu$ m, CPL = 1.20 mm (SD 0.05); labrum process flat and rounded, without exposed process, beneath in the centre a hollow with yellowish/reddish hairs, left and right with a hairless area, followed by an area with long yellowish hairs, LBW = 0.26 mm (SD 0.03). Mesosoma: shagreened, scattered shallow punctured (Pd 28  $\mu$ m); PSI = 1.33 mm (SD 0.05); propodeum structure rugose in the centre, as a general rule with longitudinal lamina and a small central lateral boundary line, PBA1 = 0.50 mm (SD 0.04). Metasoma: smooth and shiny, very scattered punctures (Pd = 14-28  $\mu$ m), posterior depression of T1-T5.

Genitals: Fig. 28, 29.

**S p e c i m e n s e x a m i n e d** (identity number, sex, locality, altitude above sea level, latitude and longitude coordinates, flower-visiting behaviour, date of collection; MA: private collection A. Kratochwil, UMBB: collection 'Übersee-Museum' Bremen, Germany: Females: MA95/33: 1 ♀, Madeira, Cabo do Castelo, south of Camacha, garden, 500 m, 32°39'51.20"N, -16°50'46.06"E, *Geranium maderense*, 09.04.1995; MA05/29: 1 ♀, Madeira, Ponta de São Lourenço, coastal rock, partly ruderalised, 80 m, 32°44'40.19"N, -16°43'22.21"E, *Rapistrum rugosum*, 26.03.2005;

MA05/40: 1 ♀, Madeira, Ponta de São Lourenço, coastal rock, partly ruderalised, 70 m, 32°44'44.34"N, -16°43'16.19"E, 26.03.2005; MA05/138-MA05/141: 4 ♀ ♀, Madeira, Larano east of Porto da Cruz, vegetable garden, 280 m, 32°45'45.14"N, -16°48'29.69"E, *Brassica oleracea*, 29.03.2005; MA05/153-MA05/15: 8 ♀ ♀, Madeira, Larano east of Porto da Cruz, vegetable garden, 280 m, 32°45'45.14"N, -16°48'29.69"E, *Raphanus raphanistrum* subsp. *raphanistrum*, 29.03.2005; MA05/161: 1 ♀, Madeira, west of Ponta do Garajau, south of Caniço, coastal rock, partly ruderalised, 80 m, 32°38'23.20"N, -16°51'13.01"E, *Rapistrum rugosum*, 29.03.2005; MA05/175: 1 ♀, Madeira, west of Ponta do Garajau, south of Caniço, coastal rock, partly ruderalised, 80 m, 32°38'23.20"N, -16°51'13.01"E, *Crepis vesicaria* subsp. *haenseleri*, 30.03.2005; MA05/176, MA05/177: 2 ♀ ♀, Madeira, west of Ponta do Garajau, south of Caniço, coastal rock, partly ruderalised, 80 m, 32°38'23.20"N, -16°51'13.01"E, *Crepis vesicaria* subsp. *haenseleri*, 30.03.2005; MA05/179: 1 ♀, Madeira, west of Ponta do Garajau, south of Caniço, coastal rock, partly ruderalised, 80 m, 32°38'23.20"N, -16°51'13.01"E, *Sinapis arvensis*, 30.03.2005; MA05/207: 1 ♀, Madeira, Ponta da Oliveira, Caniço de Baixo, coastal rock, partly ruderalised, 35 m, 32°38'28.16"N, -16°49'53.02"E, 02.04.2005; MA05/232-MA05/236, MA05/238-MA05/242: 10 ♀ ♀, Madeira, west of Ribeira Brava, Ribeira da Caldeira, E 216, coastal rock, 5 m, 32°40'25.21"N, -17°04'09.99"E, *Sinapidendron angustifolium*, 02.04.2005; MA05/244: 1 ♀, Madeira, west of Ribeira Brava, between Ribeiro da Corujeira and Ribeira da Caldeira, E 213, coastal rock, 20 m, 32°40'34.34"N, -17°04'27.05"E, *Sonchus oleraceus*, 02.04.2005; MA05/245: 1 ♀, Madeira, west of Ribeira Brava, between Ribeiro da Grujeira and Ribeiro do Caldeira, E 214, coastal rock, 20 m, 32°40'34.34"N, -17°04'27.05"E, *Sinapidendron angustifolium*, 02.04.2005; MA05/291: 1 ♀, Madeira, above Paul do Mar, ER 213, ruderal site, 30 m, 32°45'28.83"N, -17°13'41.69"E, *Sinapis arvensis*, 03.04.2005; MA05/294-MA05/296: 3 ♀ ♀, Madeira, above Paul do Mar, ER 213, ruderal site, 30 m, 32°45'28.83"N, -17°13'41.69"E, *Raphanus raphanistrum* subsp. *raphanistrum*, 03.04.2005; MA05/321: 1 ♀, Madeira, Ponta de São Lourenço, coastal rock, partly ruderalised, 80 m, 32°44'40.19"N, -16°43'22.21"E, *Rapistrum rugosum*, 04.04.2005; MA05/322-MA05/324: 3 ♀ ♀, Madeira, Ponta de São Lourenço, coastal rock, partly ruderalised, 80 m, 32°44'40.19"N, -16°43'22.21"E, *Sinapidendron angustifolium*, 04.04.2005; MA05/329: 1 ♀, Madeira, Ponta de São Lourenço, coastal rock, partly ruderalised, 80 m, 32°44'40.19"N, -16°43'22.21"E, *Rapistrum rugosum*, 04.04.2005; MA05/336-MA05/340: 5 ♀ ♀, Madeira, Ponta de São Lourenço, coastal rock, partly ruderalised, 80 m, 32°44'40.19"N, -16°43'22.21"E, *Sinapidendron angustifolium*, 04.04.2005; MA05/344-MA05/346: 3 ♀ ♀, Madeira, Ponta de São Lourenço, coastal rock, partly ruderalised, 80 m, 32°44'40.19"N, -16°43'22.21"E, *Rapistrum rugosum*, 04.04.2005; MA05/378: 1 ♀, Madeira, Referta south of Porto da Cruz, rock, 200 m, 32°45'18.77"N, -16°49'07.14"E, *Crepis vesicaria* subsp. *haenseleri*, 06.04.2005; Males: MA95/34, MA95/35: 2 ♂ ♂, Madeira, Ponta de São Lourenço, coastal rock, partly ruderalised, 80 m, 32°44'35.16"N, -16°42'01.06"E, *Rapistrum rugosum*, 10.04.1995; MA95/36: 1 ♂, Madeira, Ponta de São Lourenço, coastal rock, partly ruderalised, 80 m, 32°44'35.16"N, -16°42'01.06"E, *Crepis vesicaria* subsp. *haenseleri*, 10.04.1995; MA05/30: 1 ♂, Madeira, Ponta de São Lourenço, coastal rock, partly ruderalised, 80 m, 32°44'40.19"N, -16°43'22.21"E, *Rapistrum rugosum*, 26.03.2005; MA05/38: 1 ♂, Madeira, Ponta de São Lourenço, coastal rock, partly ruderalised, 100 m, 32°44'44.01"N, -16°43'20.74"E, *Leontodon taraxacoides* subsp. *longirostris*, 26.03.2005; MA05/41: 1 ♂, Madeira, Ponta de São Lourenço, coastal rock, partly ruderalised, 50 m, 32°44'39.19"N, -16°43'05.43"E, *Oxalis pes-caprae*, 26.03.2005; MA05/208: 1 ♂, Madeira, Ponta da Oliveira, Caniço de Baixo, coastal rock, partly ruderalised, 35 m, 32°38'28.16"N, -16°49'53.02"E, 02.04.2005; MA05/285: 1 ♂, Madeira, above Porto Moniz, roadside, planted, 390 m, 32°51'35.12"N, -17°10'26.56"E, *Argyranthemum pinnatifidum* subsp. *pinnatifidum*, 03.04.2005; MA05/314: 1 ♂, Madeira, Ponta de São Lourenço, coastal rock, partly ruderalised, 80 m, 32°44'40.19"N, -16°43'22.21"E, *Rapistrum rugosum*, 04.04.2005; MA05/379: 1 ♂, Madeira, Referta south of Porto da Cruz, rock, 200 m, 32°45'18.77"N, -16°49'07.14"E, *Crepis vesicaria* subsp. *haenseleri*, 06.04.2005; MA05/384: 1 ♂, Madeira, Ponta de São Lourenço, coastal rock, partly ruderalised, 80 m, 32°44'40.19"N, -16°43'22.21"E, *Rapistrum rugosum*, 06.04.2005; UMBB 170, UMBB 171: 2 ♂ ♂, Madeira, 2 km east south east of Seixal, 25 km northwest of Funchal, 11.04.1994, leg. H. Hohmann; UMBB 173: 1 ♂, Madeira, Caniçal, 20 km east of Funchal, 31.03.1994, leg. H. Hohmann.

