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Morphometric and molecular analyses support the species status of *Amegilla teneriffensis* (Cockerell, 1930) and *A. maderae* (Sichel, 1868) (Anthophila: Apidae: Anthophorinae)

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Abstract

Amegilla quadrifasciata (Villers, 1789) has been recorded as a widespread bee species across the Mediterranean basin, including the Madeira Archipelago and the Canary Islands. Until now, these island populations have been differentiated from mainland populations as two subspecies: *Amegilla quadrifasciata maderae* (Sichel, 1868) and *A. quadrifasciata teneriffensis* (Cockerell, 1930), respectively. We now show, using DNA sequences and multivariate morphometric and morphological analyses, that these former subspecies most likely represent two distinct species: *A. maderae* (Sichel, 1868) ***status resurrected*** and *Amegilla teneriffensis* (Cockerell, 1930) ***stat. nov.***, upgraded to species rank and sister species to *A. quadrifasciata*. Mainland populations of *A. quadrifasciata* across its range are genetically and morphometrically largely homogeneous and differentiated from *A. maderae* and *A. teneriffensis*. In comparison to *A. quadrifasciata*, *A. maderae* and *A. teneriffensis* have larger body size in females, but not in males, whilst *A. maderae* females exhibit dark polymorphic hair colour forms.

Key words: taxonomy, biogeography, island endemism, body size, hair colour variation

Introduction

Volcanic oceanic islands typically have high proportions of endemic vascular plant and animal species, especially if they are at a considerable distance from the mainland. Speciation processes triggered by isolation barriers are thought to lead, via genetic drift (in combination with adaptation to new environmental conditions), to the evolution of endemic species and subspecies, and in some cases to the radiation of whole taxonomic groups (Whittaker & Fernández-Palacios 2007; Losos & Ricklefs 2009).

The Atlantic archipelagos of Madeira and the Canary Islands are excellent models for questions of island biogeography and specifically harbour many endemic wild bee species (Kratochwil *et al.* 2021). On the Madeira Archipelago, 22 wild bee species (Hymenoptera, Anthophila) have been detected to date, including eight endemic species and one endemic subspecies (Kratochwil & Schwabe 2018a; Kratochwil *et al.* 2018, 2022). The Canary Islands have 160 wild bee taxa (138 species), including 93 endemic taxa with 57 endemic species and 36 endemic subspecies (Hohmann *et al.* 1993; Kratochwil *et al.* 2018; Kratochwil & Schwabe 2018b; Kratochwil unpublished data). Processes of wild bee colonisation and speciation have been investigated for both archipelagos, e.g. of the endemic *Andrena wollastoni* group (Kratochwil 2020; Kratochwil *et al.* 2021) and species of the subgenus *Suandrena* (Kratochwil *et al.* 2014; Kratochwil 2021a).

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The range of *Amegilla* (*Amegilla) quadrifasciata* (Villers, l789) extends from Portugal, across North Africa, southern and eastern Europe to Siberia. Northwards, the species reaches Luxembourg, Germany and Poland, southwards Sudan, Ethiopia, Yemen and Pakistan (Scheuchl & Widmer 2016; Kratochwil 2025a). The westernmost border was thought to encompass the Madeira Archipelago (Portugal) and the Canary Islands (Spain). The question of whether the taxa of the *A. quadrifasciata* group on the Madeira Archipelago and Canary Islands are endemic subspecies or species remained unresolved until now.

The type of *A. quadrifasciata* (Villers, 1789) is lost, and therefore it was necessary to designate a neotype (Kratochwil 2025a). The type specimen described by Villers (1789) originated from the southern part of France, and the neotype was therefore selected from this region. Univariate and multivariate morphometric analysis of specimens from different countries of Europe, North Africa and Central Asia (Algeria, Bulgaria, Crete, Cyprus, France, Germany, Greece, Italy, Kyrgyzstan, Morocco, Spain, Tunisia, Türkiye, former borders of Yugoslavia) served to validate the species (Kratochwil 2025a). According to the results of the analysis of 24 morphological (continuous) variables, it was suggested that all specimens from the taxon's continental European, Asian and northern African distribution belong to *A. quadrifasciata* (Kratochwil 2025a).

The specimens collected on Madeira Island, Porto Santo and the Desertas Islands (Madeira Archipelago) are characterised by dark polymorphic hair colouration. Sichel (1868) described this taxon as *Anthophora maderae*, and Alfken (1940) documented its species status, but other authors (Dours 1869; Brooks 1988) considered this taxon to be only a colour variant of *A. quadrifasciata*. Until now, the populations of the Madeira Archipelago have been taxonomically categorised as *A. quadrifasciata maderae* (Sichel, 1868); see Kratochwil *et al.* (2018, 2022).

Numerous authors recorded *A. quadrifasciata* on the Canary Islands (e.g., Gribodo 1883; Friese 1897; Dusmet y Alonso 1924; Bischoff 1937; Lieftinck 1958; Báez & Ortega 1978; Wolf 1980; Hohmann *et al.* 1993). Aside from hair colour characteristics, the specimens resemble morphologically those of European, central Asian and northern African populations of *A. quadrifasciata*. Cockerell (1930) described the specimens from the Canary Islands as the separate 'form' (subspecies) *Anthophora quadrifasciata teneriffensis,* due to the white and only slightly yellowish thoracic hairs and the broad pure-white tergite bands, in contrast to continental *A. quadrifasciata* with narrower whitish to ivory tergite bands.

The comparison of body size measurements of island and mainland forms of the same or closely related insect taxa, often show that those living on islands are larger. For example, Poulsen & Rasmussen (2020) found that the body size of immigrant bee species on islands tended to be larger than that of mainland species. These size differences are likely related to better dispersal ability of larger individuals. Size is therefore unlikely to be a reliable character for supporting the species status of a variant form, particularly of island faunas. Characters related to shape are likely to be more discriminatory in supporting the species status of variants. If, in a multivariate analysis, the size variable is shown on the x-axis (in the case of multivariate ratio analysis, this represents isometric size, i.e., the geometric mean of all variables) and the shape variable on the y-axis (e.g., shape PC1), then the uniform growth of body parts in relation to overall growth is characterised by the lack of a linear relationship between the measured variables i.e. the lack of a linear relationship suggests a single taxonomic unit. On the other hand, non-uniform growth in body parts (i.e., allometric variation) can be recognised by a linear relationship that differs from a slope of 0 (Baur 2025), supporting species status.

Like many island forms, *A. quadrifasciata maderae* is also characterised by dark hair colouration. *Bombus terrestris canariensis* Pérez, 1895 is also darker coloured, compared to the European yellow-black-white coloured subspecies *B. terrestris terrestris* (Rasmont *et al.* 2008, 2021). Morphological characteristics of the species formerly described as *B. canariensis* Pérez, 1895 do not differ greatly from the wide variation of *B. terrestris* s.l., except for the dark hair colour. Molecular genetic analysis by Widmer *et al.* (1998) confirmed the differentiation of the Canarian populations from the European mainland populations of *B. terrestris*. However, there are differing opinions regarding its species or subspecies status. In Rasmont *et al.* (2021) and in Ruiz *et al.* (2021), the Canarian taxon is described as a subspecies of *Bombus terrestris*, in contrast to Coppée (2010), who listed *Bombus canariensis* as a separate species. Also characterised by dark coloured hair is *Bombus xanthopus* Kriechbaumer, 1870 (Corsica, France), which is now listed as a species, but was previously described as a subspecies of *B. terrestris* (Lecocq *et al.* 2015; Rasmont *et al.* 2021; Boni *et al.* 2023). Nevertheless, the species assignment for '*xanthopus'* does not yet appear to be fully confirmed (Williams 2021).

In the following, the taxonomic status of *A. quadrifasciata teneriffensis* and *A. quadrifasciata maderae* are studied morphologically, morphometrically and with DNA barcodes in comparison to the mainland populations of *A. quadrifasciata quadrifasciata*, with the aim of answering the following questions:

—Do the different taxa of the *Amegilla quadrifasciata* group of the Madeira Archipelago, the Canary Islands and Continental Europe/northern Africa/Central Asia show allometric or isometric differences in continuous variables?

—Do isometric differences between the taxa of the Madeira Archipelago and the Canary Islands support the species status of both taxa, as suggested by DNA barcodes?

—Which morphological characters (nominal variables) distinguish the studied taxa?

Material and methods

Study area

The Madeira Archipelago has an age of 5.2 to 14.3 Ma (Galopim De Carvalho & Brandão 1991; Schmincke 1998; Geldmacher *et al.* 2000). Porto Santo is the oldest island of the Madeira Archipelago (14.3 Ma); the youngest islands are Madeira (5.2 Ma) and the Desertas Islands (5.07 Ma). The distance between Porto Santo (located in the eastern part of the archipelago) and Madeira Island is about 45 km. Porto Santo, the easternmost island of the Madeira Archipelago, is 737 km from Cape Sim (Morocco).

The eight Canary Islands differ considerably in their geological history and geomorphology. Fuerteventura and Lanzarote are the oldest islands (20.2 Ma and 15.5 Ma), followed by Gran Canaria (14.6 Ma), La Gomera (9.4 Ma), Tenerife (6.0 to 11.5 Ma) and La Palma (1.72 Ma) (Carracedo 2011). Various volcanic events have strongly influenced the floristic and faunistic composition of the islands (Carracedo 2011). Fuerteventura, the closest of the Canary Islands to the mainland, is 96 km from Stafford Point (Western Sahara).

Specimens examined

A total of 83 females and 46 males were studied. Appendix 1a–d lists the specimens analysed (identity code, acronym of depository, locality, date of collection, collector, sex, determination, determinator, further comments). Samples of *Amegilla quadrifasciata* from the European and northern African mainland (including some Mediterranean islands) as well as Central Asia were obtained from Algeria, Bulgaria, Crete, Cyprus, Germany, Greece, Italy, Kyrgyzstan, Malta, Morocco, southern Spain, Tunisia, Türkiye, and the northwestern Balkan area. The specimens from the Madeira Archipelago (*Amegilla maderae*) came from Madeira Island and Porto Santo, those of the Canary Islands (*Amegilla teneriffensis*) from El Hierro, Fuerteventura, Gran Canaria, Lanzarote, and Tenerife. In addition, a voucher code (e.g. AL1) was given, which has been attached to the specimens as a label, as well as an indication of the morphological (including morphometric) and/or molecular analysis of the specimens concerned. All specimens are deposited in the following collections:

CAK = private collection A. Kratochwil, Osnabrück, Germany
CSE = private collection C. Schmid-Egger, Berlin, Germany
EMEC = Essig Museum of Entomology, University of California, Berkeley, California, USA
NHMW = Naturhistorisches Museum Wien, Vienna, Austria
NHMUK = Natural History Museum, London, United Kingdom
OLML = Oberösterreichische Landes-Kultur GmbH, Linz, Austria
SMNK = Staatliches Museum für Naturkunde, Karlsruhe, Germany
USNM = Smithsonian Institution, National Museum of Natural History, Washington D.C., USA.

The types of *Anthophora quadrifasciata teneriffensis* Cockerell, 1930 and *Anthophora maderae* (Sichel, 1868) were studied by A. Kratochwil in the USNM and NHMW. The lectotypes and paralectotypes will be described in separate publications (Kratochwil in prep.).

Sampling of specimens for molecular analyses

Specimens were collected mostly when visiting flowers using a small net or with small glass tubes and then transferred into a cool box. They were then stored individually in glass vials at 4 °C in 99% ethanol until analysis. Vouchers are stored at SMNK.

Morphometric and morphological analyses

In this study, 24 continuous variables (Table 1) and several nominal variables were analysed; e.g., structure, colour and pubescence of head (clypeus, labrum, mandible, scapus, antennal base, antenna, flagellomeres, frons, paraocular area, vertex, genal area), mesosoma (mesoscutum, scutellum, propodeum, femur, tibia, basitarsus, mediotarsi, mesepisternum, tibial scopa, wing, pterostigma, pterostigmoid margin, wing veins) and metasoma (tergites, sternites, pygidium, genitalia).

Data were collected using a Wild M3Z modular stereomicroscope (Heerbrugg, Switzerland) using a 25x eyepiece (16.25x, 40x, 62.5x and 100x) and a phototube with a Canon EOS 7D Mark II. Photostacking was carried out with 50–100 shots per image using FOTO Stacker version 1.6/29 2017 (Boltnev & Kacher 2017). The photos were produced by AK. The Eazydraw (2020) programme was used for photo processing. The morphometric features are characterised in Table 1 and Figures 1a-e (using terms according to Michener 2007; Kratochwil 2020, 2021b).

For taxonomic differentiation, morphometric multivariate analyses were used according to Baur & Leuenberger (2011); Baur *et al.* (2014); and Baur (2025). Analyses were carried out using R v. 4.5.1 (R Core Team 2025) and the versions of the R scripts by Baur & Leuenberger (2020). Datasets were compared using the Welch two-sample t-test in R using the function t-test (R Core Team 2025; Rasch *et al.* 2011).

TABLE 1. Abbreviations, character name, definition, and magnification of the 24 continuous variables used for the morphometric analyses; definitions and methods of measurement according to Michener (2007).

Abbreviation	Character name	Definition	Magnification
BL	Body length	Length from antennal base to tip of the pygidium	16.25x
CLL	Clypeus length	Maximal central length	62.5x
CLW	Clypeus width	Maximal width	62.5x
CU2a	Submarginal cell 2, length a	Distance 1st submarginal cross vein to 1st recurrent vein	40x
CU2b	Submarginal cell 2, length b	Distance 1st recurrent vein to 2nd submarginal cross vein	40x
EL	Eye length	Maximal length (area with ommatidia, without eye ring)	40x
EW	Eye width	Maximal width	40x
FL1, FL2, FL3	Flagellomere 1, 2, 3 length	Lateral view, central distance in length, maximal width	100x
HL	Head length	length from top of vertex to apical margin of clypeus	40x
HW	Head width	Maximal width in frontal view	40x
IDL	Interocular lower distance	Distance between the lower inner edge of the left and right eye	40x
IDU	Interocular upper distance	Distance between the upper inner edge of the left and right eye	40x
IOD	Interocellar distance	Distance between the posterior ocelli	62.5x
LL	Labrum length	Central length	100x
LW	Labrum width	Central width	100x
MTL	Metasoma length	Length from base of 1st tergite to tip of pygidium	16.25x
MTW	Metasoma width	Maximal width	16.25x
OCD	Ocelloccipital distance	Distance between posterior ocellus to preoccipital ridge	62.5x
OOD	Ocellocular distance	Distance between outer ocellus and compound eye	62.5x
SCL	Scutum-scutellum length	Maximal central length	16.25x
TSCW	Tegulae-scutum width	Maximal scutum width including tegulae	16.25x
WL	Wing length	Maximal length of the forewing from wing base to tip	25x

Molecular genetic analyses

In previous studies, it has been shown that the universal animal barcode (a ca. 650 bp fragment of the mitochondrial cytochrome oxidase I (CO1) gene) often provides good resolution to separate species, especially in wild bees (Schmidt *et al.* 2015; Kratochwil *et al.* 2021); hence, this fragment was also employed here. DNA was extracted using a high-salt protocol (Paxton *et al.* 1996) from female bees that had previously been morphologically identified (Appendix 1). We sequenced the ca. 650 bp barcoding fragment of COI using standard protocols (Kratochwil *et al.* 2021) and the oligonucleotide primers LCO/HCO (Folmer *et al.* 1994).

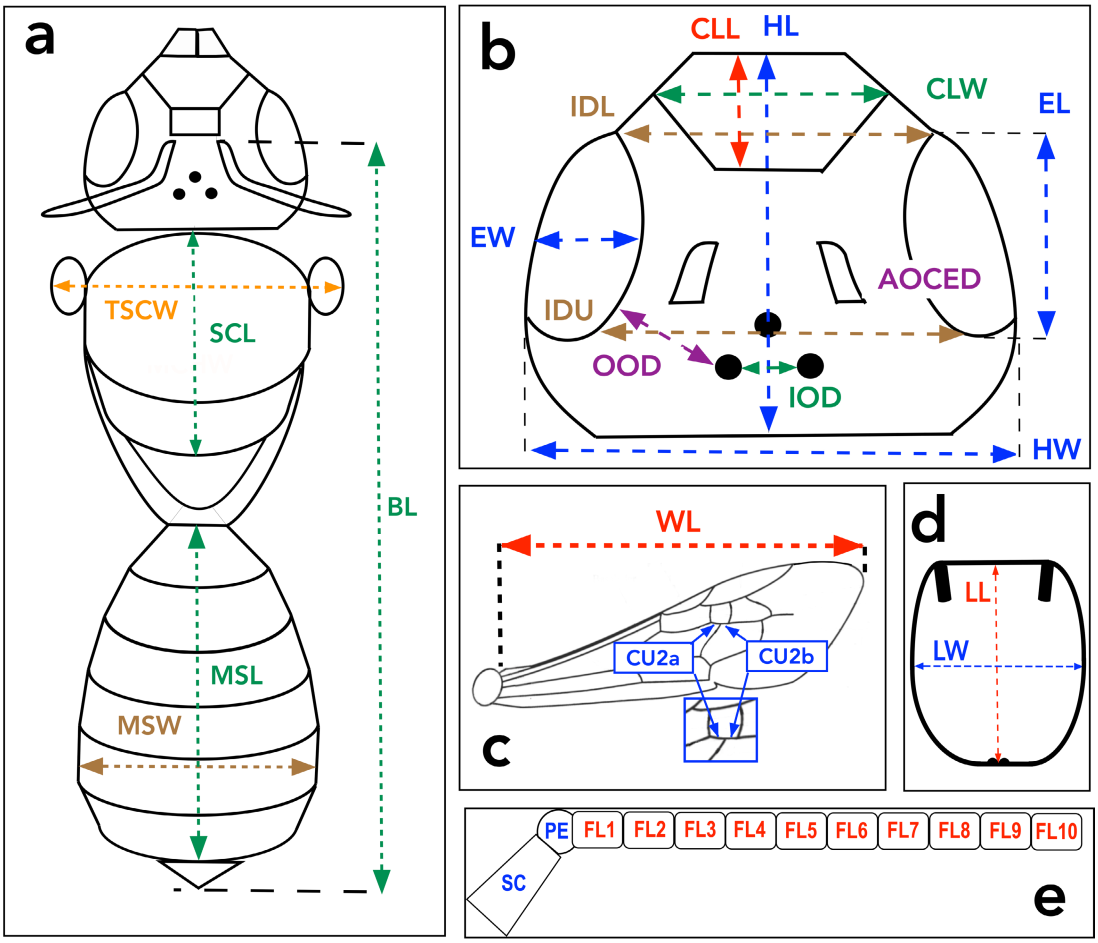

FIGURE 1. Ranges of measurements of various continuous variables (for abbreviations, character names and definitions, see Table 1 and the list of abbreviations below). a. body, b. head, c. wing, d. labrum, e. antenna (in males FL1-FL11).

Sequences were generated commercially (Macrogen Europe), edited in Geneious Prime (Kearse *et al.* 2012) and compared to BOLD accessions to verify species identity and exclude contamination. In addition, we used all sequences of reasonable length and with sufficient data from *A. quadrifasciata* available in BOLD. A newly generated sequence of *Bombus terrestris* and published sequences of two distantly related *Amegilla* species were used as outgroups. We only used data where the sequences were largely complete. In BOLD, in one case, it was not possible to assign the specimen's locality to Madeira Island or to Porto Santo (BBIOP2922_24). Furthermore, there were two obvious misidentifications of the species status in BOLD (*A_quadrifasciata*_BLLI087_25_India; *A_quadrifasciata*_GBAAP5003_India). The tree analysis placed both data as sister groups to *A. quadrifasciata*, which does not occur in India. These two datasets refer to another species, probably *Amegilla* cf. *confusa*. These sequences were therefore excluded.

A total of 59 sequences (including outgroups) were used in the analyses. Sequences were aligned using the MUSCLE algorithm as implemented in Geneious v. 6.1.2. (Kearse *et al.* 2012) and trimmed to a final alignment length of 526 bp. The aligned sequences were translated into amino acid sequences using the invertebrate mitochondrial code to identify numts. No stop codons or frame shift mutations were detected.

Phylogenetic analyses were performed with BEAST v. 1.8.2. (Drummond *et al.* 2012). First, we estimated the model of molecular evolution with Modeltest v. 3.1.2 (Nylander 2004) using the AIC; the best fitting model was TN93 + G; this was used in BEAST analyses. We generated the xml input file using Beauti v.1.8.2. We used a Yule Speciation tree prior and ran the analyses for 1,000,000 generations, sampling every 100 generations for a total of 10,000 trees. We used TreeAnnotator to summarise the trees and probabilities with a burn-in of 1000 trees. The final tree was visualised with FigTree (Rambaut 2009). Finally, only using ingroup sequences, we calculated a haplotype network with using the TCS algorithm as implemented in PopArt (Leigh & Bryant 2015).