### Historical records

- Wollaston T.V. (collected 1847): 4 ♀ ♀, 2 ♂ ♂. All specimens including types are in the collection of Wollaston, University Museum, Hope Entomological Collections, Oxford (FELLENDORF et al. 1999) and in the British Museum of Natural History (GUSENLEITNER & SCHWARZ 2002).
- SAUNDERS (1903): 1 ♀, 1 ♂ (collection of Wollaston, University Museum, Hope Entomological Collections, Oxford) labelled as '*Andrena bimaculata* Kirby? var.' He pointed out that the determination was doubtful under bad specimen condition. Dr. James E. Hogan (Hope Entomological Collections Oxford) has located the two specimens cited in SAUNDERS (1903) as '*Andrena bimaculata* Kirby? var.'. A further label by Chris O'Toole, at the Hope Entomological Collections at Oxford, reads '*Andrena (Plastandrena) bimaculata* (Kirby), teste C. O'Toole. Differs from typical mainland form in details of surface sculpturing on mesoscutum, scutellum and metasomal terga.'
- COCKERELL (1922): First description of the species as *Andrena maderensis* on the basis of 4 ♀ ♀ and 2 ♂ ♂ according to the collection of T.V. Wollaston, University Museum, Hope Entomological Collections, Oxford. He indicated the relationship to *A. bimaculata*.
- FELLENDORF et al. (1999): 20 ♀ ♀, 6 ♂ ♂: 16.03.1997, Gaula (200 m a.s.l.); from 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 (ca. 50 m a.s.l.). No specimens found on Porto Santo. 1 ♀: Stuttgart State Museum of Natural History (Germany), 1 ♀: Museu Municipal do Funchal (Madeira).

### Distribution and habitat characteristics

The main distribution centre of *Andrena maderensis* is in the south and southeastern region of Madeira Island. The range of altitudes extends from sea level up to 950 m a.s.l. According to the differentiation into thermotypes and ombrotypes (CAPELO et al. 2004), the localities where *A. maderensis* has been detected correspond mainly to temperature zone 1, 2 (infra-Mediterranean), but also to frequency zone 3 and 4 (lower and upper thermo-Mediterranean). High abundances were reached in humidity class 1 (dry), 2 (lower subhumid), 3 (upper subhumid) and 4 (lower humid). The main vegetation zones are zone 1 (Mayteno umbellatae-Oleo maderensis sigmetum), zone 2 (Helichryso melaleuci-Sideroxylo marmulanae sigmetum), zone 3, 4 (Semele androgynae-Apollonio barbujanae sigmetum).

### Flight time records

The flight activity lasts from February (first observation 11<sup>th</sup> February) to May (latest observation 23<sup>rd</sup> May). Highest abundances of males and females are reached in April.

### Flower-visiting behaviour

Flower visits by females and males have been detected on 12 plant taxa belonging to four plant families (unpublished data from A. Aguiar, A. Kratochwil, A. Schwabe and J.



Smit). 43 ♀♀ visited Brassicaceae (*Sinapidendron angustifolium* [N = 19], *Raphanus raphanistrum* subsp. *raphanistrum* [N = 11], *Rapistrum rugosum* [N = 7], *Brassica oleracea* [N = 4], *Sinapis arvensis* [N = 2]), 5 ♀♀ visited Asteraceae (*Crepis vesicaria* subsp. *haenseleri* [N = 4], *Sonchus oleraceus* [N = 1]), and 1 ♀ Geraniaceae (*Geranium maderense* [N = 1]); consequently, we assume oligolectic behaviour of pollen collecting on Brassicaceae. These observations are consistent with the hypothesis, that the species of the subgenus *Suandrena* prefer Brassicaceae (DYLEWSKA 1983, KRATOCHWIL 1991).

Frequent visits were observed on the endemic *Sinapidendron angustifolium*. Native and endemic pollen plants play a major role compared to introduced or archaeophytic plant species. Five males were found on Brassicaceae (*Rapistrum rugosum*), four males on Asteraceae (*Crepis vesicaria* subsp. *haenseleri* [2 ♂♂], *Argyranthemum pinnatifidum* subsp. *pinnatifidum* [1 ♂], *Leontodon taraxacoides* subsp. *longirostris* [1 ♀]) and 1 ♀ on Oxalidaceae (*Oxalis pes-caprae*).

### Differential diagnosis: *A. portosanctana* / *A. maderensis*

#### Female *A. portosanctana*, *A. maderensis*

Concerning average body length, females of *A. maderensis* are larger than those of *A. portosanctana* (Fig. 30a), the same is true concerning wing length (Fig. 30b).

**C o l o u r .** Head: black, part slightly greenish, mandible mostly with a red tip, differences between species in flagellum colour (*A. portosanctana*: flagellomeres 3-10 lower side yellow, upper side brownish, *A. maderensis*: flagellomeres brownish). Mesosoma: tibia 1 and 2 black, tibia 3 black, pars parte reddish brown, mediotarsi black, pars parte reddish brown, differences between species in wing colour (*A. portosanctana*: hyalin, *A. maderensis*: subhyalin), in both species veins (reddish/black) brown, pterostigma (orange) with a dark margin. Metasoma: T1-4 black partly greenish, with black to dark reddish brown depression zone; pygidium black.