Results

Habitus of *Amegilla quadrifasciata, A. maderae* and *A. teneriffensis*

Figures 2 and 3 show the dorsal and lateral views of females and males of *Amegilla quadrifasciata* (European mainland), *A. maderae* **(**Madeira Archipelago) and *A. teneriffensis* (Canary Islands). *Amegilla quadrifasciata* (Figures 2a, 2b; 3a, 3b) has light brownish, partly yellowish, reddish mesoscutum hairs. The mesepisternum and the tergite bands are whitish to ivory. In contrast, *A. maderae* (Figures 2c, 2d; 3c, 3d) has much darker (black to reddish) hairs on the mesoscutum and mesepisternum. Furthermore, the tergite bands are reddish-orange-yellow. In contrast to *A. quadrifasciata*, the tergite bands of *A. teneriffensis* are a white and considerably broader, completely covering the entire tergite depression (Figures 2e, 2f; 3e, 3f).

Morphometrics of females and males

Amegilla maderae versus *A. quadrifasciata*

Amegilla maderae is markedly larger in female body characters than *A. quadrifasciata* for the following variables: body length (BL; $p < 0.0001$), metasoma length (MTL; $p < 0.0001$), and metasoma width (MTW; $p < 0.0001$), scutum-scutellum length (SCL; $p = 0.0081$) and scutum width including tegulae (TSCW; $p = 0.003$), and weakly different in wing length (WL; $p = 0.025$). In males, only three variables are significantly larger in *A. maderae*: scutum width including tegulae (TSCW; $p = 0.00063$), metasoma length (MTL; $p = 0.026$) and scutum-scutellum length (SCL; $p = 0.0016$).

The regression lines between the first shape PC and the isosize axis are clearly separated in both sexes (Figure 4). The PCA ratio spectrum separating the two species is documented in females by the ratio of eye length/interocular upper distance (EL/IDU) to labrum length/scutum-scutellum length (LL/SCL) and in males by the ratio of eye width/scutum-scutellum length (EW/SCL) to interocular lower distance/labrum width (IDL/LW).

The variables flagellomere 2 (FL2) and proximal length of the submarginal cell (CU2a) in females and in males are responsible for the differentiation of the shape PC1.

Amegilla teneriffensis versus *A. maderae*

Amegilla teneriffensis is significantly larger in female body characters than *A. maderae* for three variables: scutum-scutellum length (SCL; $p < 0.0001$), wing length (WL; $p = 0.00063$), and body length (BL; $p = 0.041$). There is only one weakly significant variable that is larger in males of *A. teneriffensis*: metasoma width (MTW; $p = 0.032$).

The regression lines between the first shape PC and the isosize axis are clearly separated in the two taxa for both sexes (Figure 4). The PCA ratio spectrum separating the two species is characterised in females by the ratio of interocular upper distance/interocular lower distance to labrum length/proximal length of the submarginal cell (IDU/IDL : LL/Cu2a), and in males by the ratio of head length/flagellomere 3 length to flagellomere 2 length/clypeus width (HL/FL3 : FL2/CLW).

Amegilla teneriffensis versus *A. quadrifasciata*

Amegilla teneriffensis is markedly larger in the following variables from *A. quadrifasciata* in females: body length (BL; $p < 0.0001$), wing length (WL; $p < 0.0001$), tegulae-scutum width (TSCW; $p < 0.0001$), scutum-scutellum length (SCL; $p < 0.0001$), metasoma width (MTW; $p < 0.0001$), and metasoma length (MTL; $p = 0.00082$). In males, *A. teneriffensis* is markedly larger in metasoma width (MTW; $p = 0.00039$), and tegulae-scutum width (TSCW; $p = 0.00097$), and slightly larger in metasoma length (MTL; $p = 0.026$) and wing length (WL; $p = 0.042$), but not different in body length (BL) and scutum-scutellum length (SCL).

The scatterplots between the first shape PC and the isosize axis are separated in females and males (Figure 4). The PCA ratio spectrum separating the two species is characterised in females by the ratio of eye length/interocular upper distance to head length/ocelloocular distance (EL/IDU : HL/OOD), and in males by the ratio of wing length/metasoma length to eye length/tegulae-scutum width (WL/MTL : EL/TSCW). The variables submarginal cell 2, length a (CU2a) and length of flagellomere 2 (FL2) are responsible for the differentiation of shape PC1 in females of the two species, and the variables length of flagellomere 2 (FL2) and metasoma length (MTL) in males.

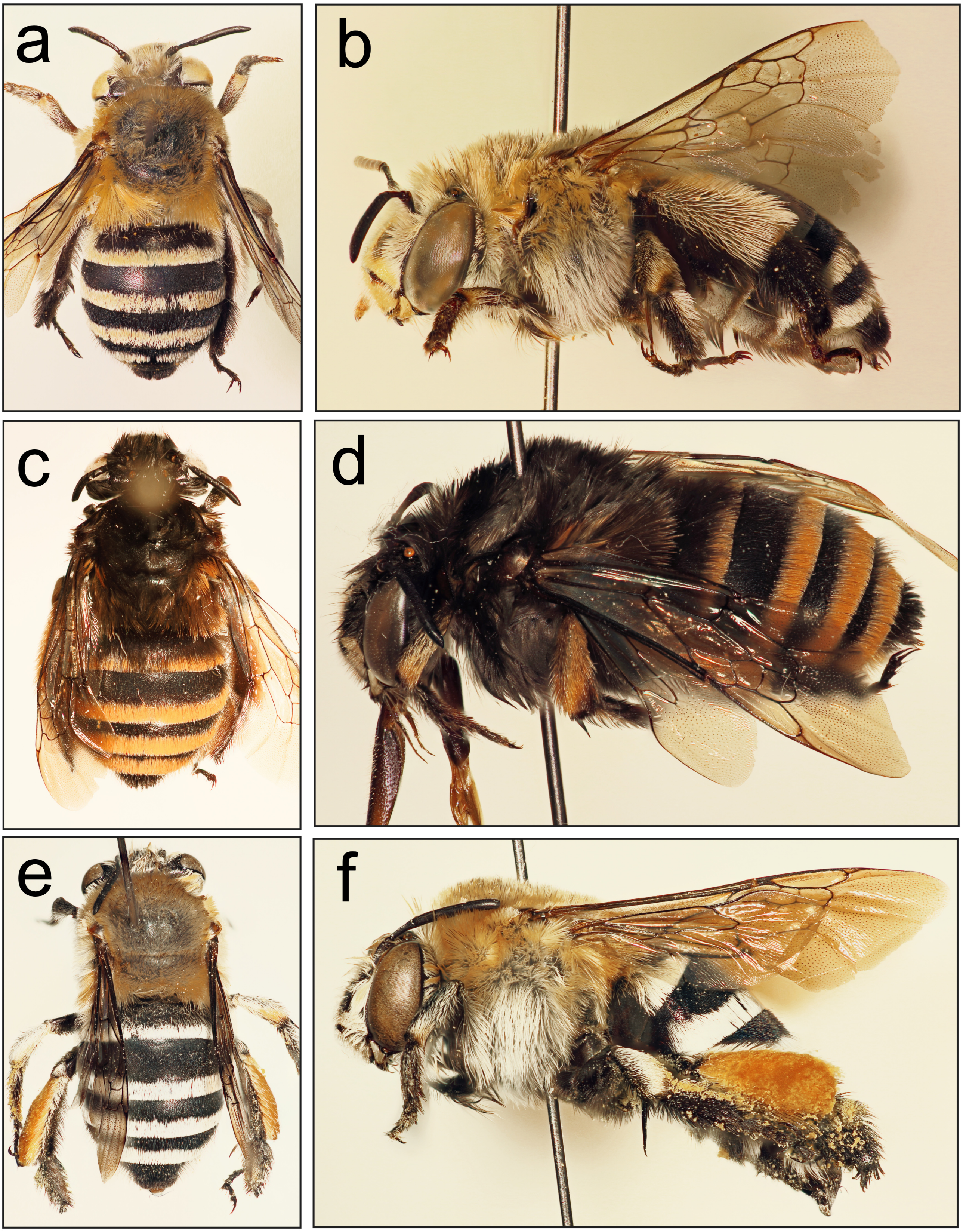

FIGURE 2. Dorsal and lateral views of females. a, b. *Amegilla quadrifasciata* (Villers, 1789), Tunisia (TU1); c, d. *A. maderae* (Sichel, 1868), Madeira Island (MA06/2); e, f. *A. teneriffensis* (Cockerell, 1930), Canary Islands, Fuerteventura (FU4).

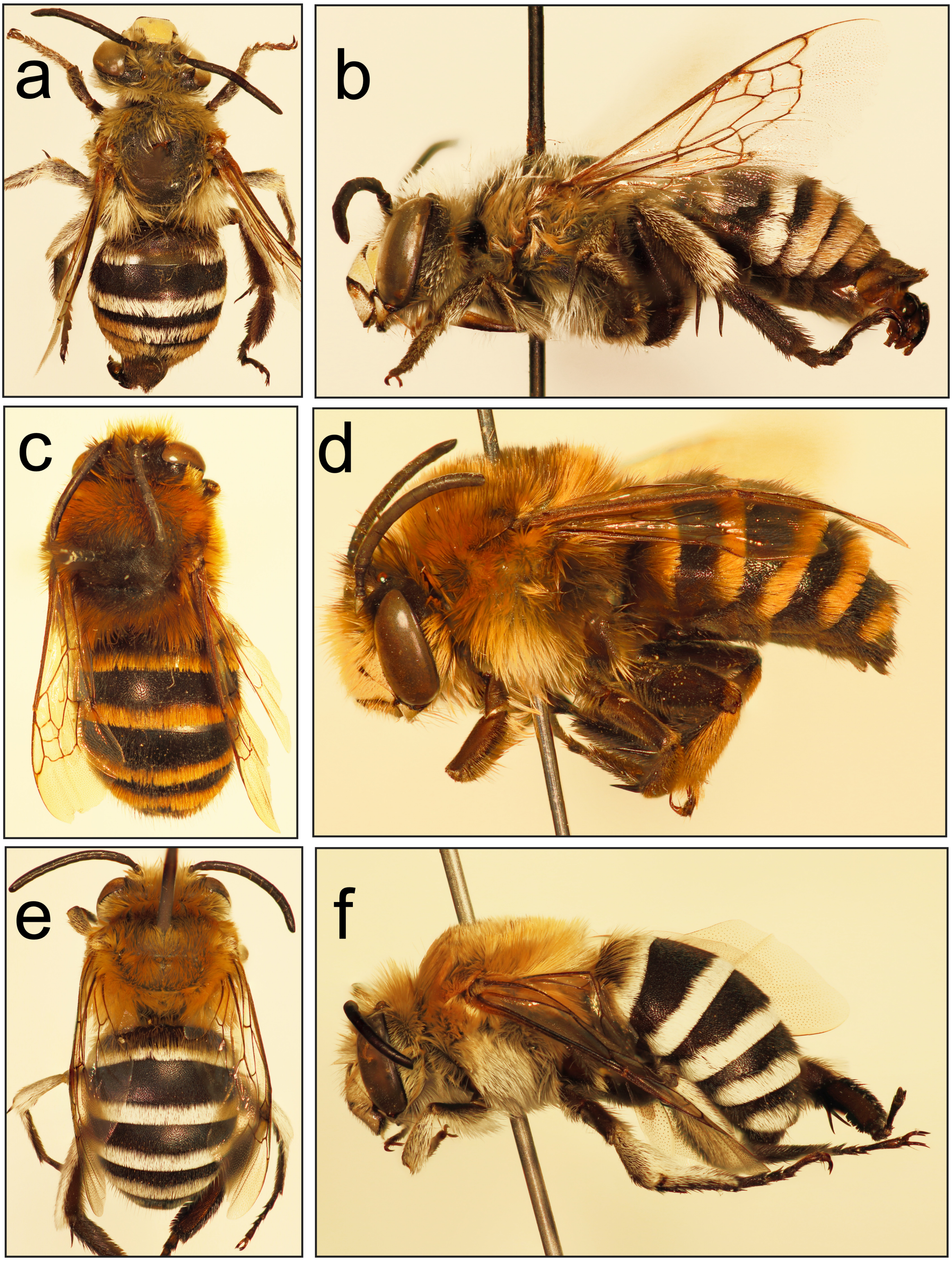

FIGURE 3. Dorsal and lateral views of males. a, b. *Amegilla quadrifasciata* (Villers, 1789), former Yugoslavia (YU3); c, d. *A. maderae* (Sichel, 1868), Madeira Island (MA05/108); e, f. *A. teneriffensis* (Cockerell, 1930), Canary Islands, Gran Canaria (GC1).

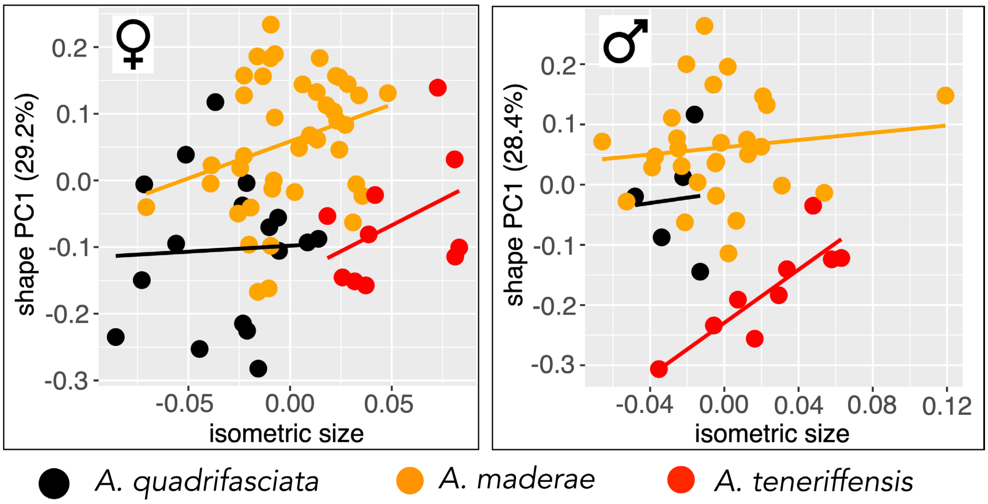

FIGURE 4. Scatterplots shape PC1 against isometric size axis of females and males of *Amegilla quadrifasciata*, *A. maderae* and *A. teneriffensis* using all variables.

Summary of morphometric results in females and males

The females of *A. maderae* are differentiated from females of *A. quadrifasciata* in all variables by larger body size characters. A similar result is found for males (three significant differences). In all variables, females of *A. teneriffensis* were significantly larger than those of *A. quadrifasciata*. This is also the case for four variables in males. The females of *A. teneriffensis* were significantly larger than those of *A. maderae* in only two variables whilst the males did not differ.

Molecular analyses

We used a total of 54 ingroup sequences (newly generated and previously published) and included five outgroup sequences (total alignment length after trimming: 526 bp). Haplotypes from the Canary Islands (Figure 5) were very distinct from all others (56 mutations). *Amegilla quadrifasciata* from Armenia, Malta, Morocco, Sardinia, Slovenia, Spain (Andalusia) and Kyrgyzstan form a uniform group, from which two specimens from Italy, one from Lebanon

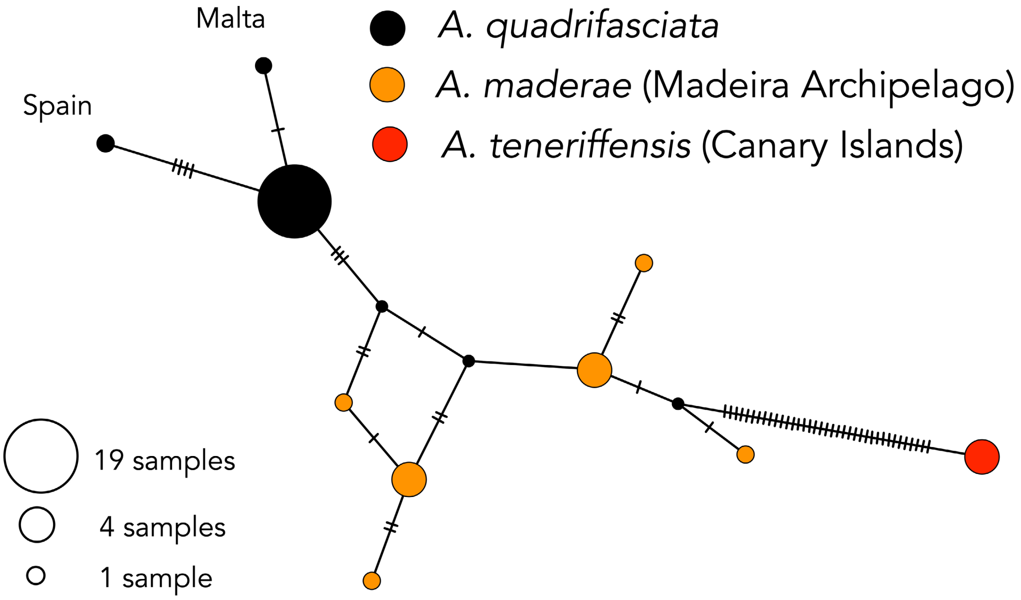

FIGURE 5. Haplotype (TCS) network of *Amegilla quadrifasciata*, *A. maderae* and *A. teneriffensis*. Circle size is relative to the number of haplotypes present in the dataset. A bar represents a single nucleotide change (mutation); dots on branches represent inferred missing haplotypes (single nucleotide changes).

and one from Cyprus with one mutation and another specimen from Cyprus with two mutations possess their own haplotypes (Figure 5), separated from the genetically closest specimen of Porto Santo by 4 mutations. The haplotype network is characterised by the specimens from the mainland (*A. quadrifasciata*) with a split off from Porto Santo and the Madeira Archipelago (*A. maderae*) and the Canary Islands (*A. teneriffensis*). The Madeira Archipelago is characterised by three haplotypes for Porto Santo, one haplotype for Madeira Island and one haplotype with mixed specimens from both islands.

When analysed with BEAST, *A. quadrifasciata, A. maderae*, and *A. teneriffensis* group together with high support (posterior probability: 0.99–1.00) (Figure 6). Within the analysed taxa, *A. teneriffensis* splits off first. Next, *A. quadrifasciata* splits and forms a sister group to *A. maderae*.

The genetic analysis shows that there are two subclades within the clade of *A. maderae*, one consisting only of specimens from Porto Santo, and a second consisting of specimens from Madeira Island and Porto Santo.

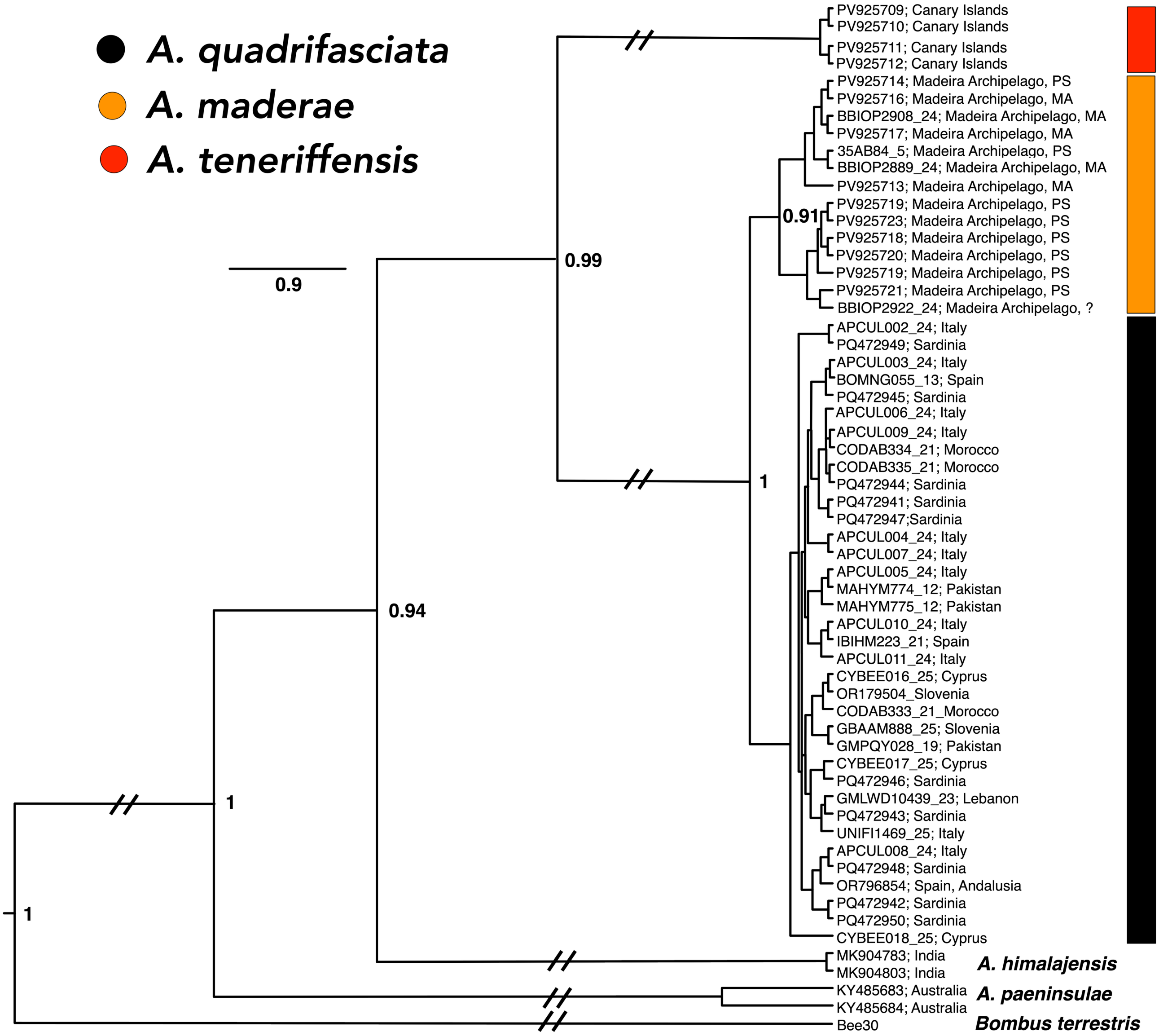

FIGURE 6. Species tree demonstrating the phylogenetic relationships of the different populations calculated with BEAST compared to the outgroup species *Bombus terrestris*, *Amegilla himalajensis*, and *A. paeninsulae*.