**P u b e s c e n c e .** Head: *A. portosanctana* with white hairs in front, yellowish hairs beside and between the antennal sockets, upper part of paraocular area with brownish hairs in contrast to *A. maderensis* with yellowish, sometimes yellowish-reddish hairs in front, with longer yellowish-reddish hairs beside and between the antennal socket, upper part of paraocular area also with brownish hairs; clypeus of *A. portosanctana* only laterally denser with yellowish-white hairs in contrast to *A. maderensis* with yellowish hairs, top-orientated and in most cases with a hairless line in the centre; genal area of *A. portosanctana* with dense whitish hairs, brighter than paraocular hairs in contrast to *A. maderensis* with dense long yellowish hairs; facial fovea of *A. portosanctana* with lower part yellowish, upper part brownish hairs in contrast to *A. maderensis* with lower part whitish hairs and upper part brownish hairs; vertex of *A. portosanctana* with dark brownish (black) hairs, *A. maderensis* with longer brownish and dark brown hairs. Mesosoma: mesoscutum and scutellum of *A. portosanctana* lateral with yellowish-white hairs, in the centre only some brownish hairs, in contrast to *A. maderensis* with yellowish-reddish, sometimes yellowish hairs; mesepisternum of *A. portosanctana* with long yellowish-white hairs, in contrast to *A. maderensis* with yellowish-reddish, sometimes yellowish hairs; propodeal corbicula of *A. portosanctana* with dense white hairs, no hairs in the centre, in contrast to *A. maderensis* with some yellowish-reddish (yellowish) hairs, some shorter hairs in the centre; trochanteral and femoral flocculus of *A.*

*portosanctana* with white hairs, in contrast to *A. maderensis* with yellowish hairs; tibial scopa of *A. portosanctana* dorsal with reddish-brown hairs with brownish tips and dorsobasal with brownish hairs and ventral with yellowish whitish hairs; in the case of *A. maderensis* dorsal with yellowish-reddish hairs with brownish tips, at the base with brown hairs and ventral with yellowish-reddish hairs. **Metasoma**: tergites of *A. portosanctana*: T1-4 with white partly closed hair bands, T5 in the centre with dark brownish hairs and lateral long white hairs, T6 with dense dark brownish hairs reaching to pygidium, centre of T1 and T2 with long, T3-4 with shorter whitish hairs; tergites of *A. maderensis*: T1 with a (whitish-yellowish) yellowish hair row and lateral fragmented fine bands, T2-4 with yellowish hair bands (T4 reduced), T2 in the centre open, T5 with dense brownish hairs central and lateral yellowish hairs, T6 with dense brownish hairs reaching to the pygidium, in the centre of T1 and T2 with long, T3-4 with shorter brownish hairs.

**Structure**. **Head**: no differences in HL/HW (Fig. 30c); differences in FL1:FL2:FL3 (*A. portosanctana*: 2.4:1.1:1.0, *A. maderensis*: 2.5:1.0:1.2), in OOD:POD:OCD (*A. portosanctana*: 3.5:2.7:1.0, *A. maderensis*: 3.0:2.1:1.0), in HW:MsW:MtW (*A. portosanctana*: 1.1:1.1:1.0, *A. maderensis*: 1.0:1.0:1.0), in FVL/FVW-Index (Fig. 30d) and in clypeal length (Fig. 30e); labrum in *A. portosanctana* with basal area margin rounded, as a general rule slightly trapezoid (sometimes undulated or curled), with no or with a fragmented apical process of the basal area (sometimes asymmetric and/or emarginated), beneath long yellowish/reddish hairs in contrast to *A. maderensis* with a short trapezoid apical process, usually (slightly) asymmetric and emarginated, sometimes left and right side thickened; in some cases margin of the basal area undulated, beneath with long reddish hairs; no significant differences in labrum process width at the top (Fig. 30f). **Mesosoma**: PSI and PBAI of *A. portosanctana* smaller than in *A. maderensis* (Fig. 30g,h); propodeum sculpture of *A. portosanctana* rugose, as a general rule with some longitudinal lamina and a small central lateral boundary line in contrast to *A. maderensis* (rugose in the centre, only some longitudinal lamina or missing, small central lateral boundary line).

#### **Male *A. portosanctana*, *A. maderensis***

Like females, male *A. maderensis* have a larger average body length than those of *A. portosanctana* (Fig. 31a); the same trend becomes evident concerning wing length (Fig. 31b), but there is a high variation due to small specimen numbers.

**Colour**. No differences except wing colour (*A. portosanctana*: hyalin, *A. maderensis*: subhyalin).

**Pubescence**. **Head**: *A. portosanctana* with white hairs in front, yellowish hairs beside and between the antennal sockets and upper part of paraocular area with brownish hairs in contrast to *A. maderensis* with yellowish-reddish in front, longer yellowish-reddish hairs beside/between the antennal socket and upper part of paraocular area with brownish hairs; clypeus of *A. portosanctana* with whitish lateral hairs, hairless in the centre in contrast to *A. maderensis* with yellowish lateral hairs, mostly hairless line in the centre; genal area of *A. portosanctana* with dense whitish hairs, brighter as paraocular hairs and upper area with brownish hairs in contrast to *A. maderensis* with dense long yellowish hairs and upper area with brownish hairs; in vertex pubescence no differences. **Mesosoma**: mesoscutum of *A. portosanctana* with whitish hairs lateral, in the centre only with a few hairs, some brownish in contrast to *A. maderensis* with yellowish-

reddish (-brownish) hairs; scutellum of *A. portosanctana* similar to mesoscutum, in contrast to *A. maderensis* with lateral (yellowish) reddish-brown hairs, in the centre brownish hairs; mesepisternum of *A. portosanctana* with long whitish hairs, in contrast to *A. maderensis* with long yellowish-whitish hairs. **Metasoma:** tergites of *A. portosanctana*: T2-4 with fine whitish hair bands, in the centre slightly open, T6 with central reddish, lateral whitish hairs, T7 with reddish hairs, in the centre T1 and T2 with long, T3-4 with shorter whitish hairs; tergites of *A. maderensis*: T1 with a yellowish-whitish hair row, T2-4 with fine yellowish-whitish hair bands, in the centre mostly open, T5 with yellowish (reddish) hairs central and lateral with whitish (-yellowish) hairs, T6 with reddish hairs reaching to the pygidium, in the centre of T1 and T2 (T3) with long whitish, (T3) T4 with shorter reddish hairs; T8 of *A. portosanctana* with narrow with white hairs, T8 of *A. maderensis* with narrow with reddish hairs.