Differential diagnosis: Amegilla quadrifasciata, A. maderae, A. teneriffensis in females and males.

Mean, standard deviation, maximum and minimum value of all continuous variables of the three species can be found for the females in Appendix 2 and for the males in Appendix 3.

Heads in females:

Structure, colour and puncturation: The head has a black cuticle except for the clypeus, labrum, supraclypeal area and mandible base (Figures 7a–c). The ground colour of the clypeus is black in *A. quadrifasciata* and apically more or less reddish-brown (Figure 8a), in *A. maderae* and *A. teneriffensis* mostly black (Figures 8c, 8d). There are clear differences in the light-coloured pattern of the clypeus, labrum, supraclypeal area and mandible base: *A. quadrifasciata* yellowish, *A. maderae* whitish-ivory, and *A. teneriffensis* white (Figures 8a–c). The apical light clypeus band is indented towards the centre in *A. quadrifasciata* and *A. maderae* but not in *A. teneriffensis* (Figures 8a–c). The apical pale clypeus band is narrowest in *A. maderae.* Both basal spots of the clypeus are separated centrally by a midline, which is species-specific in colour. The puncturation of the supraclypeal area and clypeus is similar in *A. quadrifasciata* and *A. maderae* (centrally: puncture diameter 27 µm, distance 27–41 µm; laterally: puncture diameter and puncture distance 27–54 µm). The punctures are shallow, rounded, partly elongated, teardrop-shaped, partly confluent, and form combs with small shiny ridges. The punctures of the supraclypeal area and clypeus are smaller in *A. teneriffensis* (14–27 µm) and have a larger distance from each other (54 µm). The punctures of *A. teneriffensis* are mostly flatter than those of *A. quadrifasciata* and *A. maderae* but have fine and sharp edges.

The labrum is yellowish in *A. quadrifasciata*, whitish-ivory in *A. maderae* and white in *A. teneriffensis.* All three species have a small black spot at the base and on each side of the labrum (Figures 9a–c). The labrum is characterised by an irregularly large, flat puncture pattern which often converges and forms a network of irregular, shiny ridges. About one third of the mandible base is coloured yellowish in *A. quadrifasciata*, whitish-ivory in *A. maderae* and white in *A. teneriffensis*, and brown to blackish towards the centre and reddish in the anterior region (Figures 8a–c).

Pubescence: In *A. quadrifasciata* the vertex is covered with few long brown hairs in the upper area and mainly characterised by a dense golden-yellowish pubescence; in *A. maderae,* the hairs are black to black-brown; and in *A. teneriffensis,* the hair colour is whitish-yellowish (Figures 7a–c). In the frons area, the hairs are yellowish to ivory-coloured and downward-curved (some shorter hairs but mainly about a quarter to half the length of the vertex hair) in *A. quadrifasciata*, black to black-brown in *A. maderae* and whitish-yellowish in *A. teneriffensis* (Figures 7a–c). The base and rear side of the scapus have dense whitish-yellowish (*A. quadrifasciata*) or white (*A. teneriffensis*) hairs (half the length of the vertex hairs) (Figures 7a, 7c), which are black to black-brown in *A. maderae*. In the upper paraocular area, the hairs are the same in colour and length as those of the frons, and in *A. maderae* they are intermingled with a few golden hairs (Figure 7b). From the base of the antenna, the paraocular area pubescence is shorter and ivory-coloured in *A. quadrifasciata*, black to black-brown with more intermingled golden hairs in *A. maderae*, and with white hairs in *A. teneriffensis*. On the clypeus, longer whitish-yellowish hairs occur laterally in *A. quadrifasciata* (Figure 8a), some black to black-brown hairs in *A. maderae* and white hairs in *A. teneriffensis* (Figures 8b, 8c). In the centre, there is a very loose, fine yellowish (partly lighter, partly darker) and very short pubescence, with hairs bent downwards in *A. quadrifasciata* (Figure 8a). In *A. maderae,* these hairs are blackish (Figure 8b), in *A. teneriffensis* white (Figure 8c). The labrum is hairy like the clypeus (Figures 9a–c). In *A. quadrifasciata,* the genal area has white-yellowish hairs on its upper side and ivory to white hairs on its lower side; in *A. maderae,* the hairs are black to black-brown on its upper side and golden on its lower side; and in *A. teneriffensis,* all hairs are white (Figure 2). In the upper posterior back of the eye there is a short pubescence, which becomes longer in the lower area (Figure 2).

Heads in males:

Structure, colour and puncturation: The head has a black cuticle except for the clypeus, labrum, supraclypeal area and mandible base, and, in contrast to females, black at the base and upper side of the first antennal segment (Figures 7d–f). Otherwise, the colours correspond to those of the females (Figures 8d–f, 9d–f). The clypeus has black stripes laterally. They are most pronounced in *A. maderae* (Figure 8e) and least pronounced in *A. teneriffensis* (Figure 8f). The punctation of the supraclypeal area and the clypeus is dense and flat (centrally: puncture diameter 27 µm, distance 27–41 µm; laterally: puncture diameter and puncture distance 27–54 µm). The punctures are partly elongated, often converging, and form combs, especially laterally, with a slight lustre. The labrum is coloured whitish-ivory in *A. quadrifasciata* and *A. maderae* and white in *A. teneriffensis* and has a small black spot basolaterally (Figures 9d–f). Similar to the clypeus, the labrum is punctured irregularly (puncture diameter 27 µm), and the punctures often converge and form a network of irregular, shiny ridges. The mandible is coloured whitish-ivory in *A. quadrifasciata* and *A. maderae* and white in *A. teneriffensis* at the base up to half way and the rest up to the tip is blackish-brownish to reddish (Figures 9d–f).

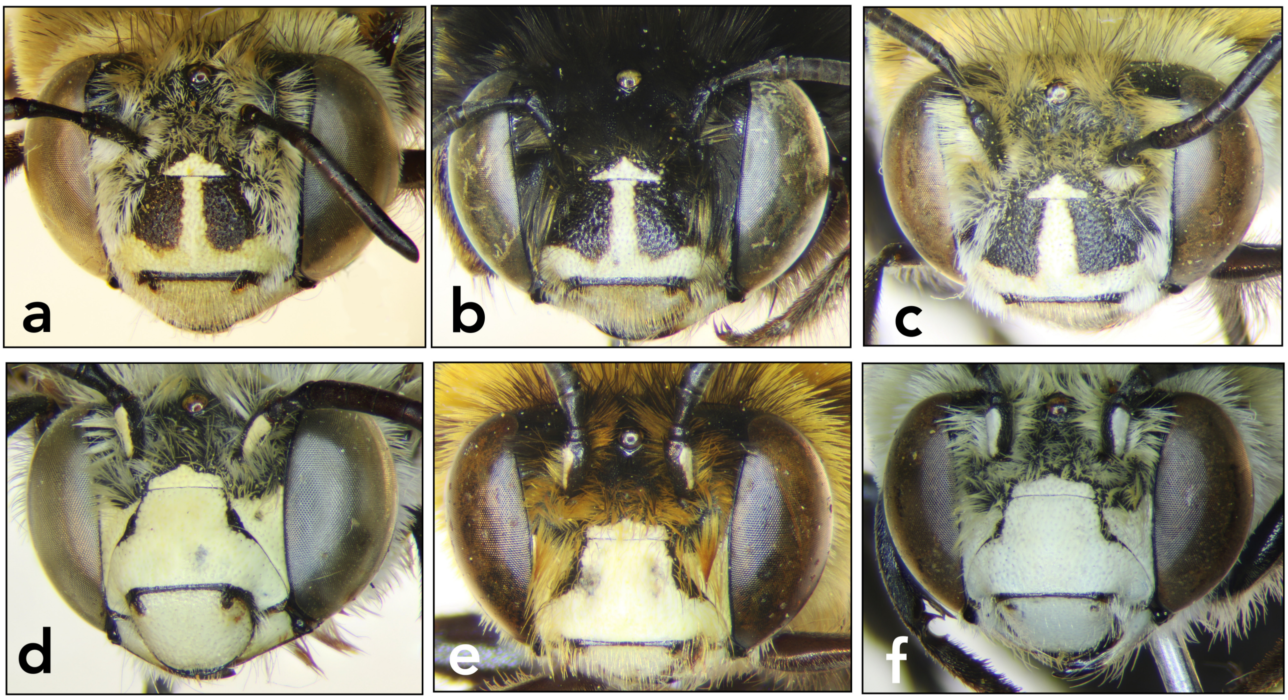

FIGURE 7. Head. a. *A. quadrifasciata* female (Tunisia; TU1); b. *A. maderae* female (Madeira Island; MA06/17; c. *A. teneriffensis* female (Canary Islands; FU4); d. *A. quadrifasciata* male (former Yugoslavia; YU3); e. *A. maderae* male (Madeira Island; MA95-69); f. *A. teneriffensis* male (Canary Islands; LA4).

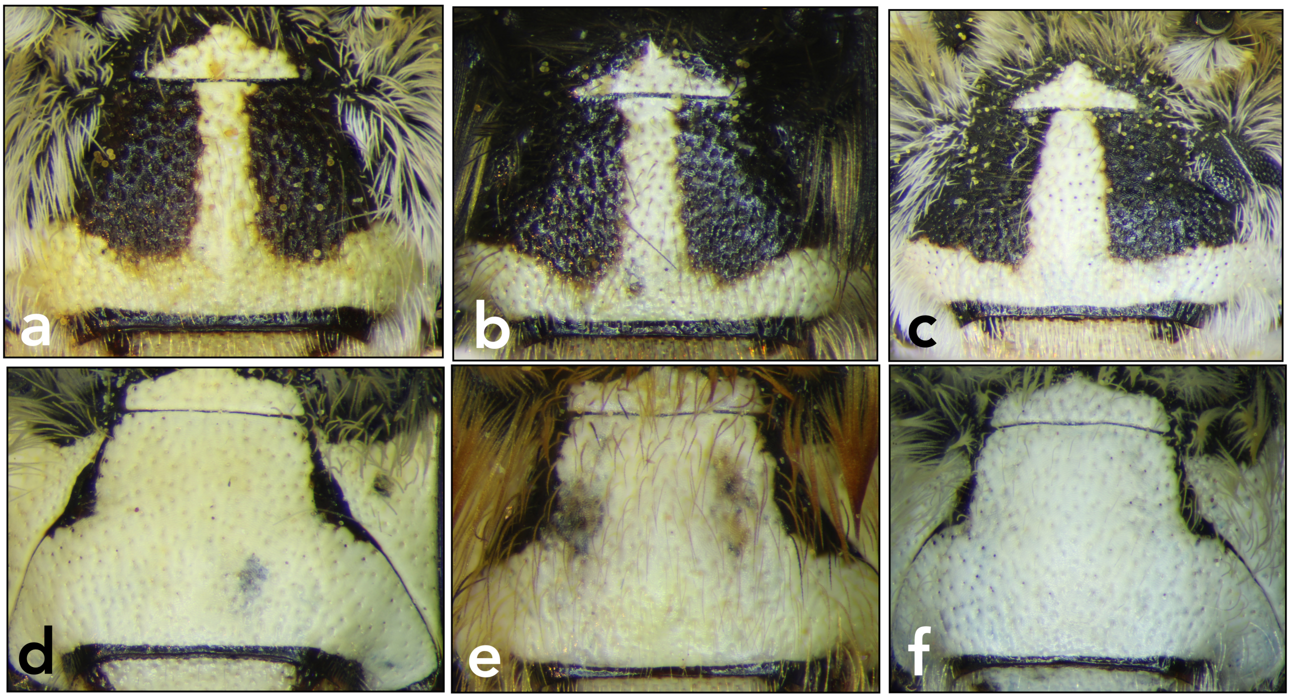

FIGURE 8. Clypeus. a. *A. quadrifasciata* female (Tunisia; TU1); b. *A. maderae* female (Madeira Island; MA06/17); c. *A. teneriffensis* female (Canary Islands; FU4); d. *A. quadrifasciata* male (former Yugoslavia; YU3); e. *A. maderae* male (Madeira Island; MA95-69); f. *A. teneriffensis* male (Canary Islands; LA4).

The antenna is dark-coloured, and the scapus has, in contrast to that of females, an elongated spot (coloured whitish-ivory in *A. quadrifasciata*, whitish-ivory in *A. maderae* and white in *A. teneriffensis*). The pedicellus and flagellomere 1 are black, flagellomere 2 is dorsally black, slightly ore stone coloured, and ventrally apically dark brown, then light brown. Flagellomeres 3–11 are black dorsally, slightly ore stone coloured and light brown ventrally. In *A. quadrifasciata* and *A. maderae*, flagellomere 1 is about twice as long as flagellomere 2, and flagellomeres 3 is about one and a half times longer. In contrast, in *A. teneriffensis*, flagellomere 1 and 3 are one and a half times longer as flagellomere 2.

Pubescence: In *A. quadrifasciata* the vertex is covered with yellowish to ivory-coloured hairs, in *A. maderae,* black to black-brown hairs and in *A. teneriffensis,* the hair colour is whitish with some blackish hairs (Figures 7d–f). In the frons area, the hairs of *A. quadrifasciata* are yellowish to ivory-coloured (Figure 7d), in *A. maderae* golden hairs dominate (Figure 7d) and in *A. teneriffensis,* light yellowish hairs. The base and rear side of the scapus have dense, white-yellowish hairs in *A. quadrifasciata* (half the length of the vertex hairs), black and golden hairs in *A. maderae*, and whitish hairs in *A. teneriffensis* (Figures 7d–f). From the base of the antenna, the pubescence of the paraocular area is longer in *A. quadrifasciata* and ivory-coloured, in *A. maderae* with dominating golden hairs, and in *A. teneriffensis* with white hairs. On the clypeus of *A. quadrifasciata,* longer whitish-yellowish hairs occur, but only laterally, in *A. maderae* golden hairs, and in *A. teneriffensis* white hairs (Figures 8d–f). In the clypeus centre, there is a very loose, fine, yellowish-silver and very short pubescence in *A. quadrifasciata* and silver pubescence in *A. teneriffensis* with hairs bent downwards. (Figures 8d, 8f), but reddish and with longer hairs in *A. maderae* (Figure 8e). In *A. quadrifasciata*, the genae has white-yellowish hairs on the upper side and ivory to white hairs on the lower side (Figure 3b). In *A. maderae,* the genae hairs are dark reddish on the upper side and light reddish on the lower side (Figure 3d); in *A. teneriffensis,* the hair colour is similar to *A. quadrifasciata* but lighter (Figure 3f).

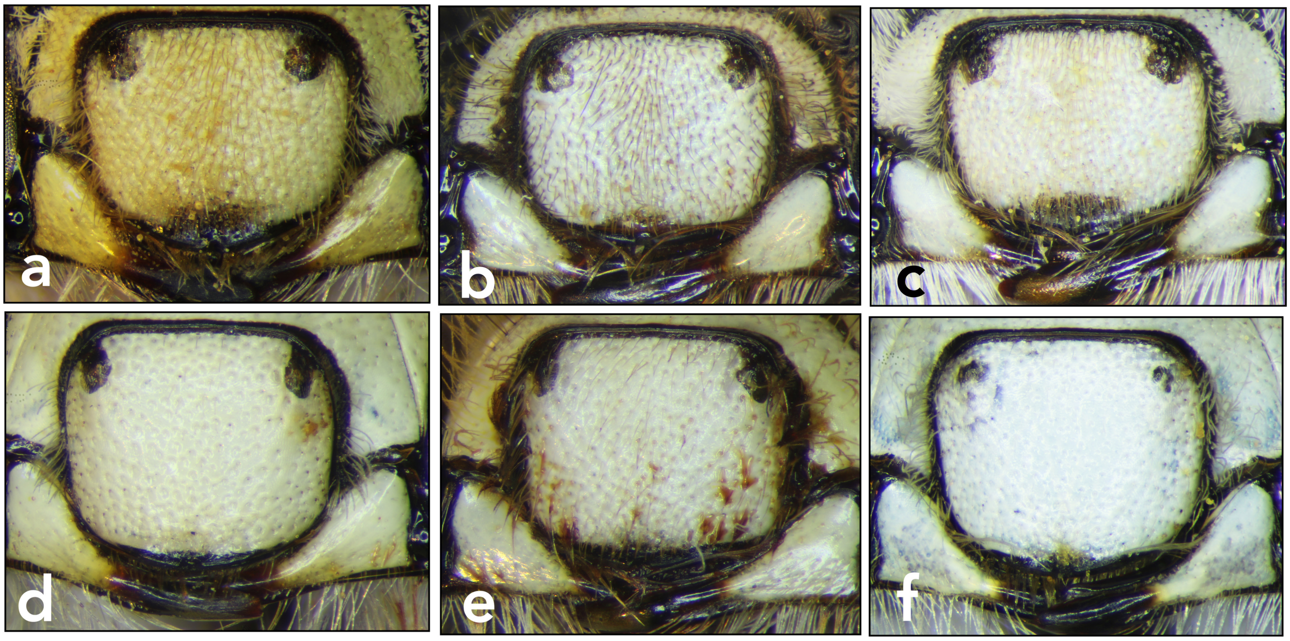

FIGURE 9. Labrum. a. *A. quadrifasciata* female (Tunisia; TU1); b. *A. maderae* female (Madeira Island; MA06/17); c. *A. teneriffensis* female (Canary Islands; FU4); d. *A. quadrifasciata* male (former Yugoslavia; YU3); e. *A. maderae* male (Madeira Island; MA95-69); f. *A. teneriffensis* male (Canary Islands; LA4).

Mesosoma in females:

Structure, colour and puncturation: The scutum is densely and finely punctured both laterally (puncture diameter and distance 14 µm) and centrally (puncture diameter 28 µm and distance 14 µm). In *A. quadrifasciata* and *A. maderae*, the punctures are oval, merge and have raised margins (Figures 10a, 10c). Laterally, there are small areas with larger punctures (diameter 41 µm) and larger distances (Figures 10a, 10c). In contrast, the punctures of *A. teneriffensis* are partly more rounded (Figure 10e). The scutellum of all three species is strongly shiny and unpunctured on the left and right sides centrally, separated by a punctured midline. This shiny area is larger in *A. maderae*, of medium size in *A. quadrifasciata*, but smaller in *A. teneriffensis* (Figures 11a, 11c, 11e). Between the three species, there are also differences in wing length (*A. quadrifasciata*: 9.9 mm; *A. maderae*: 10.2–10.4 mm, *A. teneriffensis*: 10.7 mm). The wings are tinted (smoky), and the veins are black to dark reddish-brown. In *A. quadrifasciata* the wings are lighter than in *A. maderae* and *A. teneriffensis* (Figures 12a, 12c, 12e).

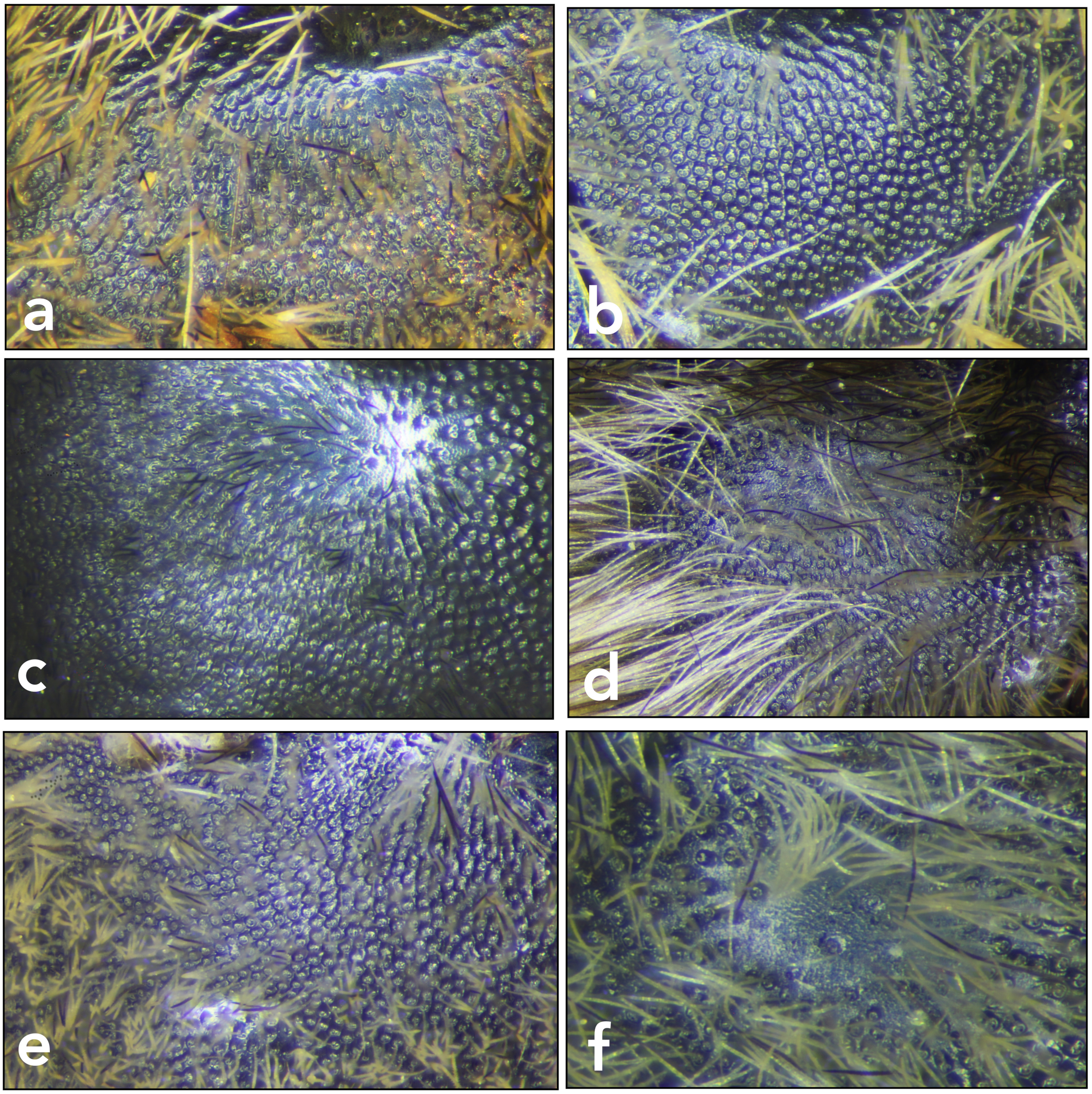

FIGURE 10. Scutum. a. *A. quadrifasciata* female (Tunisia; TU1); b. *A. quadrifasciata* male (former Yugoslavia; YU3); c. *A. maderae* female (Madeira Island; MA06/17); d. *A. maderae* male (Madeira Island; MA05-119); e. *A. teneriffensis* female (Canary Islands; EH1); f. *A. teneriffensis* male (Canary Islands; LA4).

Pubescence: The scutum of *A. quadrifasciata* has a reddish-yellowish golden pubescence that is much patchier in the centre, denser laterally and interspersed throughout the whole area, with a few black hairs of equal length (Figure 2a). The hair colour of scutellum, postscutellum and propodeum is similar to that of the scutum, but only the scutellum shows some black hairs interspersed. The scutellum is hairy only on the posterior margin, and the propodeum has a long and dense pubescence. The mesepisternum has yellowish hairs on top that become whitish, longer and denser downwards. In contrast, the thoracic hair colour of *A. maderae* is very variable and can be characterised as polymorphic. Overall, several colour types can be distinguished, ranging from almost completely black to dark brown, reddish brown and yellow-brown pubescence (Table 2). There are also differences in the pubescence colour of the anterior and posterior areas of the scutum and scutellum as well as the upper and lower areas of the mesepisternum.

TABLE 2. Colour types of *Amegilla maderae* based on 43 females and 29 males.

females	group	A	B	C	D
mesoscutum	anterior	black	black	dark brown	red brown
	posterior	black	dark brown	dark brown	brown
scutellum	anterior	black	dark brown	dark brown	brown
	posterior	black	dark brown	dark brown	brown
	lateral	black*	brown/light brown	brown	brown
mesepisternum	upper	dark brown	brown/light brown	dark brown	brown
	lower	grey brown	grey brown	grey brown	grey brown
tergite bands		orange yellow	orange yellow	yellow	yellow
	%	**40**	**11**	**14**	**5**

* partly light brown

females	group	E	F	G
mesoscutum	anterior	light brown	orange yellow	orange yellow
	posterior	brown	black	orange yellow
scutellum	anterior	brown	black	dark brown
	posterior	brown	brown	dark brown
	lateral	light brown	light brown	light brown
mesepisternum	upper	brown	brown**	orange yellow
	lower	grey brown	grey brown	grey brown
tergite bands		yellow	orange yellow	orange yellow
	%	**14**	**14**	**2**

** partly orange yellow

males	group	A	B	C
mesoscutum	anterior	orange yellow	yellow	orange yellow
	posterior	dark brown	yellow***	orange yellow****
scutellum	anterior	dark brown	yellow	orange yellow
	posterior	orange yellow	yellow	orange yellow
	lateral	orange yellow	yellow	orange yellow
mesepisternum	upper	orange yellow	yellow	orange yellow
	lower	yellowish-white	yellowish-white	yellowish-red
tergite bands		orange yellow	yellow	orange yellow
	%	**45**	**31**	**24**

*** partly brown **** with dark hairs

The thoracic pubescence of *A. teneriffensis* is similar to that of *A. quadrifasciata.* However, it is considerably lighter in the area of the scutum and scutellum (slightly reddish and light yellowish-brown), and the mesepisternum is whitish in hair colour.

In *A. quadrifasciata,* the femur of the foreleg is on its outside more or less hair-free except for some very fine and short yellowish hairs. Inside, the femur has long and light-brownish hairs basally and ventrally, followed by some darker hairs and long whitish hairs and some long black hairs. The tibia is covered with whitish hairs; these are patchy and shorter basally and denser and longer apically. Dorsally, there is a row of black hairs. Apically, there are blackish and yellowish-brownish hairs. The inside of the tibia is more or less hair-free, with only a few very short yellowish hairs. Outside, the basitarsus has basally a few whitish hairs with some yellowish hairs interspersed apically. Inside, the basitarsus has dense reddish-brownish hairs which are longer ventrally. The mediotarsi and the distitarsus are characterised by some whitish and dark-brownish hairs outside and reddish-brownish hairs inside. In *A. maderae,* the outer part of the femur of the foreleg has dirty brown hairs, and the outer part of the tibia has orange-yellowish hairs of equal length. The basitarsus has some yellowish hairs on the outer centre; all other tarsi have reddish hairs. In *A. teneriffensis,* the femur of the foreleg has loose reddish-brown hairs ventrally and basally. Apically, there are some black hairs, and in the lower part, there are long white hairs. The outer side of the tibia has white hairs that are short basally and longer apically. The apical hairs are reddish. Dorsally, there is a reddish-brown to black row of hairs. The basitarsus of the foreleg has some short white hairs centrally on the outside and dark reddish hairs on the edges. All other tarsi have reddish hairs. In *A. quadrifasciata*, the femur of the mid leg has outside ventrally a characteristic row of dense black hairs and basically a whitish hair patch. Inside, there are only very few short, light-brownish hairs with a large hair-free area. Furthermore, there are long, dirty-brownish hairs ventrally. Outside, the tibia is covered with whitish hairs. They are more extensive and denser than in the fore leg and shorter and patchy basally, and denser and longer apically. Ventrally, there is a row of blackish hairs.

At the apex, there are blackish and yellowish-brownish hairs. The tibia has inside some light-brownish hairs. The basitarsus shows a loose blackish and brownish pubescence, inside reddish-brownish hairs and white hairs are ventrally followed by dirty-brownish hairs. The mediotarsi and the distitarsus are characterised by some dark-brownish hairs outside and reddish-brownish hairs inside. The femur of the mid leg of *A. maderae* is bordered with dirty brown hairs. The tibia has orange-yellowish hairs on the outside and orange-reddish hairs on the margins. The basitarsus has reddish-brown hairs, like the other tarsi.

The femur of the midleg of *A. teneriffensis* is also characterised by dirty brown hairs on its edges. The outside of the tibia is covered with whitish hairs, the inside with black hairs. The basitarsus has ventrally white hairs, which fade out apically. The inner side of the basitarsus has reddish-brown hairs, and the rest of the limbs are reddish-brown.

The femur of the hind leg of *A. quadrifasciata* has a pubescence similar to that of the midleg. Outside, the tibia is covered with long and dense whitish hairs (Figure 13a). Dorsally, there is a row of long black hairs. Inside, the tibia is covered with shorter brownish hairs, ventrally with long and dense black hairs. The basitarsus outside is characterised by long, loose black hairs and the inside with dense reddish-brownish hairs. Long black hairs exist dorsally and ventrally (basally longer than apically). The pubescence of the mediotarsi and the distitarsus are similar to to that of the midleg.

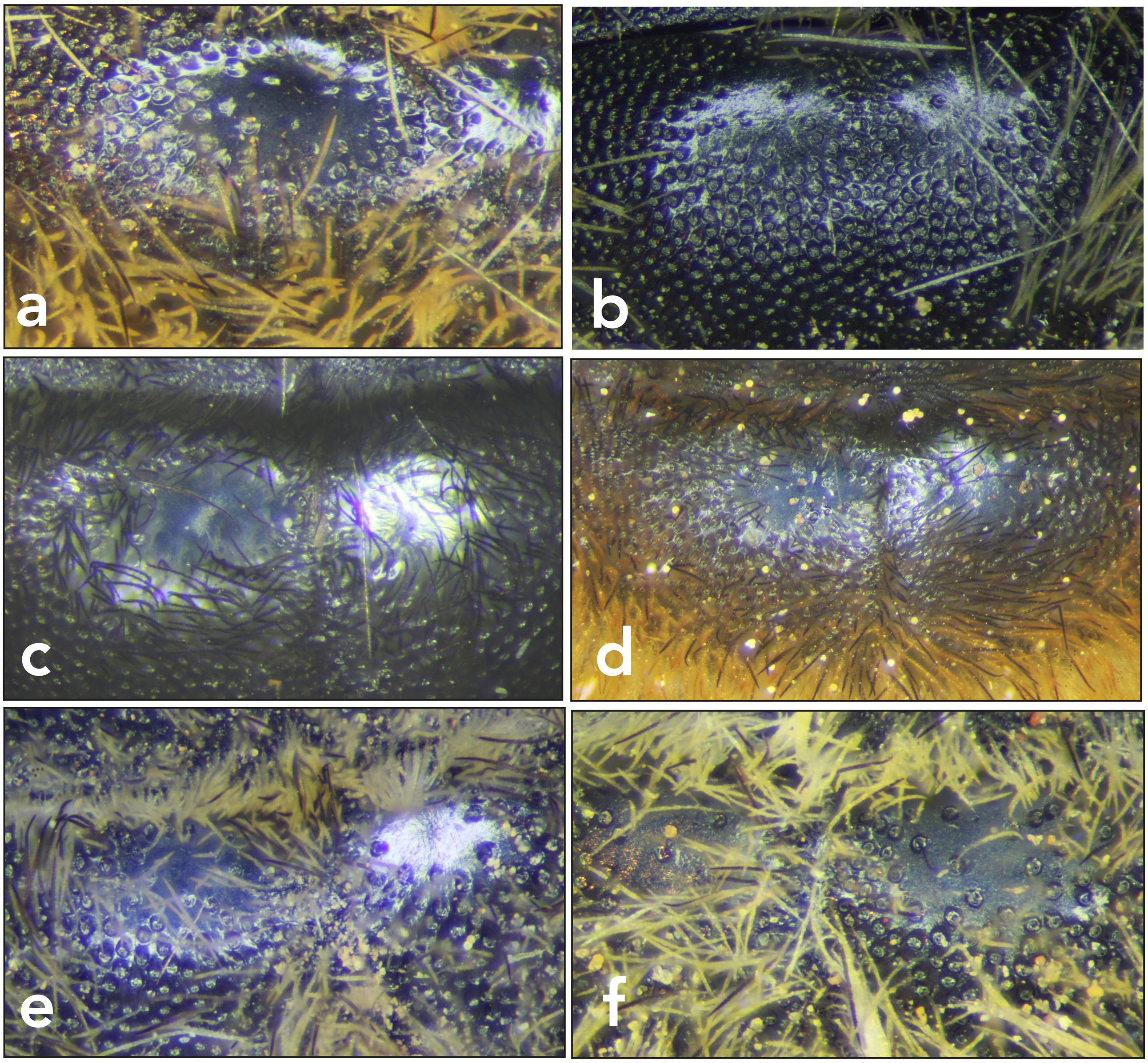

FIGURE 11. Scutellum. a. *A. quadrifasciata* female (Tunisia; TU1,); b. *A. quadrifasciata* male (former Yugoslavia; YU3); c *A. maderae* female (Madeira Island; MA06/17); d. *A. maderae* male (Madeira Island; MA95-75,); e *A. teneriffensis* female (Canary Islands; EH1); f. *A. teneriffensis* male (Canary Islands; LA4).

In *A. maderae,* the femur of the hindleg has dirty brown hairs on the lower margin. The tibia has orange-yellowish hairs on the outside and orange-reddish hairs on its margins (Figure 13c). The basitarsus and all other tarsi have reddish-brown hairs. In *A. teneriffensis,* the lower edge of the femur has dirty brown hairs. The outer side of the tibia is characterised by white hairs that are short basally and longer apically, the inner side has black hairs (Figure 13e). The basitarsus has white hairs ventrally that fade out apically. Inside, there is a reddish-brown pubescence. The other tarsi have reddish-brown hairs.

Mesosoma in males:

Structure, colour and puncturation: The scutum is black and densely and finely punctured both laterally (puncture diameter and distance 14 µm) and centrally (puncture diameter 28 µm and distance 14 µm). Similar to females, the punctures of *A. quadrifasciata* and *A. maderae* are oval, they merge and have raised margins (Figures 10b, 10d). Laterally and centrally are small areas with a larger puncture diameter (41 µm) and a larger puncture distance (Figures 10b, 10d). In contrast, the punctures of *A. teneriffensis* are much more rounded (Figure 10f). In all three species, the thoracic surface is dull and only slightly shiny. Similar to the females, the scutellum is strongly shiny and unpunctured on the left and right sides in the centre, separated by a punctured midline. This shiny area is larger in *A. maderae*, of medium size in *A. quadrifasciata*, but smaller and duller in *A. teneriffensis* (Figures 11b, 11d, 11f).

The wings are slightly tinted (smoky), with black to dark reddish-brown veins (Figures 12b, 12d, 12f). In *A. quadrifasciata,* the wings are tinted only in the vein area, darkest in *A. maderae* and tinted in the whole wing area in *A. teneriffensis* (Figures 12b, 12d, 12f). The colour of the femur, tibia, basitarsus, mediotarsi and distitarsus of all pairs is similar to females of the different species.

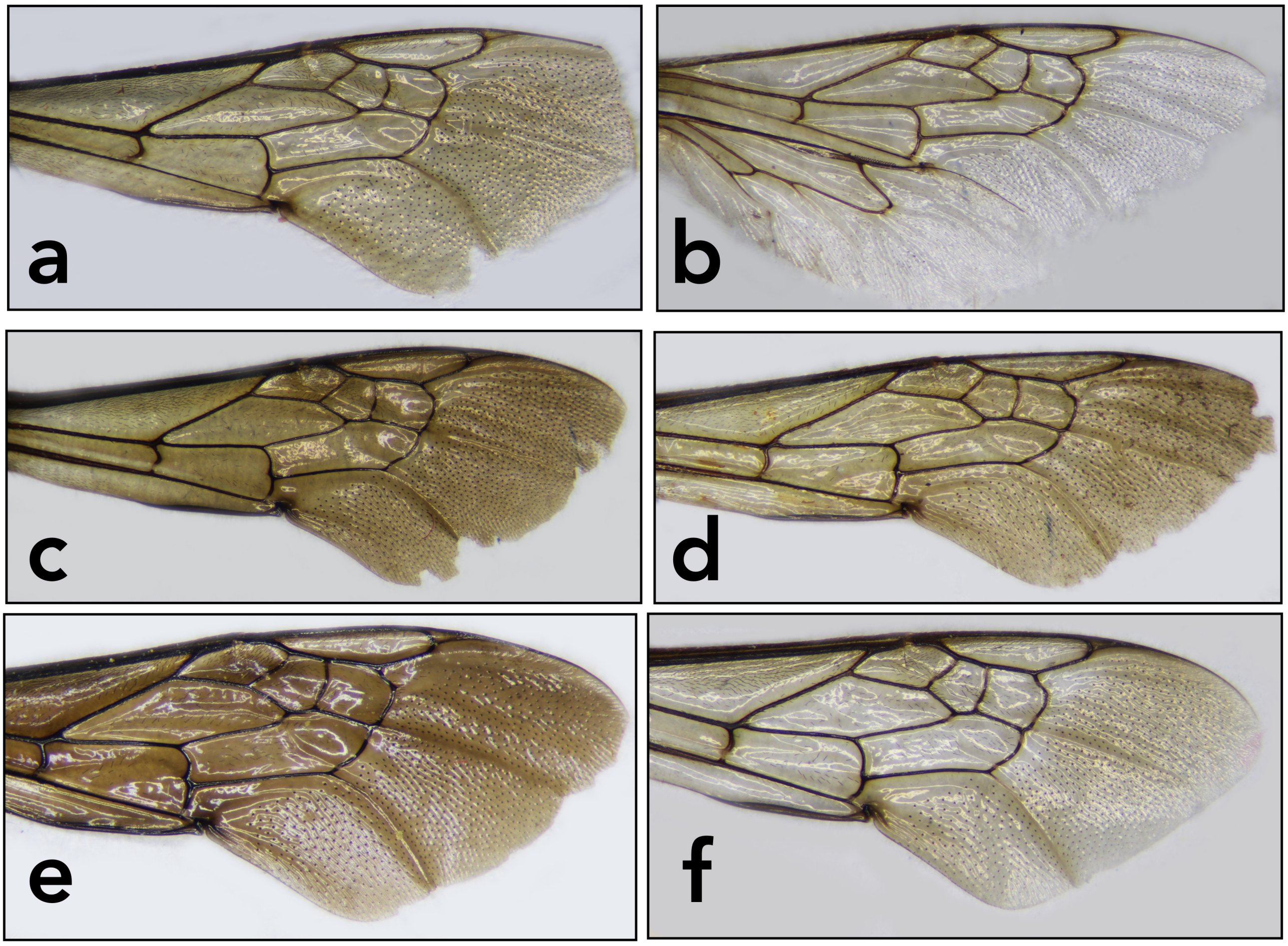

FIGURE 12. Wings. a. *A. quadrifasciata* female (Tunisia; TU1); b. *A. quadrifasciata* male (former Yugoslavia; YU3); c. *A. maderae* female (Madeira Island; MA06/17); d. *A. maderae* male (Madeira Island; MA95-75); e *A. teneriffensis* female (Canary Islands; FU4); f. *A. teneriffensis* male (Canary Islands; GC1).