**Structure.** **Head:** no differences in HL/HW (Fig. 31c) and HW:MsW:MtW index; differences in FL1:FL2:FL3 (*A. portosanctana*: 3.5:2.6:1.0, *A. maderensis*: 3.3:2.1:1.0) and in OOD:POD:OCD (*A. portosanctana*: 3.5:2.6:1.0, *A. maderensis*: 3.2:2.1:1.0), and in clypeal length (Fig. 31d); labrum in *A. portosanctana* flat and rounded, without exposed process of the basal area, beneath in the centre a hollow with whitish/yellowish hairs, left and right side with a hairless area, followed by an area with long yellowish hairs in contrast to *A. maderensis* flat and rounded, without exposed process, beneath in the centre a hollow with yellowish/reddish hairs, left and right side with a hairless area, followed by an area with long yellowish hairs; significant differences in labrum process width at the top (Fig. 31e). **Mesosoma:** PSI and PBAI of *A. portosanctana* smaller than in *A. maderensis* (Fig. 31f,g); propodeum sculpture of *A. portosanctana* rugose in the centre, no lateral boundary line in contrast to *A. maderensis* (rugose in the centre, as a general rule with longitudinal lamina, small central lateral boundary line).

There are no differences in genital morphology.

### Species characteristics within the genus *Suandrena* — phylogenetical and biogeographical aspects

The status of species of the subgenus *Suandrena* WARNCKE (1968) is quite unclear and should be revised. Generally the females within the subgenus *Suandrena* are not well differentiated. Concerning *A. maderensis*, *A. portosanctana*, *A. notata* and *A. fratella*, WARNCKE (1968) defines as nominate species *Andrena m. maderensis* COCKERELL, 1922 (Madeira) and considered the other three taxa as subspecies of *A. maderensis*: *A. m. portosanctana* COCKERELL, 1922 (Porto Santo), *A. m. notata* WARNCKE, 1968 (Canary Islands) and *A. m. fratella* WARNCKE, 1968 (Morocco); see also GUSENLEITNER & SCHWARZ (2002). The type specimens of *A. m. notata* WARNCKE, 1968 (holotype, two paratypes, no other specimens) and *A. m. fratella* WARNCKE, 1968, (holotype, three paratypes, 12 other specimens) have been deposited in the Biology Centre of the Upper Austrian Provincial Museum Linz.

DYLEWSKA (1983) gives a revision of the Palearctic subgenus *Suandrena* and presents an identification key (pages 17, 18). She noted erroneously (analogous to W. Grünwaldt) that types of *A. portosanctana* do not exist. In her opinion a differentiation in the subspecies *A. m. maderensis* and *A. m. portosanctana* without analysing the types is not possible. A female of *A. maderensis* analysed by Dylewska exists in the collection of

Grünwaldt. She stated that this female corresponds to the description by Cockerell (page 24). Probably this female is identical to the female of Fig. 21. It seems strange, that DYLEWSKA (1983) took two females and one male as the basis for the description of *A. maderensis*, which were collected in Tunis (the females by Grünwaldt, the male by Schmiedeknecht) and which are surely not specimens of *A. maderensis*.

In the opinion of DYLEWSKA (1983) *A. m. fratella* is synonym to *A. leucocyanea* PÉREZ, 1895 and *A. m. notata* is synonym to *A. cyanomicans mirna* WARNCKE, 1970. We do not support the interpretation of DYLEWSKA (1983), that 'notata' is a subspecies of the mainland species *A. cyanomicans* PÉREZ, 1895.

Remarkably, in the Warncke collection only the holotype and the paratypes are labelled as *A. maderensis fratella*. All other specimens were characterised as '*A. cyanomicans fratella* det. Dr. Warncke'. WARNCKE (1974) revised the classification of *A. m. fratella* as *A. cyanomicans fratella*. In our opinion *A. notata* und *A. fratella* are good species clearly differentiated from *A. cyanomicans*. This will be shown in a separated publication (KRATOCHWIL & SCHEUCHL in prep.).

Within the subgenus *Suandrena* there are two different colour types of pubescence: **Brown type**: e.g. *A. suerinensis* FRIESE, 1884, *A. planiventris* DOURS, 1872, *A. aetherea* WARNCKE, 1974, *A. cyanomicans*, *A. maderensis*; **white-black (-rusty) type**: *A. savignyi* SPINOLA, 1838, *A. fratella*, *A. notata*, *A. mirna*, *A. leucocyanea*, *A. portosanctana*. The morphological similarity of the terminalia and the absence of a broadened apex of sternite 8, which is developed e.g. in *A. cyanomicans*, *A. fratella* and *A. notata*, suggest a closer relationship of *A. maderensis* and *A. portosanctana* among themselves than to the mainland species *A. cyanomicans* and *A. fratella*. In this case the two different colour types do not document closer relationships within a special colour type.

Comparing *A. portosanctana* with *A. maderensis*, the hair colour is quite different, in *A. portosanctana* there lacks an unpunctated median line and the labrum process is plane and more rounded. According to our results *A. portosanctana* is a distinct species and not a subspecies of *A. maderensis* or of *A. cyanomicans*, which are larger in body size, covered totally with brown hairs and with a labrum process elevated. *A. portosanctana* is much more similar in habitus to *A. notata* and *A. fratella* with smaller body size, predominantly with white hairs, only with black hairs in the area of the mesothorax, the scopa rubiginous and the process of labrum in front flat and rounded.

We formulate the hypothesis that *A. portosanctana* (Porto Santo) is the ancestor of *A. maderensis* (Madeira) and that *A. portosanctana* (Porto Santo) and *A. notata* (Canary Islands) descended from the mainland species *A. fratella* (Morocco) or an ancestor of this species. Further *A. portosanctana* and *A. maderensis* are not related to the North African species *A. leucocyanea* which is characterised by strongly broadened penis valvae and a flagellum with tubercula.

In this context some biogeographic data fit well in this interpretation. *Andrena notata* is restricted in the distribution on Fuerteventura and Lanzarote (Canary Island). Fuerteventura, locus typicus of *A. notata*, is the eldest island of the Canary Archipelago (23 million years) followed by Lanzarote (15), Gran Canaria (15) and La Gomera (11). The geological structure of Tenerife is built up by three former islands of different ages (Roque del Conde: 12 million years, Teno and Anaga: 7); the youngest are the most westward situated islands: La Palma (1.7) and El Hierro (1.1); see GEYER & MARÍ (2010), VAN DEN BOGAARD (2013).

As mentioned in Chapter ‘Material and Methods’, Porto Santo is geologically the oldest island (14 million years) of the Madeira Archipelago. Much younger are Madeira (4.6) and Desertas Islands (3.6), see GALOPIM DE CARVALHO & BRANDÃO (1991) and GELDMACHER et al. (2000). Concerning the geological age of the different islands of the Madeira Archipelago, we hypothesise, that the oldest one, Porto Santo, was colonised before the existence of Madeira. In former geological times Porto Santo had a much more expanded size and relief energy, but erosion processes diminished the island area and reduced the relief.