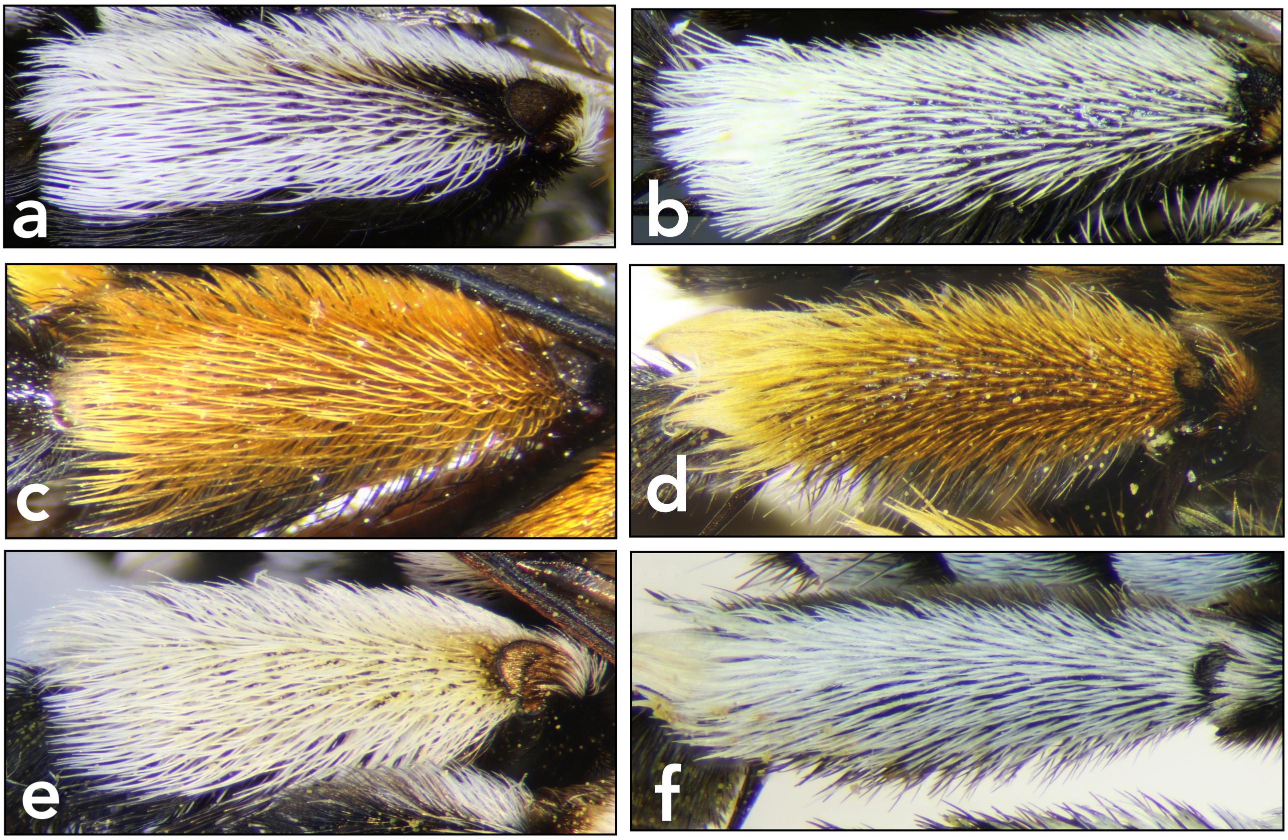

FIGURE 13. Scopa. a. *A. quadrifasciata* female (France; FR1); b. *A. quadrifasciata* male (former Yugoslavia; YU4); c. *A. maderae* female (Madeira Island; MA06/17); d. *A. maderae* male (Madeira Island; MA6-69); e. *A. teneriffensis* female (Canary Islands; EH1); f. *A. teneriffensis* male (Canary Islands; LA4).

Pubescence: The scutum of *A. quadrifasciata* has a yellowish pubescence (Figures 3a, 3b) which is very patchy in the centre, denser laterally and interspersed with a few black hairs of equal length. The scutellum, postscutellum and propodeum are hairy, like the scutum, but the hairs of the propodeum are longer and denser. The mesepisternum has pale yellowish, weakly feathered hairs that become more whitish, longer and denser towards the base. The scutum of *A. maderae* is very variable in hair colour, as are the females. The mesepisternum of *A. teneriffensis* is reddish-yellowish. The femur, tibia, basitarsus, mediotarsi and distitarsus of the foreleg, midleg and hindleg are all similar to those of the females of the respective species (tibia outside see Figures 13 b, 13d, 13f).

Metasoma in females:

Structure, colour and puncturation: The cuticle of tibia 1 and 2 is black and partly reddish-brown in *A. quadrifasciata*, totally black in *A. maderae* and *A. teneriffensis*, and the depressions are partially metallic reddish-green in all three species. Tibia 1 has a flat puncture pattern, with a puncture diameter of 0.14 µm and distances of 0.14–0.28 µm in *A. quadrifasciata* whereas in *A. maderae* and *A. teneriffensis* the puncture diameter and distances are somewhat larger (0.28 µm, >0.28–42 µm); at the base and centre, the distances are larger whilst apically the punctures are smaller. In all species, the puncture distances of tergite 2 to tergite 4 are smaller, and the depression of tergite 4 is broader than that of tergite 1 to tergite 3. Tergite 5 is basically black (in *A. quadrifasciata* apically reddish). The pygidium is black chagrinated in *A. quadrifasciata*, but partly orange in *A. maderae* and *A. teneriffensis.* In all three species, the pygidium is elongated oval and apically rounded, with a slightly raised lateral margin.

Pubescence: Tergite 1 of *A. quadrifasciata* has long whitish to ivory-coloured hairs apically, with only a few long hairs centrally. The yellowish to ivory-coloured bands cover the entirety of the depression (Figure 14a). There are very short, close-fitting black hairs on the entire tergite area except for the depressions. In *A. maderae,* the bands are reddish-orange, centrally with loose bands (Figure 14c); centrally, there are dark brown or black hairs with sometimes light tips. In *A. teneriffensis,* the bands are white, centrally covering the entire depression (Figure 14e).

The pubescence of tergite 2 to tergite 4 of all three species is similar to that of tergite 1 but without the basally and centrally longer hairs. In contrast to *A. quadrifasciata* and *A. maderae* in which hairs partly cover the depression of tergite 4, the white band of *A. teneriffensis* is broad and covers the whole depression (Figure 14e). All in all, the tergite bands of *A. teneriffensis* are of broad and close pubescence. In the three species, tergite 5 has long black-brown hairs centrally and long white hairs laterally. Tergite 6 is characterised next to the pygidium with two tufts of parallel black or black-brown hairs.

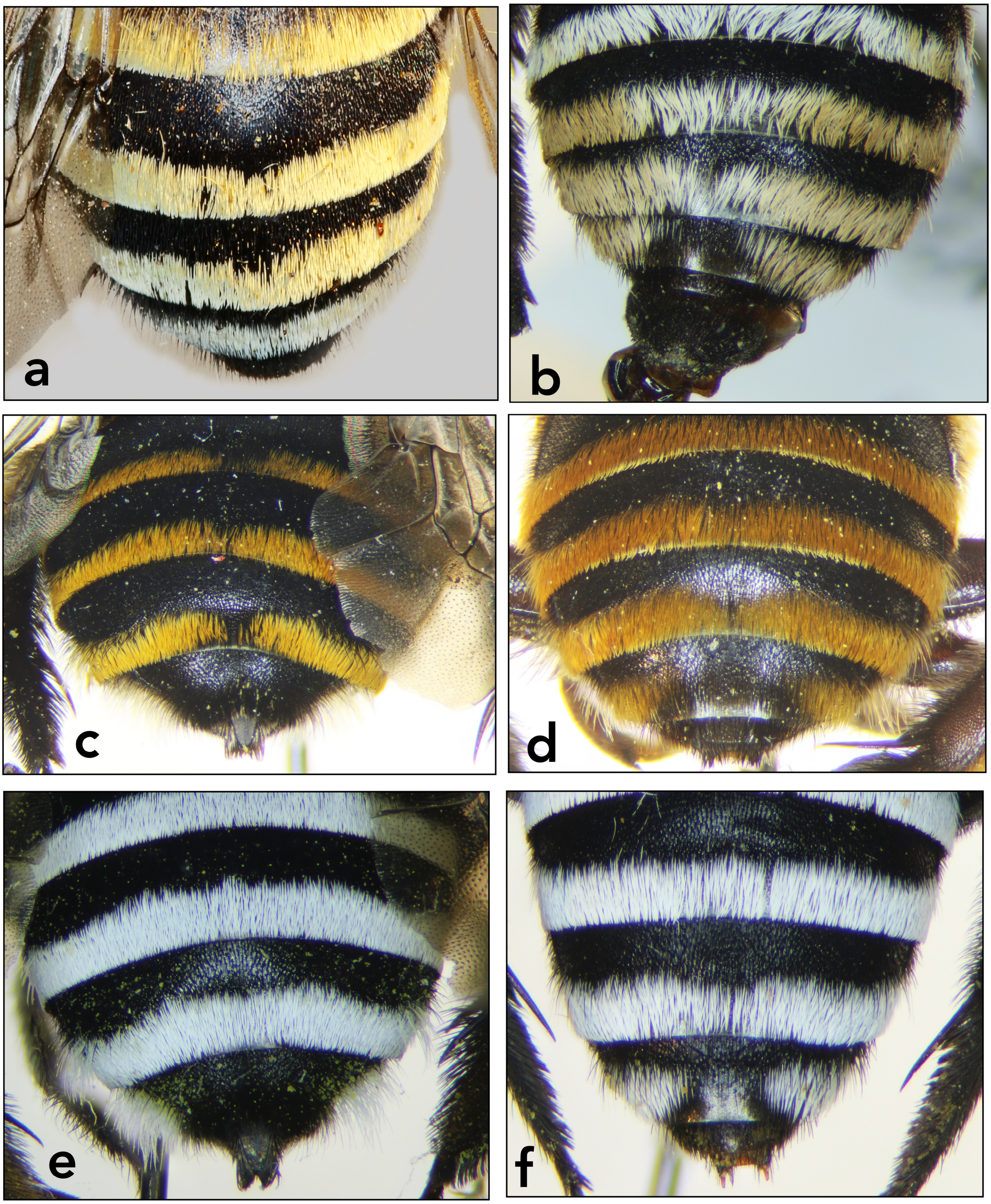

FIGURE 14. Metasoma. a. *A. quadrifasciata* female (France; FR1); b. *A. quadrifasciata* male (former Yugoslavia; YU3); c. *A. maderae* female (Madeira Island; MA06/17); d. *A. maderae* male (Madeira Island; MA6-69); e. *A. teneriffensis* female (Canary Islands; FU4); f. *A. teneriffensis* male (Canary Islands; LA4).

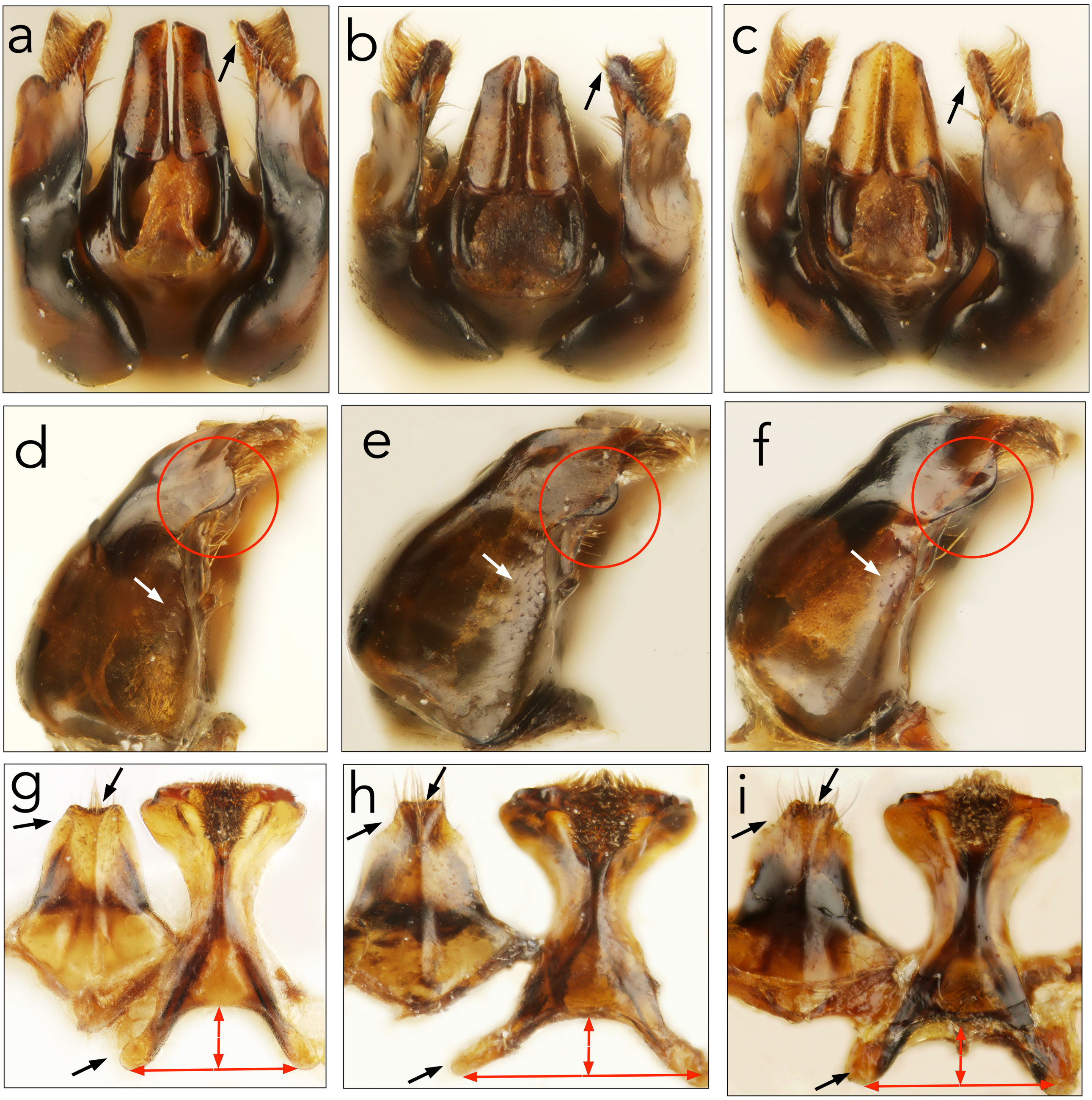

FIGURE 15. Genitalia; genital capsule, dorsal and ventral; S7, S8. a, d, g. *Amegilla quadrifasciata* (France, Agay, Saint Raphaël, Côte d'Azur); b, e, h. *A. maderae* (Madeira Island, Cabo Girão, Câmara de Lobos); c, f, i. *A. teneriffensis* (Canary Islands, Lanzarote, Playa Blanca); preparation H.-R. Schwenninger (Stuttgart).

Metasoma in males:

Structure, colour and puncturation: The colour of the cuticle of tergites 1 and 2 and the depressions are similar to those of the respective females (Figures 14b, 14d, 14f). In tergites 3 and 4, there are no differences in puncture diameter and distance, but also in colour to the females. This also applies to the other tergites. In *A. quadrifasciata,* the square-shaped genitalia appear longer in dorsal view in contrast to *A. maderae* and *A. teneriffensis* (Figures 15a–c). In the three species, the gonocoxite has an inner basal margin and is thickened and slightly curved. At the rounded apex of the gonocoxite are thicker black hairs inside and some thinner yellowish hairs outside. The short gonostylus, which ends with the valves, is hairy outside. It is about three times longer than wide. Between the three species, there are different distances from the gonocoxite notch to the gonostylus end and in the length of the stylus: longer distance, smaller stylus in *A. quadrifasciata*, shorter distance and broader stylus in *A. maderae*, longer distance (similar to *A. quadrifasciata)* but broader stylus (smaller than in *A. maderae*) in *A. teneriffensis* (Figures 15a–c). The outer gonocoxite projection basally is largely right-angled in *A. quadrifasciata,* rounded in *A. maderae*, and flat and slightly rounded in *A. teneriffensis* (Figures 15d–f); appendages of sternite 7 are longer in *A. maderae* than in *A. quadrifasciata* and *A. teneriffensis* (Figures 15g–i). Sternite 8 in *A. quadrifasciata* is indented above but not laterally, in *A. maderae* is not indented above but laterally, in *A. teneriffensis* it is indented above and laterally.

Pubescence: There are no differences to the respective females (Figures 14b, d, f).

Key to females of *Amegilla quadrifasc*iata, *A. maderae* and *A. teneriffensis*

1. Body pubescence predominantly black to dark brown and reddish brown; pubescence of vertex, frons, paraocular area, scapus, clypeus and labrum black to black-brown; scopa hair colour orange-yellowish, the margins with orange-reddish hairs; tergite bands with orange-yellowish hairs not covering the entire depression; clypeus pattern areas, labrum and mandible base whitish-ivory coloured; apical pale clypeus band narrow; scutellum with a large shiny area; . . . . *Amegilla maderae*

\- Body pubescence predominantly reddish-yellowish-golden or slightly reddish and light yellowish-brown; head pubescence yellowish to ivory-coloured, whitish-yellowish or white, scopa with whitish or white hairs; tergite bands with whitish to ivory-coloured or white hairs; clypeus pattern areas, labrum and mandible base yellowish or white coloured; 2

2. Pubescence of mesoscutum, scutellum, postscutellum and propodeum reddish-yellowish-golden; vertex hairs golden-yellow, frons, paraocular area with yellowish to ivory-coloured hairs; scapus, clypeus and labrum with whitish-yellowish hairs; the scopa is covered with long and dense whitish hairs; tergite bands with whitish to ivory-coloured hairs not covering the entire depression; clypeus pattern areas, labrum and mandible base yellowish coloured; mesoscutum with oval, merged and raised punctures, scutellum with medium-sized shiny area; wings lighter in colour . . . .*Amegilla quadrifasciata*

3. Pubescence of mesoscutum, scutellum, postscutellum and propodeum slightly reddish and light yellowish-brown; vertex, frons and paraocular area with whitish-yellowish hairs; scapus, clypeus and labrum with white hairs; the scopa is covered with long and dense pure white hairs; tergite bands pure white and covering the entire depression; clypeus pattern areas yellowish or white, labrum white; punctures of mesoscutum partially more rounded; scutellum with narrower shiny area; wings darker . . . .*Amegilla teneriffensis*

Key to males of *Amegilla quadrifasc*iata, *A. maderae* and *A. teneriffensis*

1. Body pubescence predominantly black to dark brown and reddish brown; pubescence of vertex black to black-brown, frons golden hairs, paraocular area golden hairs, scapus black and golden hairs, clypeus reddish and labrum black to black-brown; tergite bands with orange-yellowish hairs not covering the entire depression; genae dark reddish on the upper side and light reddish on the lower side; clypeus area, labrum and mandible base whitish-ivory coloured; clypeus with pronounced black stripes laterally; scapus with elongated whitish ivory spot; flagellomere 1 about twice as long as flagellomere 2, flagellomere 3 is about one and a half times longer; scutellum with a large shiny area; dark wings; for genitalia, see Figures 15 . . . . *Amegilla maderae*

\- Body pubescence predominantly yellowish or slightly reddish-yellowish; head pubescence yellowish to ivory-coloured, whitish-yellowish or white, tergite bands with whitish to ivory-coloured or white hairs; clypeus area, labrum and mandible base whitish-ivory or white coloured 2

2. Pubescence of mesoscutum, scutellum, postscutellum and propodeum yellowish; vertex hairs yellowish to ivory-coloured, mesepisternum pale yellowish; frons yellowish to ivory-coloured, paraocular area with ivory-coloured hairs; scapus with white-yellowish; clypeus, labrum and mandible base with whitish-ivory hairs; tergite bands with whitish to ivory-coloured hairs not covering the entire depression; genae has white-yellowish hairs on the upper side and ivory to white hairs on the lower side; scapus with elongated whitish-ivory spot; clypeus area, labrum and mandible base whitish-ivory coloured; flagellomere 1 is about twice as long as flagellomere 2, flagellomere 3 is about one and a half times longer; mesoscutum with oval, merged and raised punctures, scutellum with medium-sized shiny area; wings tinted only in the vein area; genitalia given in Figure 15.. . . . .*Amegilla quadrifasciata*

3. Pubescence of mesoscutum, scutellum, postscutellum and propodeum slightly reddish-yellowish; vertex whitish with some blackish hairs; frons and paraocular area with white hairs; scapus whitish hairs, clypeus silver pubescence; genae with white-yellowish hairs on the upper side and ivory to white hairs on the lower side; clypeus and labrum white; black labrum stripes least pronounced, and a small black spot basolaterally; scapus with elongated white spot; clypeus area, labrum and mandible base white coloured; the flagellomeres 1 and 3 are one and a half times longer as the flagellomere 2; punctures of mesoscutum partially more rounded; scutellum with narrower shiny area; wings tinted in the whole area; for genitalia, see Figure 15 . . . .*Amegilla teneriffensis*

Discussion

We here analyse the status of two island lineages of the *A. quadrifasciata* group from the Canary Islands and Madeira using an integrative taxonomic approach combining morphological with morphometric and DNA barcoding data. We find the island populations to be distinct and accordingly raise them to species status. In the following, we discuss our findings in detail.

Detection of new endemic, cryptic species

Following previous studies that now recognise the species status of former subspecies in the subgenus *Micrandrena* (Kratochwil 2020; Kratochwil *et al.* 2021) and in the subgenus *Suandrena* (Kratochwil *et al.* 2014; Kratochwil 2021a) of the Canary Islands and the Madeira Archipelago, the present study shows that this change in species status also applies to representatives of the genus *Amegilla*, which occurs on both archipelagos.

Islands and island archipelagos are hotspots of endemism and frequently harbour cryptic species (Kier *et al.* 2009). Our detection of two new wild bee species within *Amegilla* increases the number of endemic bee species in the Madeira Archipelago and the Canary Islands. Twenty-two species have been recorded from the Madeira Archipelago, of which nine are endemic, nine are introduced and four are native. In the case of the Canary Islands, there are 160 wild bee taxa, of which 138 are species, including 93 endemic taxa (57 endemic species and 36 endemic subspecies), 58 native species and 10 introduced species (Kratochwil unpublished updated data). As island endemics, these species have a special protection status (Hending 2025) whereas as subspecies of an otherwise widespread mainland species, they only had a subordinate conservation status.

Cryptic species, which are in our case also sibling species (Bickford *et al.* 2007), are often the result of a recent speciation event (Gómez *et al.* 2002) in which natural barriers prevent gene flow between populations, causing reproductive isolation and speciation (cryptic speciation sensu Hending 2025).

There are probably cryptic species unrecognised within many described island subspecies, and a further taxonomic revision of these island forms is an important task for the future. A characteristic feature of cryptic species is that they are morphologically difficult to distinguish and therefore not easily recognised (Fišer *et al.* 2018). Only by modern morphometric analyses and molecular genetic methods in the frame of the integrative taxonomy can these cryptic species be detected.

Integrative methods for the detection of cryptic species

Taxon differentiation can be extremely difficult, especially for fauna and flora on island archipelagos with only a short period of time available for diversification and differentiation (Kratochwil 2020, 2021a; Kratochwil *et al.* 2021). In many taxa, morphology seems unreliable because of high variability of nominal characters (Nguembock *et al.* 2008; Jörger & Schrödl 2013; Kratochwil 2025b). Due to their high morphological variability, colour patterns rarely represent reliable distinguishing features between species as Carolan *et al.* (2012) demonstrated in *Bombus*. Molecular genetic results may also involve considerable uncertainty (Borowiec *et al.* 2025).

The most widely used taxonomic approach for insects is based on classical morphospecies analysis followed by DNA barcoding. The use of these two methods is already referred to as integrative taxonomy (e.g., Cheng *et al.* 2025; Marconi *et al.* 2022; Orr *et al.* 2022, 2024).

Our analysis combines three different methods, namely morphological, morphometric and DNA barcoding data, as used, e.g., by Gu *et al.* (2022) and Milankov *et al.* (2008). The use of morphometric methods is less common. Yeates *et al.* (2011) analysed 28 literature sources that used an integrative taxonomy approach. Morphometric methods were used in only four cases, the majority of which involved amphibians and only one of which involved insects (Syrphidae). Hending (2025) emphasises that morphometric analyses are a particularly promising method for distinguishing between cryptic species in closely related taxa and the most reliable method for identifying invertebrate species that are otherwise difficult to distinguish (Huber 1998).

In contrast to conventional morphometric methods, multivariate morphometric methods under allometric scaling are highly effective in distinguishing between morphologically similar species (Baur & Leuenberger 2011, 2020; Baur *et al.* 2014). It is striking that the method employed here has been developed specifically for those insect groups (e.g. Chalcidoidea; Baur 2025) that have few nominal variables, or for museum material where only a few individuals are available for analysis or where destructive methods are not permissible, restricting molecular genetic analysis.

Our investigation is therefore based on three different methods: morphometric analysis using allometric scaling, molecular genetic analysis, and morphological analysis based on nominal parameters, also taking variable traits into account. The methods used provided good separation of the taxa studied, and the implementation of different types of data (i.e. morphology, morphometry and genetics) represent an essential component of integrative taxonomy, lending confidence to our (re)elevation of two former subspecies within *Amegilla* to species status.

Colonisation and body size traits

Our molecular analyses suggest that the mainland populations of *A. quadrifasciata* across a large range—from Morocco, Sardinia, Slovenia, Armenia and Kyrgyzstan—are genetically quite homogeneous, with some local variation. The molecular genetic results presented here also suggest that *A. teneriffensis* is a basal taxon that split off very early from an ancestor that was probably distributed in North Africa. Today, North Africa is inhabited by *A. quadrifasciata*.

Surprisingly, our sequence data suggest that *Amegilla maderae* is a sister species of *A. quadrifasciata*, and that both were separated from each other after *A. teneriffensis* had already split off. In which way the Madeira Archipelago was colonised remains an open question and cannot be answered with the current state of knowledge. The distance between Porto Santo (Madeira Archipelago) and Cape Sim (Morocco) is 737 km. It cannot be excluded that the Madeira Archipelago was colonised directly by *A. quadrifasciata* populations from North Africa or their ancestors and not via the Canary Islands (minimum distance to the Madeira Archipelago 450 km), as is hypothesised for the *Andrena wollastoni* group (Kratochwil *et al.* 2021).

Early colonisation from North Africa of the Canary Islands (distance 96 km), as suggested by the phylogenetic tree (Figure 6), is consistent with findings for other wild bee species colonising the Canary Islands and can also be assumed in the case of *Amegilla teneriffensis* and its ancestor. Specimens of the *Andrena wollastoni* group (including *Andrena tiaretta* Warncke, 1974) likely colonised the Canary Islands via North Africa and expanded to the Madeira Archipelago, whilst species of the subgenus *Suandrena* (*Andrena fratella* Warncke, 1968) likely colonised the Canary Islands via North Africa and the Madeira Archipelago (Kratochwil *et al.* 2014; Kratochwil 2021a).

The species of the genus *Amegilla* likely have a large flight range because of their considerable body size (females about 13–17 mm). Members of this genus are also very fast-flying bees, making them potentially successful colonisers. Violent sandstorms (‘Calima’ events) from the Sahara occasionally reach the Canary Islands and, as satellite images show, also the Madeira archipelago (Menéndez 2009; Rodríguez & López-Darias 2024). Such events could easily lead to the wind dispersal (passive and/or active) of small animal species between the two archipelagos (e.g. Odonata; Weihrauch 2011), which may explain the close relationship between *A. maderae* and *A. teneriffensis*.

There are many examples of sister groups of other bee species in which bees of the two islands of the Madeira Archipelago, Porto Santo and Madeira Island, differ significantly from each other: *Andrena portosanctana*—*A. maderensis*, *Osmia latreillei*—*Osmia madeirensis*, *Andrena dourada*—*Andrena wollastoni* (Kratochwil 2020, 2021a; Kratochwil *et al.* 2014, 2018a, 2021a, 2022). Our preliminary investigations have shown that the morphometric differences between *Amegilla* females from Madeira Island and Porto Santo are significant in isosize analyses and the best ratio analyses resulted in two overlapping scatterplots, suggesting some differentiation. A comparison with other bee species suggests that, for *Amegilla* too, the older island of Porto Santo (14.3 Ma) was colonised first, followed by colonisation of the younger Madeira Island (5.2 Ma) in a subsequent step. We interpret these two subclades from the perspective of incipient diversification. Further investigations into the island-specific differences of *A. maderae* are in preparation.

Our univariate morphometric results show that the specimens of *A. teneriffensis* and *A. maderae* are significantly larger in numerous body size characters compared to *A. quadrifasciata*. This supports the findings of Poulsen & Rasmussen (2020) that the body size of bee taxa that have colonised islands tends to be larger than that of mainland species, while mainland species are smaller, independent of their taxonomic rank. In our case, this can be explained by the idea that larger individuals have better dispersal ability than smaller ones, which led to a greater body size in island populations.

Polymorphic dark colour forms of *Amegilla maderae*

Whether the diversity of different colour forms within a bee species has a genetic basis (genetic polymorphism) or is environmentally determined (polyphenism) is unknown and probably varies from case to case (Rapti *et al.* 2014). *Amegilla maderae* is a polymorphic species concerning hair colour. Dark hair-coloured bee taxa occur frequently on islands. An example is *Bombus terrestris canariensis* Pérez, 1895 from the Canary Islands (Rasmont *et al.* 2021). *Bombus xanthopus* Kriechbaumer, 1870 (Corsica) is also characterised as a dark island colour form and is now listed as a separate species from *B. terrestris* (Rasmont *et al.* 2021). Another example of colour variation on islands is *Anthophora urbana clementina* Cockerell, 1939, which is darker and more orange than the mainland form (Orr *et al.* 2023), and *Anthophora plumipes*, in which the hair colour of about 10% of females is black and the other 90% are brown in mainland northern Europe, whilst almost 100% of females are black in Great Britain (Falk 2015).

The phenomenon of dark colour morphs is clearly not limited to islands. Different colour forms of a species often occur in mainland populations as well, as in *Anthophora plumipes*. Variability may not be limited to females but can also extend to males (Rasmont *et al.* 1986). Wood & Praz (2024) detected two distinct colour forms in *Anthophora onosmarum* Morawitz, 1876 (black pubescence in Greece and central Türkiye; yellow pubescence in central and eastern Türkiye and Iran). However, the fact that this is not only due to regional reasons is shown by reference to two colour forms of this species collected at one locality by the apidologist Klaus Warncke from Germany (Wood & Praz 2024).

The colour forms of *Bombus* species have been studied most intensively by Oskar Vogt and Edgar Krüger, who found specimens of various colour morphs within a species both in the offspring of a single nest and in a limited local area, but also across great geographic regions (e.g., Krüger 1928, 1931, 1940; Vogt 1909, 1911).

There are many hypotheses about the reasons of different colour forms, e.g., Müllerian mimicry, epigenetic effects, thermal melanism, genetic drift (Rapti *et al.* 2013, Orr *et al.* 2023; Kasparek *et al* 2024). Many aspects are speculative, and further research is needed to understand the origin of, the mechanistic basis for, and the adaptive value of colour variation.

In the discussion on colour forms to date, no distinction has generally been made between colours of the integument (cuticle) and hair colouration. The variability of abdominal cuticular red or black colouration has been demonstrated in detail in *Andrena savignyi* (Kratochwil 2025b). In *Amegilla maderae*, seven different hair colour forms in females and three in males were detected in this study. Eight different body regions were distinguished: mesoscutum (anterior, posterior); scutellum (anterior, posterior, lateral), mesepisternum (upper side, lower side), tergite bands, all because they differ in colouration. The phenomenon is too complex to explain in a single term (e.g., melanic, rufinic; further examples see Reinig 1937).

Very little is known about colour variation in Anthophorine bees (Wood & Praz 2024). Our study highlights the need to investigate such colour phenomena within and between populations of a species, particularly in relation to genetic versus environmental causes (e.g. Kasparek *et al.* 2024).

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Declarations

Collecting Permits: Collecting permits were issued by the governments of the Canary Islands and authorities of the Madeira Archipelago.

Ethics approval: No ethics approval was required for this study.

Consent for publication: All authors read, contributed to, and approved the manuscript.

References

Alfken, J.D. (1940) Die Arthropodenfauna von Madeira nach den Ergebnissen der Reise von Prof. Dr. O. Lundblad Juli–August 1935. XXV. Hymenoptera: *Prosopis*, *Andrena*, *Anthophora*, *Megachile* und *Osmia*. *Arkiv för zoologi, Uppsala*, 32 (4), 1–2.

Báez, M. & Ortega, G. (1978) Lista preliminar de los Himenópteros de las Islas Canarias. *Boletín de la Asociación Española de Entomologia*, 2, 185–199.

Baur, H. (2025) Morphometric Methods for Species Recognition. *In*: Heraty, J. & Woolley, J. (Eds.), *Chalcidoidea of the World*. CABI, Wallingford, Oxfordshire, pp. 789–795.
https://doi.org/10.1079/9781800623545.0069

Baur, H. & Leuenberger, C. (2011) Analysis of ratios in multivariate morphometry. *Systematic Biology*, 60, 813–825.
https://doi.org/10.1093/sysbio/syr061

Baur, H., Kranz-Baltensperger, Y., Cruaud, A., Rasplius, J.-Y., Timokhov, A.V. & Gokhan, V.E. (2014) Morphometric analysis and taxonomic revision of *Anisopteromalus* Ruschka (Hymenoptera: Chalcidoidea: Pteromalidae)—An integrative approach. *Systematic Entomology*, 39, 691–709.
https://doi.org/10.1111/syen.12081

Baur, H. & Leuenberger, C. (2020) Multivariate Ratio Analysis (MRA): R-scripts and tutorials for calculating Shape PCA, Ratio Spectra and LDA Ratio Extractor. Available from: https://zenodo.org/records/4250142 (accessed 14 October 2025)
https://doi.org/10.5281/zenodo.4250142

Bickford, D., Lohman, D.J., Sodhi, N.S., Ng, P.K., Meier, R., Winker, K., Ingram, K.K. & Das, I. (2007) Cryptic species as a window on diversity and conservation. *Trends in Ecology and Evolution*, 22 (3), 148–155.
https://doi.org/10.1016/j.tree.2006.11.004

Bischoff, H. (1937) Hymenoptera aculeata (excl. Formicidae und Halictinae) von den Kanarischen Inseln. *Societas Scientiarum Fennica Commentationes Biologicae*, 6 (10), 1–3.

Boltnev, A. & Kacher, O. (2017) *FOTO Stacker Version 1.6 (29)*. FOTO Stacker, LLC, Mason, Ohio. [program]

Boni, C.B., Coppola, F., Quaranta, M., Giannini, F. & Felicioli, A. (2023) *Bombus terrestris terrestris* (Linnaeus, 1758) and hybrids with the endemic *Bombus xanthopus* spotted on Capraia Island (Tuscan Archipelago, Italy): some conservation management implications. *The Science of Nature*, 110 (3), 14.
https://doi.org/10.1007/s00114-023-01843-y

Borowiec, M.L., Zhang, Y.M., Neves, K., Ramalho, M.O., Fisher, B.L., Lucky, A. & Moreau, C.S. (2025) Evaluating UCE data adequacy and integrating uncertainty in a comprehensive phylogeny of ants. *Systematic Biology*, syaf001.
https://doi.org/10.1093/sysbio/syaf001

Brooks, W. (1988) Systematics and phylogeny of the anthophorine bees (Hymenoptera: Anthophoridae; Anthophorini). *University of Kansas Science Bulletin*, 53 (9), 436–575.

Carolan, J.C., Murray, T.E., Fitzpatrick, U., Crossley, J., Schmidt, H., Cederberg, B., McNally, L., Paxton, R.J., Williams, P.H. & Brown, M.J. (2012) Colour patterns do not diagnose species: quantitative evaluation of a DNA barcoded cryptic bumblebee complex. *PLoS One*, 7 (1), e29251.
https://doi.org/10.1371/journal.pone.0029251

Carracedo, J.C. (2011) *Geología de Canarias I. (Origen, evolución, edad y volcanismo)*. Editorial Rueda, Madrid, 398 pp.

Cheng, Y., Dehant, V., Rivoldini, A., Rekier, J. & Bizouard, C. (2025) Basic Earth Parameters from VLBI observations using Bayesian inversions in the time domain: updated insights of the Earth‘s interior. *EGUsphere*, 2025, 1–18.
https://doi.org/10.5194/egusphere-2025-4428

Cockerell, T.D.A. (1930) Descriptions and records of bees CXXVI. *Annals and magazine of natural history, zoology, botany and geology*, 10 (3), 273–282.
https://doi.org/10.1080/00222933108673310

Coppée, A. (2010) *Bombus terrestris (L. 1758) A complex species or a species complex. Intraspecific pheromonal and genetic variations of Bombus terrestris (L.), Impacts on the speciation*. Laboratoire de Zoologie, Université de Mons, Mons, 177 pp.

Dours, J.M.A. (1869) *Monographie iconographique du genre Anthophora Lat*. Imp. Lenoel-Herouart, Amiens, 210 pp., 2 pls.
https://doi.org/10.5962/bhl.title.9337

Drummond, A.J., Suchard, M.A., Xie, D. & Rambaut, A. (2012) Bayesian phylogenetics with BEAUti and the BEAST 1.7. *Molecular Biology and Evolution*, 29, 1969–1973.
https://doi.org/10.1093/molbev/mss075

Dusmet y Alonso, J.M. (1924) Algunos himenópteros de Canarias. *Boletín de la Sociedad Española de Historia Natural*, 24, 455–458.

EazyDraw (2020) *Vector drawing software. Version 9.8.1*. Dekorra Optics LLC, Sauk City, Wisconsin. [program]

Falk, S. (2015) *Field Guide to the Bees of Great Britain and Ireland*. British Wildlife Publishing, Plymouth, 432 pp.

Fišer, C., Robinson, C.T. & Malard, F. (2018) Cryptic species as a window into the paradigm shift of the species concept. *Molecular Ecology*, 27 (3), 613–635.
https://doi.org/10.1111/mec.14486

Folmer, O., Black, M., Hoeh, W., Lutz, R. & Vrigenhoek, R. (1994) DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. *Molecular Marine Biology and Biotechnology*, 3, 294–299.

Friese, H. (1897) *Die Bienen Europa's (Apidae europaeae) nach ihren Gattungen, Arten und Varietaten auf vergleichend morphologisch-biologischer Grundlage. Theil III. Solitære Apiden. Genus Podalirius*. Friedländer & Sohn, Berlin 316 pp.

Galopim de Carvalho, A.M. & Bandão, J.M. (1991) *Geologia do Arquipélago da Madeira*. Museu Nacional de História Natural (Mineralogia e Geologia) da Universidade de Lisboa, Lisbon, 170 pp.

Geldmacher, J., van der Bogaard, P. & Schminke, H.-U. (2000) The 40 Ar/39 Ar age dating of the Madeira Archipelago and hotspot track (Eastern North Atlantic). *Geochemistry, Geophysics, Geosystems*, 1 (2), 1999GC000018. https://doi.org/10.1029/1999GC000018

Gómez, A., Serra, M., Carvalho, G.R. & Lunt, D.H. (2002) Speciation in ancient cryptic species complexes: evidence from the molecular phylogeny of *Brachionus plicatilis* (Rotifera). *Evolution*, 56 (7), 1431–1444. https://doi.org/10.1111/j.0014-3820.2002.tb01455.x

Gribodo, G. (1883) Le crociere dell Yacht 'Corsaro' del capitano Armatore Enrico d'Albertis. IV. Imenotteri. *Annali del Museo civico di Storia Naturale di Genova*, 18, 684–690.

Gu, X., Zheng, Y., Li, H. & Guo, J. (2022) A case of integrative taxonomy based on traditional morphology, molecular systematics and geometric morphometrics in the taxonomy of Torrenticolidae (Acari, Hydrachnidiae). *Systematic and Applied Acarology*, 27 (5), 905–921. https://doi.org/10.11158/saa.27.5.6

Hending, D. (2025) Cryptic species conservation: a review. *Biological Reviews*, 100 (1), 258–274. https://doi.org/10.1111/brv.13139

Hohmann, H., La Roche, F., Ortega, G. & Barquin, J. (1993) Bienen, Wespen und Ameisen der Kanarischen Inseln (Insecta: Hymenoptera: Aculeata). *Veröffentlichungen aus dem Übersee-Museum Bremen, Naturwissenschaften*, 12 (1), 14–465, (col.) pls. I–XII; 12 (2), 493–712.

Huber, J.T. (1998) The importance of voucher specimens, with practical guidelines for preserving specimens of the major invertebrate phyla for identification. *Journal of Natural History*, 32 (3), 367–385. https://doi.org/10.1080/00222939800770191

Jörger, K.M. & Schrödl, M. (2013) How to describe a cryptic species? Practical challenges of molecular taxonomy. *Frontiers in Zoology*, 10 (1), 1–27. https://doi.org/10.1186/1742-9994-10-59

Kasparek, M., Tunca, R.I. & Özgül, O. (2024) Can Bergmann's rule and the thermal melanism hypothesis explain the variation in colour and size observed in the wild bee *Eoanthidium insulare* (Apoidea: Megachilidae) across its Palaearctic range? *Journal of Asia-Pacific Entomology*, 27 (1), 102174. https://doi.org/10.1016/j.aspen.2023.102174

Kearse, M., Moir, R., Wilson, A., Stones-Havas, S., Cheung, M., Sturrock, S., Buxton, S., Cooper, A., Markowitz, S., Duran, C., Thierer, T., Ashton, B., Meintjes, P. & Drummond, A. (2012) Geneious Basic: an integrated and extendable desktop software platform for the organization and analysis of sequence data. *Bioinformatics*, 28, 1647–1649. https://doi.org/10.1093/bioinformatics/bts199

Kier, G., Kreft, H., Lee, T.m., Jetz, W., Ibisch, P.l., Nowicki, C., Mutke, J. & Barthlott, W. (2009) A global assessment of endemism and species richness across Island and mainland regions. *Proceedings of the National Academy of Sciences*, 106 (23), 9322–9327. https://doi.org/10.1073/pnas.0810306106

Kratochwil, A. (2020) Revision of the *Andrena wollastoni* group (Hymenoptera, Anthophila, Andrenidae) from the Madeira Archipelago and the Canary Islands: upgrading of three former subspecies and a description of three new subspecies. *Linzer biologische Beiträge*, 52 (1), 161–244.