Due to larger distances the colonization of Porto Santo by *A. fratella* or an ancestor of this species might have taken somewhat longer than the colonization of Fuerteventura and Lanzarote. But the environmental conditions seem to be suitable. Porto Santo is characterised by the most distinct dry climate of all islands of the Madeira Archipelago. Lanzarote and Fuerteventura show an analogous situation within the Canary Archipelago but with even stronger environmental conditions. *A. notata* and *A. portosanctana* show present-day similarities in habitat conditions. But there are also differences in contrast to *A. maderensis*: On Fuerteventura and Lanzarote *A. notata* does not reach altitudes above 500 m a.s.l., but the altitudinal distribution of *A. maderensis* ranges to 1000 m a.s.l. into the subhumid zone.

All in all the probability is high that a mainland ancestor of *A. fratella* colonised first Porto Santo (or stepping-stone islands which today are under sea-level) and developed to the endemic *A. portosanctana*. Subsequently Madeira Island was colonised by *A. portosanctana*, which developed to Madeira’s own endemic species, *A. maderensis*.

Analogously, it is likely that *A. dourada* is an early colonizer and became an old endemic species, long before the existence of Madeira. So we hypothesise that *A. dourada* was the ancestor of *A. wollastoni* (KRATOCHWIL & SCHEUCHL, 2013). Of special interest is the third example: *Osmia madeirensis* VAN DER ZANDEN, 1991 is a well characterised endemic species of Madeira Island. This species developed from an ancestor of *Osmia latreillei* (information by letter; A.W. Ebmer). The distribution area of *Osmia latreillei* extends from the Canary Islands to Jordania. On Porto Santo Island only *Osmia latreillei iberoafricana* (PETERS, 1975) occurs, being absent on Madeira Island. The relationship to *Osmia latreillei iberoafricana* (PETERS, 1975) has to be investigated. Parallel to the findings above, we draw the conclusion that primarily the mainland species *O. latreillei iberoafricana* colonised Porto Santo (or one of the former stepping-stone islands). The colonization of Madeira Island led to the endemic *Osmia madeirensis*.

#### ***A. portosanctana* an endangered endemic species**

A special conservation program should start to avoid extinction of the Porto Santo endemic *A. portosanctana*. This species probably has only a scattered distribution all over the island. Two populations with higher individual numbers of *A. portosanctana* were detected in March 2012 on two sites on the sandy beach with higher accumulations of the annual *Cakile maritima* subsp. *maritima*. All other seven localities were characterised by low individual numbers and by limitation of pollen resources of different Brassicaceae species. Because nesting sites are not a limitation factor, a support of Brassicaceae species could be helpful, to increase the population sizes of *A. portosanctana*. Further data, a long-term monitoring and suitable nature conservation measures are necessary to guarantee the survival of this endemic species.

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## Zusammenfassung

Die für Porto Santo, Madeira-Archipel, Portugal, endemische *Andrena* (*Suandrena*) *portosanctana* COCKERELL, 1922, wurde von Cockerell auf der Basis von drei Weibchen, die im Jahr 1921 gesammelt wurden, beschrieben. Seither konnten keine weiteren Weibchen oder das Männchen dieser Art nachgewiesen werden. Erst im Jahr 2011 tauchten zwei Weibchen, die auf Porto Santo gesammelt und als *A. cyanomicans* PÉREZ, 1895 determiniert waren, in einer Privatsammlung auf. Sie stimmten in allen morphologischen Merkmalen mit der Beschreibung von *A. portosanctana* von Cockerell überein. Im Jahr 2012 wurden auf Porto Santo an acht verschiedenen Lokalitäten zahlreiche Weibchen und erstmals auch Männchen nachgewiesen. Eine Differentialdiagnose zwischen *A. portosanctana* und der nahe verwandten *A. maderensis* COCKERELL, 1922, die auf der Insel Madeira endemisch ist, wurde durchgeführt. Für zahlreiche morphologische Merkmale konnten zwischen den beiden Arten Unterschiede aufgezeigt werden, z.B. Körpergröße, Flügel-, Clypeus-, Pterostigma-, Propodeum-Länge, Breite des Labrumanshangs, Umfang und Stärke der Punktierung von Clypeus und Mesoscutum, Strukturierung des Labrumanshangs und des Propodeum, Färbung der Flagellomeren, Färbung der Behaarung von Kopf, Mesosoma, Corbiculae und Metasoma. Durch die morphologische Differentialdiagnose kann die Existenz zweier verschiedener Arten deutlich belegt werden. Darüber hinaus werden Angaben zur Verbreitung, zum Lebensraum, zu Flugzeiten und zum Blütenbesuchverhalten der beiden Arten angefügt. Evolutionsbiologische und biogeographische Aspekte, auch unter Berücksichtigung anderer Wildbienenarten des Madeira-Archipels, werden diskutiert. Ebenso wird auf die Rolle früherer und heutiger Bewirtschaftungsmaßnahmen und landschaftlicher Eingriffe auf die Populationsgröße von *A. portosanctana* eingegangen. Aufgrund der zumindest zeitweisen geringen Populationsgrößen der Brassicaceae und der wahrscheinlich geringen Populationsgröße von *A. portosanctana* ist von einer Gefährdung der Art auszugehen. Ein spezifisches Artenschutzprogramm wäre eine sinnvolle Maßnahme, dem Aussterben dieser endemischen Art vorzubeugen.

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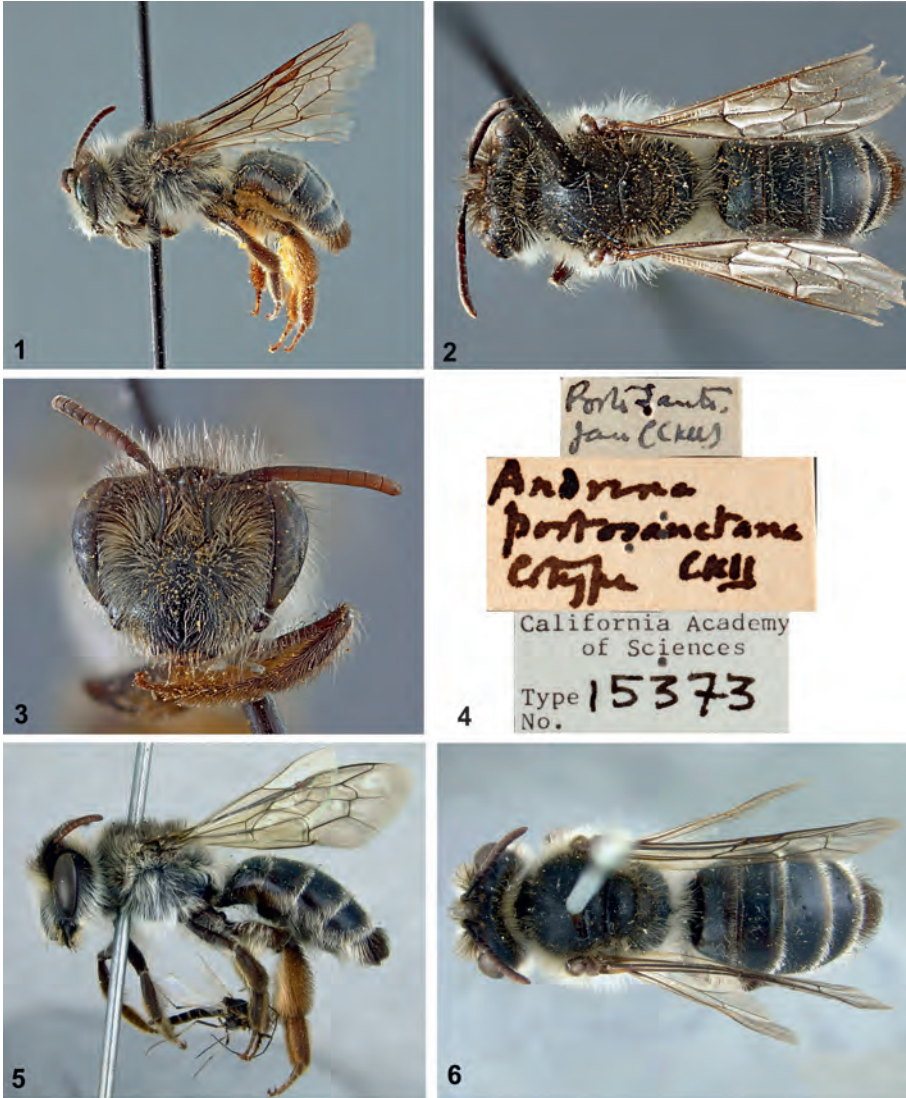


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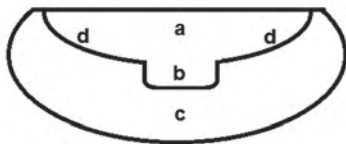
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**Figs. 1-4:** Syntype of *Andrena portosanctana* (female) deposited in the California Academy of Science, California, San Francisco, USA (CAS TYPE 15373); (1) lateral view; (2) dorsal view; (3) head frontal view; (4) labels; photos: V. Smith.

**Fig. 5-6:** Syntype of *Andrena portosanctana* (female) deposited in Department of Entomology, NMNH, Smithsonian Institution, Washington DC, USA (USNM 24656, barcode number 00533697); (5) lateral view; (6) dorsal view; photos: Department of Entomology, NMNH, Smithsonian Institution.



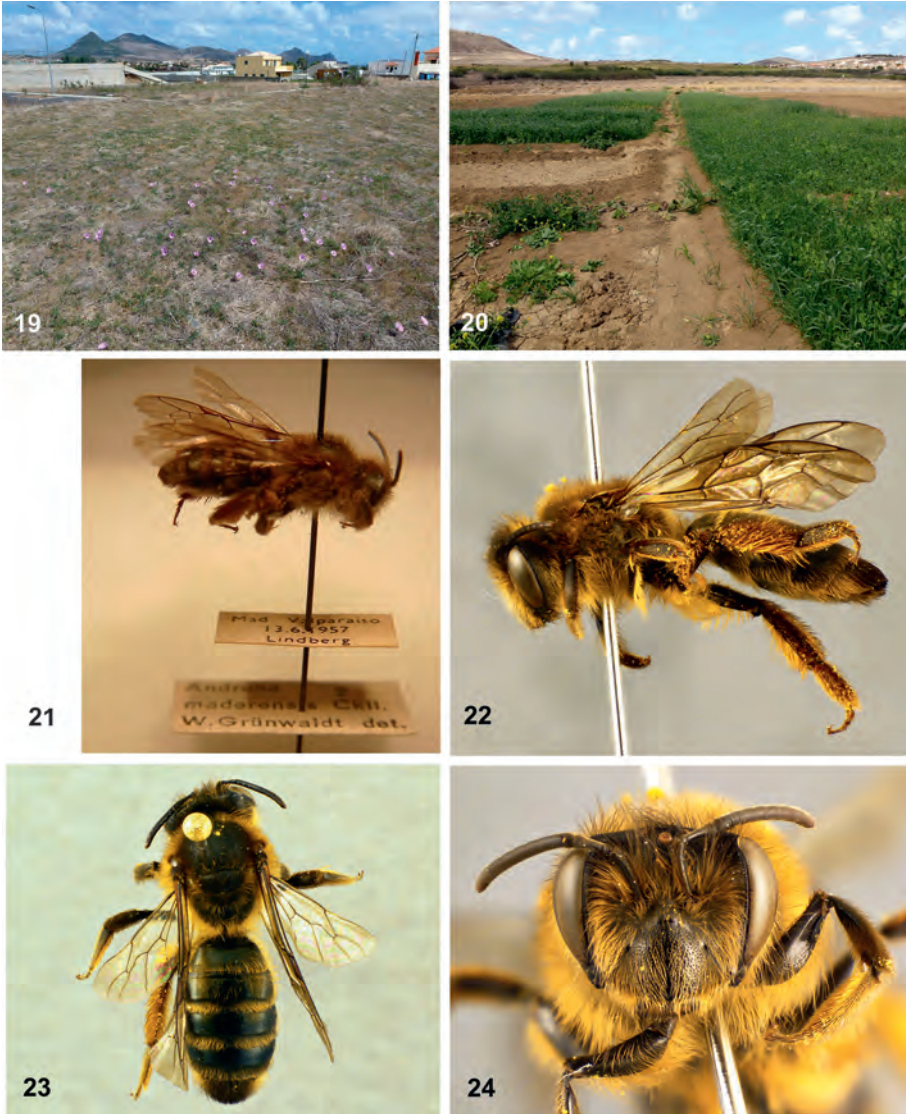
**Figs. 7-8:** Syntype of *Andrena portosanctana* (female) deposited in the Department of Entomology, NMNH, Smithsonian Institution, Washington DC, USA (USNM 24656, barcode number 00533697); (7) head frontal view; (8) labels; photos: Department of Entomology, NMNH, Smithsonian Institution.

**Fig. 9:** Labrum differentiated in a) basal area, b) apical (distal) process of the basal area, c) vertical area, d) margin of the basal area.

**Figs. 10-12:** *A. portosanctana*: (10) female (17.03.2012), (11) female flower-visiting *Cakile maritima* subsp. *maritima* (18.03.2012); (12) male (17.03.2012); photos: A. Kratochwil.



**Figs. 13-14:** *A. portosantana* genital (13) front view, (14) sideview; photos: L. Haitzinger.  
**Figs. 15-18:** Localities, where *A. portosantana* was detected: (15) sand area of the south coast of Porto Santo (18.03.2012); (16) east of Campo de Baixo, south of restaurant 'Mare Sol', sand area with scattered *Cakile maritima* subsp. *maritima*, 5 m a.s.l. (18.03.2012); (17) dry rocky grassland at the base of Pico da Cabrita. (18) Vereda do Pico Branco, fallow land with *Oxalis pes-caprae* aspect, 310 m a.s.l.; photos: A. Schwabe.