Kratochwil, A. (2021a) Taxonomic re-evaluation of *Andrena cyanomicans* Pérez, 1895, *A. fratella* Warncke, 1968, *A. maderensis* Cockerell, 1922, *A. mirna* Warncke, 1969, *A. notata* Warncke, 1968, and *A. portosanctana* Cockerell, 1922 (Hymenoptera, Anthophila, *Suandrena*). *Linzer biologische Beiträge*, 53 (2), 631–698.

Kratochwil, A. (2021b) First record of a gynandromorph of *Osmia submicans* Morawitz, 1870 (Hymenoptera, Megachilidae) – characterisation by morphological and morphometric parameters and critical note on gynander classification. *Linzer biologische Beiträge*, 53 (1), 3–31.

Kratochwil, A. (2025a) Neotype designation (female) of *Amegilla* (*Amegilla*) *quadrifasciata* (Villers, 1789) (Anthophila, Anthophoridae) – historical background, morphometric validation, description of the male. *Linzer biologische Beiträge*, 57 (1), 193–225.

Kratochwil, A. (2025b) Redescription of *Andrena savignyi* Spinola, 1838 (Hymenoptera, Anthophila, Andrenidae). *Linzer biologische Beiträge*, 56 (2), 487–526.

Kratochwil, A. & Schwabe, A. (2018a) Wild bees (Anthophila) of Porto Santo (Madeira Archipelago) and their habitats: species diversity, distribution patterns and bee-plant network. *Linzer biologische Beiträge*, 50 (2), 1219–1247.

Kratochwil, A. & Schwabe, A. (2018b) Wild bees (Anthophila) of Macaronesia – biogeographical and evolutionary aspects. *Berichte der Reinhold-Tüxen-Gesellschaft*, 30, 149–162.

Kratochwil, A., Schwabe, A. & Scheuchl, E. (2014) *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. *Linzer biologische Beiträge*, 46 (2), 1535–1567.

Kratochwil, A., Smit, J. & Aguiar, A. (2018) Updated checklist of the wild bees of the Madeira Archipelago (Hymenoptera: Apoidea: Anthophila). *Linzer biologische Beiträge*, 50 (2), 1213–1228.

Kratochwil, A., Schwabe, A., Paxton, R., Aguiar, A. & Husemann, M. (2021) Morphological and genetic data suggest a complex pattern of inter-island colonisation and differentiation for wild bees (Hymenoptera: Anthophila: *Andrena*) on the Macaronesian Islands. *Organisms Diversity & Evolution*, 22 (1), 189–204.
https://doi.org/10.1007/s13127-021-00513-z

Kratochwil, A., Schwabe, A., Aguiar, A.M.F. & Smit, J. (2022) Intra-island distribution of the wild-bee species of Madeira Island, habitat preferences and flower-visiting behaviour (Hymenoptera, Apoidea, Anthophila). *Boletim do Museu de História Natural do Funchal*, 22, 55–113.

Krüger, E. (1928) Über die Farbenvariationen der Hummelart *Bombus agrorum* Fabr. *Zeitschrift für Morphologie und Ökologie der Tiere*, 11 (3/4), 361–494.
https://doi.org/10.1007/BF02433459

Krüger, E. (1931) Über die Farbenvariationen der Hummelart *Bombus agrorum* Fabr. 11. Teil. *Zeitschrift für Morphologie und Ökologie der Tiere*, 24 (1), 148–237.
https://doi.org/10.1007/BF00491804

Krüger, E. (1940) Über die Farbenvariationen der Hummelart *Bombus variabilis*. *Zeitschrift für Morphologie und Ökologie der Tiere*, 37 (2), 276–386.
https://doi.org/10.1007/BF00408262

Lecocq, T., Brasero, N., De Meulemeester, T., Michez, D., Dellicour, S., Lhomme, P., De Jonghe, R., Valterová, I., Urbanová, K. & Rasmont, P. (2015) An integrative taxonomic approach to assess the status of Corsican bumblebees: implications for conservation. *Animal Conservation*, 18 (3), 236–248.
https://doi.org/10.1111/acv.12164

Leigh, J.W. & Bryant, D. (2015) PopART: Full-feature software for haplotype network construction. *Methods in Ecology and Evolution*, 6 (9), 1110–1116.
https://doi.org/10.1111/2041-210X.12410

Lieftinck, M.A. (1958) A preliminary account of the Bees of Canary Islands (Hym. Apoidea). *Societas Scientiarum Fennica Commentationes Biologicae*, 18 (5), 1–34.

Losos, J.B. & Ricklefs, R.E. (2009) Adaptation and diversification on islands. *Nature*, 457, 830–836.
https://doi.org/10.1038/nature07893

Marconi, M., Modesti, A., Alvarez, L.P., Ogoña, P.V., Mendoza, A.C., Vecco-Giove, C.D., Luna, J.O., Di Giulio, A. & Mancini, E. (2022) DNA Barcoding of stingless bees (Hymenoptera: Meliponini) in Northern Peruvian forests: A plea for integrative taxonomy. *Diversity*, 14 (8), 632.
https://doi.org/10.3390/d14080632

Menéndez, I., Derbyshire, E., Engelbrecht, J., von Suchodoletz, H., Zöller, L., Dortha, P., Carrillo, T., & Rodríguez de Castro, F. (2009) Saharan dust and the aerosolson the Canary Islands: past and present. *In*: Cheng, M. & Liu, W. (Eds.), *Airborne particulates*. Nova Science Publishers, New York, New York, pp. 39–80.

Michener, C.D. (2007) *The Bees of the World* (2nd ed.). Johns Hopkins University Press, Baltimore, 953 pp.

Milankov, V., Ståhls, G., Stamenković, J. & Vujić, A. (2008) Genetic diversity of populations of *Merodon aureus* and *M. cinereus* species complexes (Diptera, Syrphidae): integrative taxonomy and implications for conservation priorities on the Balkan Peninsula. *Conservation Genetics*, 9 (5), 1125–1137.
https://doi.org/10.1007/s10592-007-9426-8

Nguembock, B., Fjeldså, J., Couloux, A. & Pasquet, E. (2008) Phylogeny of *Laniarius*: molecular data reveal *L. liberatus* synonymous with *L. erlangeri* and “plumage coloration” as unreliable morphological characters for defining species and species groups. *Molecular Phylogenetics and Evolution*, 48 (2), 396–407.
https://doi.org/10.1016/j.ympev.2008.04.014

Nylander, J.A.A. (2004) *MrModeltest. Version 2*. Program distributed by the author, Uppsala University, Uppsala. [program]

Orr, M.C., Hung, K.L.J., Wilson-Rankin, E.E., Simpson, P.M., Yanega, D., Kim, A.Y. & Ascher, J.S. (2023) Scientific note: first mainland records of an unusual island bee (*Anthophora urbana clementina*) highlight the value of community science for adventive species detection and monitoring. *Apidologie*, 54 (5), 46.
https://doi.org/10.1007/s13592-023-01025-9

Orr, M.C., Chesters, D., Williams, P.H., Wood, T.J., Zhou, Q., Bossert, S., Sless, T., Warrit, N., Rasmont, P., Ghisbain, G., Boustani, M., A’rong, L., Feng, Y., Niu, Z-Q. & Zhu, C-D. (2024) Integrative taxonomy of a new species of a bumble bee-mimicking brood parasitic bee, *Tetralonioidella mimetica* (Hymenoptera, Apoidea, Apidae), investigated through phylogenomics. *Journal of Hymenoptera Research*, 97, 755–780.
https://doi.org/10.3897/jhr.97.129470

Paxton, R.J., Thorén, P.A., Tengö, J., Estoup, A. & Pamilo, P. (1996) Mating structure and nestmate relatedness in a communal bee, *Andrena jacobi* (Hymenoptera: Andrenidae), using microsatellites. *Molecular Ecology*, 5, 511–519.
https://doi.org/10.1111/j.1365-294X.1996.tb00343.x

Poulsen, N.R. & Rasmussen, C. (2020) Island bees: do wood nesting bees have better island dispersal abilities? *Apidologie*, 51 (6), 1006–1017.
https://doi.org/10.1007/s13592-020-00778-x

R Core Team (2025) R: A language and environment for statistical computing. R Foundation for statistical computing, Vienna, Austria. Available from: https://www.r-project.org/ (accessed 14 October 2025)

Rambaut, A. (2009) FigTree. Version 1.4.0. 2006–2012. Available from: http://tree.bio.ed.ac.uk/software/figtree/ (accessed 14 October 2025)

Rapti, Z., Duennes, M.A. & Cameron, S.A. (2014) Defining the colour pattern phenotype in bumble bees (*Bombus*): a new model for evo devo. *Biological Journal of the Linnean Society*, 113 (2), 384–404. https://doi.org/10.1111/bij.12356

Rasch, D., Kubinger, K.D. & Moder, K. (2011) The two-sample t test: pre-testing its assumptions does not pay off. *Statistical papers*, 52, 219–231. https://doi.org/10.1007/s00362-009-0224-x

Rasmont, P., Scholl, A., De Jonghe, R., Obrecht, E. & Adamski, A. (1986) Identité et variabilité des mâles de bourdons du genre *Bombus* Latreille sensu stricto en Europe occidentale et centrale (Hymenoptera, Apidae, Bombinae). *Revue suisse de Zoologie*, 93 (3), 661–682. https://doi.org/10.5962/bhl.part.79505

Rasmont, P., Coppée, A., Michez, D. & De Meulemeester, T. (2008) An overview of the *Bombus terrestris* (L. 1758) subspecies (Hymenoptera: Apidae). *Annales de la Société entomologique de France*, 44 (2), 243–250. https://doi.org/10.1080/00379271.2008.10697559

Rasmont, P., Ghisbain, G. & Terzo, M. (2021) *Bumblebees of Europe and neighbouring regions*. NAP Editions, Verrières-le-Buisson, 628 pp.

Reinig, W.F. (1937) *Melanismus, Albinismus und Rufinismus: ein Beitrag zum Problem der Entstehung und Bedeutung tierischer Färbungen*. Georg Thieme Verlag, Leipzig, 122 pp.

Rodríguez, S. & López-Darias, J. (2024) Extreme Saharan dust events expand northward over the Atlantic and Europe, prompting record-breaking PM10 and PM2.5 episodes. *Atmospheric Chemistry and Physics*, 24 (20), 12031–12053. https://doi.org/10.5194/acp-24-12031-2024

Ruiz, C., Cejas, D., Muñoz, I. & De la Rua, P. (2021) Characterizing the mitogenome of the endemic bumblebee subspecies from the Canary Islands for conservation purposes. *Sociobiology*, 68 (3), e5910. https://doi.org/10.13102/sociobiology.v68i3.5910

Scheuchl, E. & Widmer, W. (2016) *Taschenlexikon der Wildbienen Mitteleuropas: Alle Arten im Porträt*. Quelle & Meyer Verlag, Wiebelsheim, 920 pp.

Schmidt, S., Schmid-Egger, C., Morinére, J., Haszprunar, G. & Hebert, P.D.N. (2015) DNA barcoding largely supports 250 years of classical taxonomy: Identifications for Central European bees (Hymenoptera, Apoidea partim). *Molecular Ecology Resources*, 15, 985–1000. https://doi.org/10.1111/1755-0998.12363

Schmincke, H.U. (1998) Zeitliche, strukturelle und vulkanische Entwicklung der Kanarischen Inseln, der Selvagens-Inseln und des Madeira-Archipels. *In*: Bischoff, W. (Ed.), *Die Reptilien der Kanarischen Inseln, der Selvagens-Inseln und des Madeira-Archipels*. Aula, Wiesbaden, pp. 27–69.

Sichel, F.J. (1868) *Hymenoptera mellifera*. *In*: *Die Reise der österreichischen Fregatte Novara um die Erde in den Jahren 1857, 1858, 1859 unter den Befehlen des Commodore B. von Wüllerstorf-Urbair. Zoologischer Theil, 2. Band, l. Abtheilung, A., Hymenoptera (bearb. v. H. de Salissure)*. k.-k. Hof- u. Staatsdruckerei, Wien, pp. 143–156.

Villers, C.D. (1789) *Caroli Linnaei Entomologia, Faunae Suecicae Descriptionibus Aucta. D.D. Scopoli, Geoffroy, De Geer, Fabricii, Schrank etc. speciebus vel in Systemate non enumeratis, vel nuperrime detectis, vel speciebus Galliae Australis locupletata, generum specierumque rariorum iconibus ornate 3. Curante et augente Carolo de Villers, Acad. Lugd. Massil. Villa-Fr. Rhotom. Necnon Geometriae Regio Professore*. Sumptibus Piestre et Delamolliere, Lugduni, 657 pp.

Vogt, O. (1909) Studien über das Artproblem. Mitteilung 1: Über das Variieren der Hummeln. *Sitzungsbericht der Gesellschaft Naturforschender Freunde zu Berlin*, 1909 (1), 28–84.

Vogt, O. (1911) Studien über das Artproblem. Mitteilung 2: Über das Variieren der Hummeln. 2. Teil (Schluss). *Sitzungsbericht der Gesellschaft Naturforschender Freunde zu Berlin*, 1911 (1), 31–74.

Weihrauch, F. (2011) A review of the distribution of Odonata in the Macaronesian Islands, with particular reference to the *Ischnura puzzle*. *Journal of the British Dragonfly Society*, 27 (1), 28–46.

Whittaker, R.J. & Fernandez-Palacios, J.M. (2007) *Island biogeography: ecology, evolution, and conservation. 2^{nd} Edition*. Oxford University Press, Oxford, 416 pp.

Widmer, A., Schmid-Hempel, P., Estoup, A. & Scholl, A. (1998) Population genetic structure and colonization history of *Bombus terrestris* s.l. (Hymenoptera: Apidae) from the Canary Islands and Madeira. *Heredity*, 81, 563–572. https://doi.org/10.1046/j.1365-2540.1998.00407.x

Williams, P.H. (2021) Not just cryptic, but a barcode bush: PTP re-analysis of global data for the bumblebee subgenus *Bombus* s. str. supports additional species (Apidae, genus *Bombus*). *Journal of Natural History*, 55 (5–6), 271–282. https://doi.org/10.1080/00222933.2021.1900444

Wolf, H. (1980) Zur Kenntnis der Aculeaten-Fauna von Gran Canaria und Teneriffa. *Vieraea*, 9 (1–2), 65–78.

Wood, T. & Praz, C.J. (2024) Discovery of *Anthophora onosmarum* Morawitz, 1876 in Europe (Hymenoptera, Apidae). *Alpine Entomology*, 8, 153–160. https://doi.org/10.3897/alpento.8.138225

Yeates, D.K., Seago, A., Nelson, L., Cameron, S.L., Joseph, L.E.O. & Trueman, J.W. (2011) Integrative taxonomy, or iterative taxonomy? *Systematic Entomology*, 36 (2), 209–217. https://doi.org/10.1111/j.1365-3113.2010.00558.x

APPENDIX 1a. Specimens examined (*Amegilla quadrifasciata*): Taxon, sex, voucher, country, island, locality, altitude (m a.s.l.), latitude, longitude, date of collection, collector, determinator; determination label, collection, morphological or molecular analysis.

Taxon	Sex	Voucher	Country	Island	Locality	Alt.	Latitude	Longitude	Date	Collector	Determinator	Determination label	Coll.	Anal.
A. quadrifasciata	F	AL1	Algeria		Bord et Kiffan	?	?	?	20.09.1981	Dr. T. Soldán	M. Schwarz	Anthophora 4-fasciata	OLML	morph
A. quadrifasciata	F	BU2	Bulgaria		sept.-or. Pobilite Kamani	?	?	?	01.07.1976	B. Tkalců	B. Tkalců	probably Amegilla quadrifasciata	OLML	morph
A. quadrifasciata	F	GR1	Greece	Crete	Sitia	?	?	?	17.–20.05.1963	J. Gusenleitner	P. Westrich	Anthophora quadrifasciata	OLML	morph
A. quadrifasciata	F	CY1	Cyprus		16 km NE Pophos, Kannaviou	500	?	?	08.07.1987	A.W. Ebmer	P. Westrich	Anthophora quadrifasciata	OLML	morph
A. quadrifasciata	F	FR1	France		Agay (Var)	?	?	?	23.06.1972	Dr. C. Pádr	M. Schwarz	Anthophora 4-fasciata	OLML	morph
A. quadrifasciata	F	FR2	France		Agay (Var)	?	?	?	23.06.1972	Dr C. Pádr	M. Schwarz	Anthophora 4-fasciata	OLML	morph
A. quadrifasciata	F	GE1	Germany		Mainfranken	?	?	?	03.06.1946	J. Heinrich	F. Parre	Anthophora 4-fasciata	OLML	morph
A. quadrifasciata	F	GR2	Greece	Santorin	north of Imerovigli	240	N36°26'39.1"	E25°25'39.2"	25.09.2014	A. Kratochwil	A. Kratochwil	Amegilla quadrifasciata	CAK	morph
A. quadrifasciata	F	IT1	Italy		Capo di Noli, Liguria	?	?	?	09.1991	?	M. Schwarz	Anthophora 4-fasciata	OLML	morph
A. quadrifasciata	F	KY1	Kyrgyzstan		sept. Con, Aryk (Frunze)	1050	?	?	05.07.1983	B. Tkalců	B. Tkalců	probably Amegilla quadrifasciata	OLML	morph
A. quadrifasciata	F	MO1	Morocco		15 km SE Sefrou	?	?	?	27.05.1995	Mi. Halada	P. Rasmont	Amegilla quadrifasciata	OLML	morph
A. quadrifasciata	F	MO2	Morocco		Tafraout	1100	?	?	23.04.1980	W. Perraudin	P. Rasmont	Amegilla quadrifasciata	OLML	morph
A. quadrifasciata	F	SP1	Spain		La Escala, Catalonia	?	?	?	15.07.1974	E. Heiss	P. Westrich	Anthophora quadrifasciata	OLML	morph
A. quadrifasciata	F	TU1	Tunisia		50–30 km S Jendouba	300	?	?	11.07.1979	A.W. Ebmer	P. Westrich	Anthophora quadrifasciata	CAK	morph
A. quadrifasciata	F	TUR1	Turkestan		Urfa	?	?	?	30.06.1968	J. Gusenleitner	P. Westrich	Anthophora quadrifasciata	OLML	morph
A. quadrifasciata	F	YU1	Yugoslavia		Cras Gera, Uleinj	?	?	?	15.-20.07.1967	Dr Z. Pédr	M. Schwarz	Anthophora 4-fasciata	OLML	morph
A. quadrifasciata	F	YU2	Yugoslavia		Cras Gera, Uleinj	?	?	?	15.-20.07.1967	Dr Z. Pédr	M. Schwarz	Anthophora 4-fasciata	OLML	morph
A. quadrifasciata	M	AL2	Algeria		Aures, Ain Zaatout	?	?	?	26.–27.05.1971	A. Hoffer, J. Horák	B. Tkalců	probably Amegilla quadrifasciata	OLML	morph
A. quadrifasciata	M	BU1	Bulgaria		sept.-or. Kavarna	?	?	?	05.07.1976	B. Tkalců	B. Tkalců	probably Amegilla quadrifasciata	OLML	morph
A. quadrifasciata	M	FR3	France		Agay (Var)	?	?	?	23.06.1972	Dr C. Pádr	M. Schwarz	Anthophora 4-fasciata	OLML	morph
A. quadrifasciata	M	YU3	Yugoslavia	Losini	Sveti Jakov	?	?	?	16.07.1971	A.W. Ebmer	P. Westrich	Anthophora quadrifasciata	CAK	morph
A. quadrifasciata	M	YU4	Yugoslavia	Losini	Sveti Jakov	?	?	?	16.07.1971	A.W. Ebmer	B. Tkalců	Amegilla quadrifasciata	CAK	morph

APPENDIX 1b. Specimens examined (*Amegilla maderae*, Madeira Island).