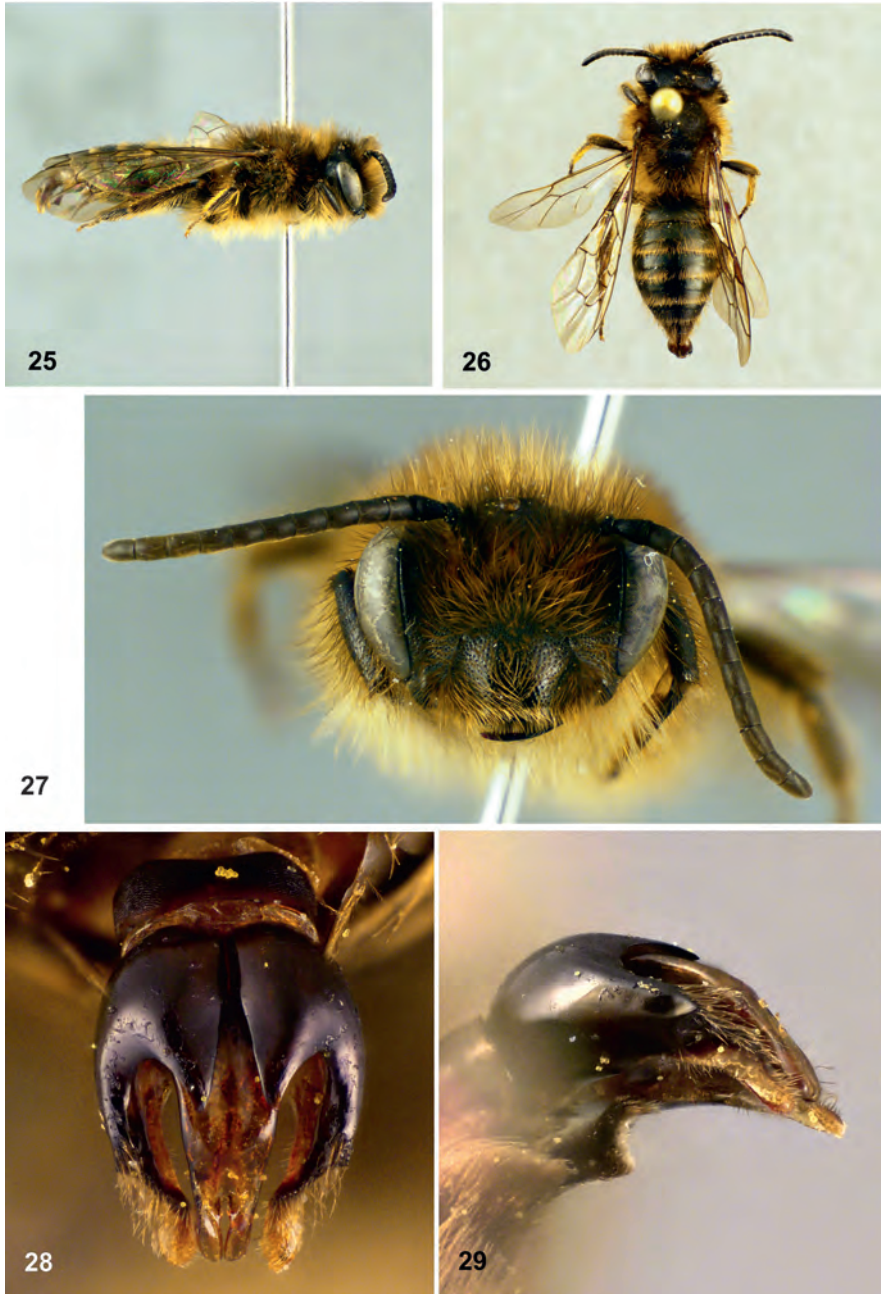


**Figs. 19-20:** (19) Vila Baleira, near sports field, ruderal site with *Convolvulus althaeoides* 25 m a.s.l. (20.03.2012), (20) Campo de Baixo, near tennis court, ruderal sites, crop fields, 20 m a.s.l. (20.03.2012); photos: A. Schwabe.

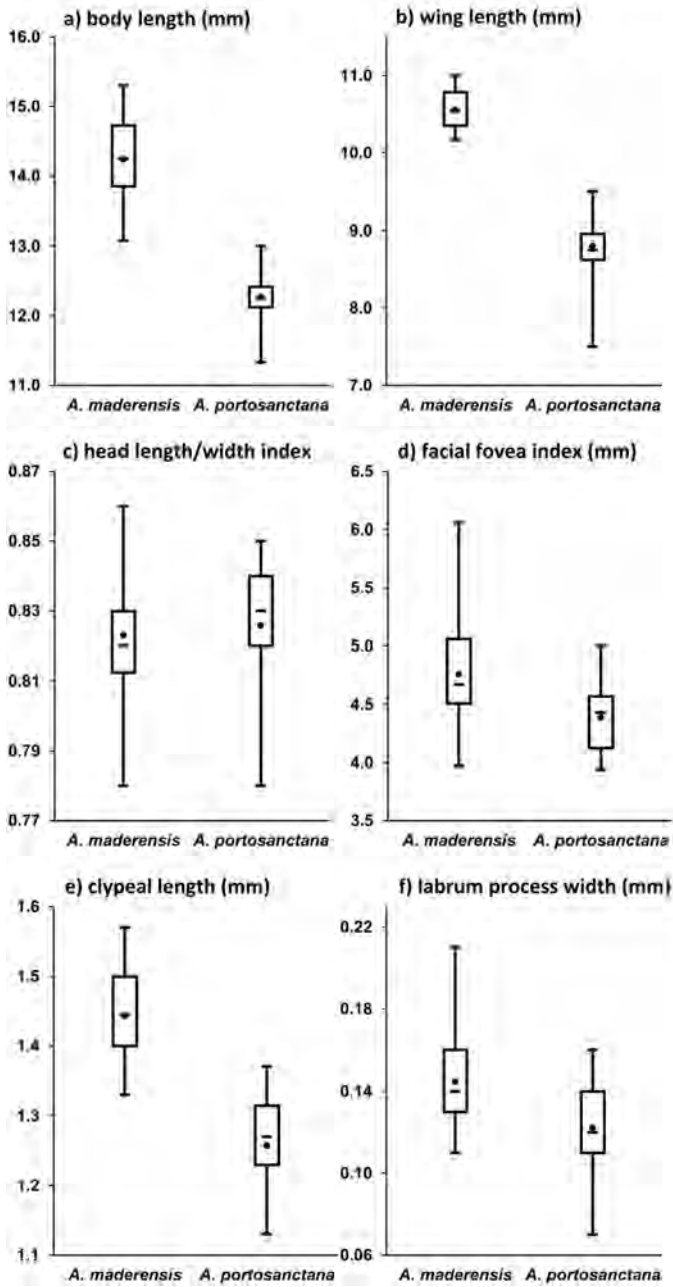
**Fig. 21:** Female of *Andrena maderensis*, collected by Lindberg, 13.06.1957. Bavarian State Collection of Zoology (Munich); photo: J. Schubert.

**Fig. 22-24:** Female of *Andrena maderensis*, collected by A. Kratochwil (MA05/346: Madeira, Ponta de São Lourenço, coastal rock, partly ruderalized, 80 m, 32°44'40.19"N, -16°43'22.21"E, *Rapistrum rugosum*, 04.04.2005); (22) lateral view; (23) dorsal view; (24) head frontal view; photos: L. Haitzinger.

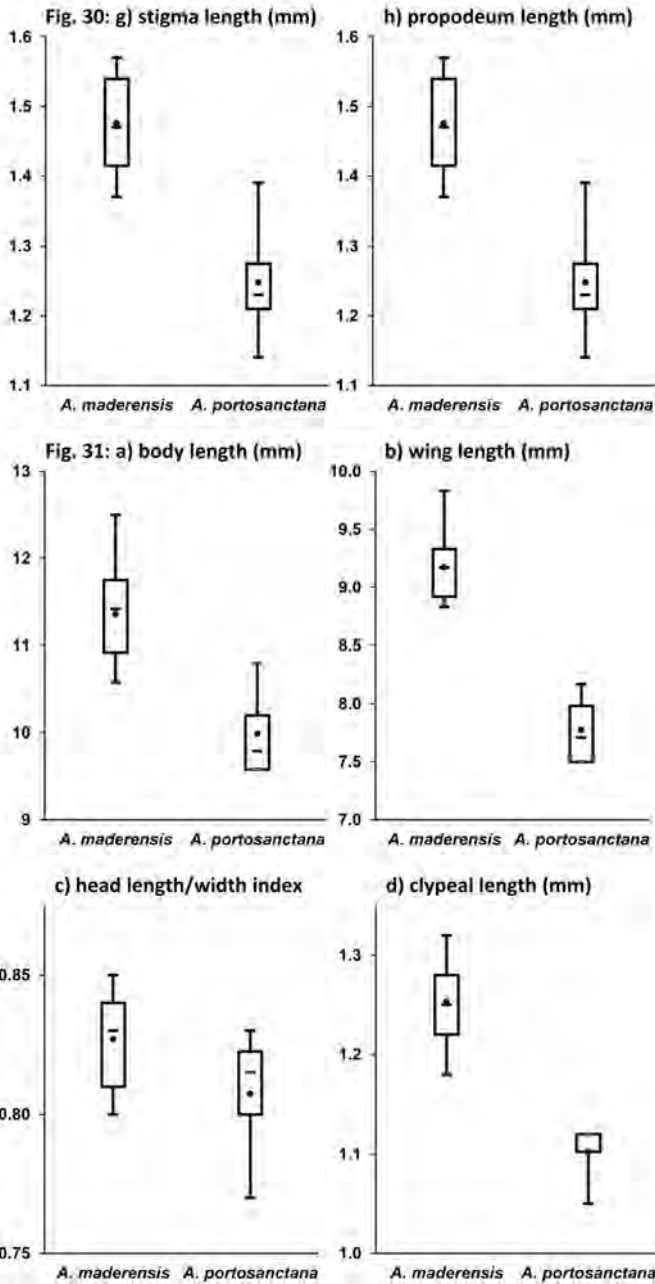
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**Figs. 25-29:** Male of *Andrena maderensis*, collected by A. Kratochwil (MA05/38: Madeira, Ponta de São Lourenço, coastal rock, partly ruderalized, 100 m, 32°44'44.01"N, -16°43'20.74"E, *Leontodon taraxacoides* subsp. *longirostris*, 26.03.2005); (25) lateral view; (26) dorsal view; (27) head frontal view; genital (28) front view, (29) sideview; photos: L. Haitzinger.



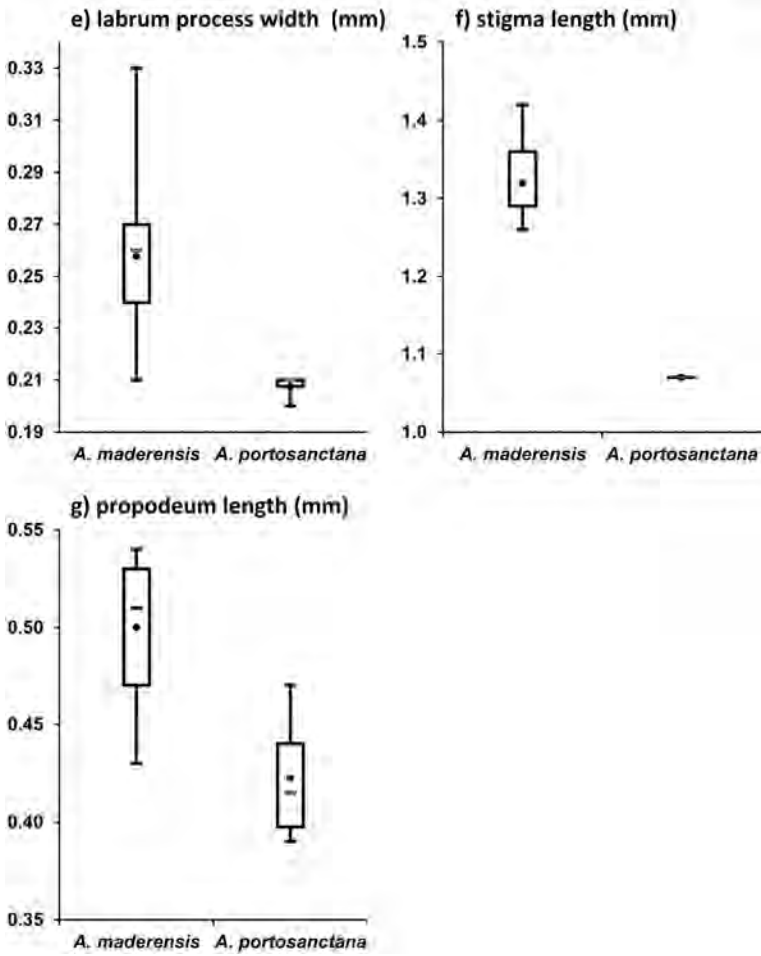
**Fig. 30:** Morphological differences between females of *A. portosanctana* (N = 19) and *A. maderensis* (N = 30): (a) body length; (b) wing length; (c) head length/width index; (d) facial fovea index; (e) clypeal length; (f) labrum process width.



**Fig. 30 ff.:** Morphological differences between females of *A. portosanctana* (N = 19) and *A. maderensis* (N = 30): (g) stigma length; (h) propodeum length.

**Fig. 31:** Morphological differences between males of *A. portosanctana* (N = 4) and *A. maderensis* (N = 13): (a) body length; (b) wing length; (c) head length/width index; (d) clypeal length.





**Fig. 31 ff.:** Morphological differences between males of *A. portosantana* (N = 4) and *A. maderensis* (N = 13): (e) labrum process width; (f) stigma length; (g) propodeum length.