Taxon	Sex	Voucher	Country	Island	Locality	Alt.	Latitude	Longitude	Date	Collector	Determinator	Determination label	Coll.	Anal.
A. maderae	F	MA1	Portugal	Madeira	Este de Calheta, Paul do Mar	400	N32°44'15.10"	W17°10'15.91"	03.01.2007	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA2	Portugal	Madeira	Rochinha	78	N32°44'40.19"	W16°43'22.21"	02.04.1995	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA3	Portugal	Madeira	Reservatorio do Paul do Mar	107	N32°45'51.92"	W17°13'50.32"	28.12.2006	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA4	Portugal	Madeira	petrol station, E Ponta da Sol	27	N32°40'35.91"	W17°04'36.98"	29.12.2006	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA5	Portugal	Madeira	Cais, E Madalena do Mar	11	N32°41'34.43"	W17°07'29.24"	25.03.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA6	Portugal	Madeira	Reservatorio do Paul do Mar	107	N32°45'51.92"	W17°13'50.32"	28.12.2006	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA7	Portugal	Madeira	Cais, E Madalena do Mar	11	N32°41'34.43"	W17°07'29.24"	25.03.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA8	Portugal	Madeira	Ponta da Oliveira	22	N32°38'28.16"	W16°49'53.02"	11.04.1995	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA9	Portugal	Madeira	Cais, E Madalena do Mar	11	N32°41'34.43"	W17°07'29.24"	25.03.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA10	Portugal	Madeira	Ponta da Oliveira	22	N32°38'28.16"	W16°49'53.02"	11.04.1995	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA11	Portugal	Madeira	Ponta da Oliveira	22	N32°38'28.16"	W16°49'53.02"	13.04.1995	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA12	Portugal	Madeira	Ribeira Brava, Pico da Cruz	54	N32°40'09.25"	W17°03'46.32"	05.04.1995	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA13	Portugal	Madeira	Ponta do Garajau, S Caniço	112	N32°38'18.33"	W16°51'02.84"	07.04.1995	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA14	Portugal	Madeira	Ribeira Brava, Pico da Cruz	54	N32°40'09.25"	W17°03'46.32"	25.03.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA15	Portugal	Madeira	W Ponta do Garajau	82	N32°38'23.20"	W16°51' 3.01"	30.03.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA16	Portugal	Madeira	petrol station, E Ponta da Sol	27	N32°40'35.91"	W17°04'36.98"	29.12.2006	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA17	Portugal	Madeira	Ribeira Brava, Pico da Cruz	54	N32°40'09.25"	W17°03'46.32"	05.04.1995	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA18	Portugal	Madeira	petrol station, E Ponta da Sol	27	N32°40'35.91"	W17°04'36.98"	29.12.2006	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA19	Portugal	Madeira	Ribeiro do Caldeira	37	N32°40'25.21"	W17°04'09.99"	02.04.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	MA20	Portugal	Madeira	Ribeira Brava, Pico da Cruz	479	N32°40’11.8‘‘	W17°03'45.5"	01.04.2022	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	molec
A. maderae	F	MA21	Portugal	Madeira	E Caniçal	433	N32°44’36.5‘‘	W16°43'21,8"	02.04.2022	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	molec
A. maderae	F	MA22	Portugal	Madeira	E Caniçal	433	N32°44’36.5‘‘	W16°43'21,8"	02.04.2022	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	molec
A. maderae	M	MA23	Portugal	Madeira	Ponta da Oliveira	22	N32°38'28.16"	W16°49'53.02"	02.04.1995	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	MA24	Portugal	Madeira	Ponta de São Lourenço	71	N32°44'35.16"	W16°42'01.06"	10.04.1995	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	MA25	Portugal	Madeira	Cais, E Madalena do Mar	11	N32°41'34.43"	W17°07'29.24"	25.03.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	MA26	Portugal	Madeira	Cabo Girão, S Quinta Grande	603	N32°39'27.08"	W17°00'23.91"	28.03.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	MA27	Portugal	Madeira	Câmara do Bispo	316	N32°39'17.50"	W17°01'02.02"	28.03.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	MA28	Portugal	Madeira	Fajã dos Padres,	325	N32°39'21.12"	W17°01'04.44"	28.03.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	MA29	Portugal	Madeira	Arco da Calheta	333	N32°42'22.13"	W17°08'22.47"	08.04.1995	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	MA30	Portugal	Madeira	Ribeira Brava, Pico da Cruz	54	N32°40'09.25"	W17°03'46.32"	05.04.1995	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	MA31	Portugal	Madeira	Arco da Calheta	333	N32°42'22.13"	W17°08'22.47"	08.04.1995	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	MA32	Portugal	Madeira	Pico do Facho, Machico	266	N32°43'22.49"	W16°45'30.60"	10.04.1995	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	MA33	Portugal	Madeira	Câmara do Bispo	316	N32°39'17.50"	W17°01'02.02"	28.03.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph

APPENDIX 1c. Specimens examined (*Amegilla maderae*, Porto Santo).

Taxon	Sex	Voucher	Country	Island	Locality	Alt.	Latitude	Longitude	Date	Collector	Determinator	Determination label	Coll.	Anal.
A. maderae	F	PS1	Portugal	Porto Santo	NW Capela S. Pedro	85	N33°02'58.0"	W16°21'54.6"	30.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS2	Portugal	Porto Santo	Praia do Calhau	3	N33°03'48.02"	W16°19'7.37"	16.03.2012	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS3	Portugal	Porto Santo	Cabeco da Ponta	20	N33°02'13.9"	W16°22'0.5"	30.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS4	Portugal	Porto Santo	NW Capela S. Pedro	85	N33°02'58.0"	W16°21'54.6"	30.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS5	Portugal	Porto Santo	NW Capela S. Pedro	85	N33°02'58.0"	W16°21'54.6"	30.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS6	Portugal	Porto Santo	NW Capela S. Pedro	85	N33°02'58.0"	W16°21'54.6"	30.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS7	Portugal	Porto Santo	NW Capela S. Pedro	85	N33°02'58.0"	W16°21'54.6"	30.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS8	Portugal	Porto Santo	NW Capela S. Pedro	85	N33°02'58.0"	W16°21'54.6"	30.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS9	Portugal	Porto Santo	Vila Baleira	3	N33°03'27.44"	W16°20'05.11"	18.03.2012	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS10	Portugal	Porto Santo	Portela	145	N33°03'58.8"	W16°19'02.3"	19.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS11	Portugal	Porto Santo	Pedregal de Dendro	220	N33°05'38.62"	W16°19'34.07"	18.03.2012	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS12	Portugal	Porto Santo	Praia do Calhau	6	N33°03'48.4"	W16°19'01.9"	22.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS13	Portugal	Porto Santo	Restaurant Panorama Casinhas	150	N33°04'8.47"	W16°19'14.57"	16.03.2012	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS14	Portugal	Porto Santo	Praia do Calhau	3	N33°03'48.02"	W16°19'07.37"	16.03.2012	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS15	Portugal	Porto Santo	Praia do Calhau	3	N33°03'48.02"	W16°19'07.37"	16.03.2012	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS16	Portugal	Porto Santo	NW Capela S. Pedro	78	N33°02'56.3"	W16°21'51.7"	22.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS17	Portugal	Porto Santo	Pedregal de Dendro	220	N33°05'38.62"	W16°19'34.07"	18.03.2012	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS18	Portugal	Porto Santo	E Vila Baleira	126	N33°03'42.81"	W16°19'40.34"	31.03.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS19	Portugal	Porto Santo	E Vila Baleira	126	N33°03'42.81"	W16°19'40.34"	31.03.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS20	Portugal	Porto Santo	E Vila Baleira	126	N33°03'42.81"	W16°19'40.34"	31.03.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS21	Portugal	Porto Santo	E Vila Baleira	126	N33°03'42.81"	W16°19'40.34"	31.03.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS22	Portugal	Porto Santo	E Vila Baleira	126	N33°03'42.81"	W16°19'40.34"	31.03.2005	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	F	PS23	Portugal	Porto Santo	W Cabeco do Ponta	25	N33°02'14.4"	W16°22'00.7"	27.03.2014	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	molec
A. maderae	F	PS24	Portugal	Porto Santo	W Cabeco do Ponta	25	N33°02'14.4"	W16°22'00.7"	27.03.2014	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	molec
A. maderae	F	PS25	Portugal	Porto Santo	Miradouro do Pico do Castelo	220	N33°04'38.2"	W16°20'07.8"	27.03.2014	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	molec
A. maderae	F	PS26	Portugal	Porto Santo	Miradouro do Pico do Castelo	220	N33°04'38.2"	W16°20'07.8"	27.03.2014	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	molec
A. maderae	F	PS27	Portugal	Porto Santo	Miradouro do Pico do Castelo	220	N33°04'38.2"	W16°20'07.8"	27.03.2014	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	molec
A. maderae	F	PS28	Portugal	Porto Santo	Miradouro do Pico do Castelo	220	N33°04'38.2"	W16°20'07.8"	27.03.2014	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	molec
A. maderae	F	PS29	Portugal	Porto Santo	Miradouro do Pico do Castelo	220	N33°04'38.2"	W16°20'07.8"	27.03.2014	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	molec
A. maderae	F	PS30	Portugal	Porto Santo	Miradouro do Pico do Castelo	220	N33°04'38.2"	W16°20'07.8"	27.03.2014	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	molec
A. maderae	M	PS31	Portugal	Porto Santo	Restaurant Panorama Casinhas	150	N33°04'07.9"	W16°19'13.0"	19.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS32	Portugal	Porto Santo	Ponta da Calheta	6	N33°01'29.8"	W16°22'43.2"	20.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS33	Portugal	Porto Santo	Ponta da Calheta	20	N33°01'31.8"	W16°22'48.0"	20.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS34	Portugal	Porto Santo	Ponta da Calheta	20	N33°01'31.8"	W16°22'48.0"	20.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS35	Portugal	Porto Santo	Praia do Calhau	3	N33°03'48.2"	W16°19'07.37"	16.03.2012	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS36	Portugal	Porto Santo	west of Morenos	90	N33°02'26.6"	W16°19'07.37"	24.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS37	Portugal	Porto Santo	Ponta da Calheta	6	N33°01'29.8"	W16°22'43.2"	20.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS38	Portugal	Porto Santo	Ponta da Calheta	6	N33°01'29.8"	W16°22'43.2"	20.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS39	Portugal	Porto Santo	Ponta da Calheta	6	N33°01'29.8"	W16°22'43.2"	20.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS40	Portugal	Porto Santo	Cabeco das Flores	145	N33°02'06.2"	W16°22'56.9"	20.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS41	Portugal	Porto Santo	Morenos	130	N33°02'23.8"	W16°23'09.9"	27.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS42	Portugal	Porto Santo	Restaurant Panorama Casinhas	150	N33°04'08.47"	W16°19'14.57"	16.03.2012	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS43	Portugal	Porto Santo	Vila Baleira, sports ground	25	N33°02'35.16"	W16°21'38.48"	20.03.2012	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS44	Portugal	Porto Santo	Morenos	110	N33°02'20.72"	W16°23'11.06"	20.03.2012	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS45	Portugal	Porto Santo	Capela da Craça, Vila Baleira	160	N33°04'24.85"	W16°23'11.06"	20.03.2012	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS46	Portugal	Porto Santo	Praia do Calhau	10	N33°03'47.6"	W16°19'07.7"	23.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph
A. maderae	M	PS47	Portugal	Porto Santo	Ponta da Calheta	20	N33°01'31.8"	W16°22'48.0"	20.03.2017	A. Kratochwil	A. Kratochwil	Amegilla maderae	CAK	morph

APPENDIX 1d. Specimens examined (*Amegilla teneriffensis*).

Taxon	Sex	Voucher	Country	Island	Locality	Alt.	Latitude	Longitude	Date	Collector	Determinator	Determination label	Coll.	Anal.
A. teneriffensis	F	EH1	Spain	El Hierro	Pozo de las Calcosas	86	N27°50'21.4"	W17°56'51.6"	29.01.2014	A. Kratochwil	A. Kratochwil	Amegilla teneriffensis	CAK	morph
A. teneriffensis	F	LA1	Spain	Lanzarote	Mirador del Rio	452	N29°12'44.9"	W13°28'52.4"	02.04.2023	A. Kratochwil	A. Kratochwil	Amegilla teneriffensis	CAK	morph
A. teneriffensis	F	LA2	Spain	Lanzarote	Mirador del Rio	452	N29°12'44.9"	W13°28'52.4"	02.04.2023	A. Kratochwil	A. Kratochwil	Amegilla teneriffensis	CAK	morph
A. teneriffensis	F	LA3	Spain	Lanzarote	Mirador del Rio	452	N29°12'44.9"	W13°28'52.4"	02.04.2023	A. Kratochwil	A. Kratochwil	Amegilla teneriffensis	CAK	morph
A. teneriffensis	F	FU1	Spain	Fuerteventura	Castillo Caleta de Fuste	3	N28°23'07.8"	W13°51'46.6"	28.01.2020	A. Kratochwil	A. Kratochwil	Amegilla teneriffensis	CAK	morph
A. teneriffensis	F	FU2	Spain	Fuerteventura	Castillo Caleta de Fuste	3	N28°23'07.8"	W13°51'46.6"	28.01.2020	A. Kratochwil	A. Kratochwil	Amegilla teneriffensis	CAK	morph
A. teneriffensis	F	FU3	Spain	Fuerteventura	Castillo Caleta de Fuste	3	N28°23'07.8"	W13°51'46.6"	28.01.2020	A. Kratochwil	A. Kratochwil	Amegilla teneriffensis	CAK	morph
A. teneriffensis	F	FU4	Spain	Fuerteventura	Caleta de Fuste	3	N28°23'07.0"	W13°51'46.6"	27.01.2020	A. Kratochwil	A. Kratochwil	Amegilla teneriffensis	CAK	morph
A. teneriffensis	F	FU5	Spain	Fuerteventura	Castillo Caleta de Fuste	3	N28°23'07.8"	W13°51'46.6"	28.01.2020	A. Kratochwil	A. Kratochwil	Amegilla teneriffensis	CAK	morph
A. teneriffensis	F	FU6	Spain	Fuerteventura	Playa Blanca	14	N28°52'00"	W13°50'00"	23.02.1990	J. Gusenleitner	M. Schwarz	Anthophora 4-fasciata	OLML	morph
A. teneriffensis	F	FU7	Spain	Fuerteventura	Ajuy	7	N28°23'59.28"	W14°09'20.47"	05.01.2009	C. Schmid-Egger	P. Geisendörfer	Amegilla quadrifasciata	CSE	morph
A. teneriffensis	F	FU8	Spain	Fuerteventura	Vega de Rio Palmas	558	N28°23'40.71"	W14°04'59.06"	06.01.2009	C. Schmid-Egger	P. Geisendörfer	Amegilla quadrifasciata	CSE	morph
A. teneriffensis	F	FU9	Spain	Fuerteventura	Sotavento	5	N28°08'19.53"	W14°14'24.23"	05.01.2009	C. Schmid-Egger	P. Geisendörfer	Amegilla quadrifasciata	CSE	morph
A. teneriffensis	F	GC2	Spain	Gran Canaria	W Platero	47	N27°48’23.4’’	W15°43’47.5"	18.03.2018	A. Kratochwil	A. Kratochwil	Amegilla teneriffensis	CAK	molec
A. teneriffensis	F	GC3	Spain	Gran Canaria	W Platero	47	N27°48’23.4’’	W15°43’47.5"	18.03.2018	A. Kratochwil	A. Kratochwil	Amegilla teneriffensis	CAK	morph
A. teneriffensis	M	LA4	Spain	Lanzarote	Playa del Papagayo	25	N28°51’20.0’’	W13°52’19.1"	30.03.2023	A. Kratochwil	A. Kratochwil	Amegilla teneriffensis	CAK	morph
A. teneriffensis	M	GC1	Spain	Gran Canaria	W Platero	47	N27°48’23.4’’	W15°43’47.5"	18.03.2018	A. Kratochwil	A. Kratochwil	Amegilla teneriffensis	CAK	molec
A. teneriffensis	M	GC4	Spain	Gran Canaria	W Platero	47	N27°48’23.4’’	W15°43’47.5"	18.03.2018	A. Kratochwil	A. Kratochwil	Amegilla teneriffensis	CAK	molec
A. teneriffensis	M	GC5	Spain	Gran Canaria	W Platero	47	N27°48’23.4’’	W15°43’47.5"	18.03.2018	A. Kratochwil	A. Kratochwil	Amegilla teneriffensis	CAK	molec
A. teneriffensis	M	FU10	Spain	Fuerteventura	Vega de Rio Palmas	558	N28°23'40.71"	W14°04'59.06"	06.01.2009	C. Schmid-Egger	P. Geisendörfer	Amegilla quadrifasciata	CSE	morph
A. teneriffensis	M	FU11	Spain	Fuerteventura	Vega de Rio Palmas	558	N28°23'40.71"	W14°04'59.06"	06.01.2009	C. Schmid-Egger	P. Geisendörfer	Amegilla quadrifasciata	CSE	morph
A. teneriffensis	M	FU12	Spain	Fuerteventura	Vega de Rio Palmas	558	N28°23'40.71"	W14°04'59.06"	06.01.2009	C. Schmid-Egger	P. Geisendörfer	Amegilla quadrifasciata	CSE	morph
A. teneriffensis	M	FU13	Spain	Fuerteventura	Vega de Rio Palmas	558	N28°23'40.71"	W14°04'59.06"	06.01.2009	C. Schmid-Egger	P. Geisendörfer	Amegilla quadrifasciata	CSE	morph
A. teneriffensis	M	FU14	Spain	Fuerteventura	Morro Jable, lighthouse	15	N28°03'03.99"	W14°21'05.59"	20.12.2006	C. Schmid-Egger	P. Geisendörfer	Amegilla quadrifasciata	CSE	morph
A. teneriffensis	M	FU15	Spain	Fuerteventura	Costa Calma	29	N28°09'30.70"	W14°13'45.91"	08.01.2009	C. Schmid-Egger	P. Geisendörfer	Amegilla quadrifasciata	CSE	morph
A. teneriffensis	M	FU16	Spain	Fuerteventura	Vega de Rio Palmas	558	N28°23'40.71"	W14°04'59.06"	06.01.2009	C. Schmid-Egger	P. Geisendörfer	Amegilla quadrifasciata	CSE	morph

APPENDIX 2. Mean, standard deviation, maximum and minimum value of all continuous variables of the three species for females.

females	***quadrifasciata* - mainland (n = 17)**	***maderae* - Madeira Island (n = 19)**	***maderae* - Porto Santo (n = 24)**	***teneriffensis* - Canary Islands (n = 10)**
in mm	**mean ± SD, max, min**	**mean ± SD, max, min**	**mean ± SD, max, min**	**mean ± SD, max, min**
BL	13.91 ± 0.62, 14.80, 12.40	14.94 ± 0.89, 16.32, 13.20	15.25 ± 0.84, 17.20, 12.80	15.96 ± 1.16, 18.00, 14.40
BL/WL	1.40 ± 0.04, 1.45, 1.31	1.46 ± 0.10, 1.63, 1.20	1.47 ± 0.09, 1.70, 1.31	1.22 ± 0.10, 1.44, 1.08
CLL	1.35 ± 0.06, 1.43, 1.27	1.39 ± 0.06, 1.53, 1.30	1.40 ± 0.05, 1.50, 1.30	1.46 ± 0.06, 1.53, 1.37
CLL/CLW	0.55 ± 0.03, 0.60, 0.50	0.57 ± 0.03, 0.63, 0.52	0.57 ± 0.02, 0.64, 0.54	0.54 ± 0.02, 0.58, 0.51
CLW	2.47 ± 0.10, 2.60, 2.28	2.43 ± 0.09, 2.60, 2.28	2.44 ± 0.08, 2.57, 2.31	2.67 ± 0.08, 2.83, 2.60
CU2d	0.29 ± 0.03, 0.33, 0.23	0.33 ± 0.04, 0.39, 0.27	0.32 ± 0.03, 0.38, 0.27	0.32 ± 0.03, 0.37, 0.29
CU2p	0.49 ± 0.04, 0.57, 0.42	0.48 ± 0.03, 0.52, 0.42	0.47 ± 0.03, 0.56, 0.42	0.55 ± 0.03, 0.61, 0.52
CU2P/CU2D	1.73 ± 0.21, 2.12, 1.33	1.50 ± 0.18, 1.90, 1.15	1.47 ± 0.16, 1.85, 1.25	1.72 ± 0.13, 2.00, 1.52
EL	3.03 ± 0.07, 3.12, 2.86	3.02 ± 0.09, 3.17, 2.86	3.05 ± 0.10, 3.17, 2.86	3.10 ± 0.08, 3.28, 2.96
EL/EW	1.94 ± 0.09, 2.15, 1.81	1.98 ± 0.08, 2.15, 1.81	1.96 ± 0.13, 2.12, 1.49	1.87 ± 0.07, 1.97, 1.79
EW	1.56 ± 0.09, 1.72, 1.40	1.53 ± 0.08, 1.66, 1.40	1.56 ± 0.15, 2.13, 1.35	1.66 ± 0.08, 1.72, 1.51
FL1	0.70 ± 0.02, 0.73, 0.65	0.72 ± 0.02, 0.76, 0.69	0.71 ± 0.02, 0.75, 0.67	0.74 ± 0.04, 0.80, 0.68
FL2	0.21 ± 0.02, 0.24, 0.18	0.21 ± 0.02, 0.23, 0.18	0.20 ± 0.01, 0.23, 0.18	0.21 ± 0.02, 0.24, 0.18
FL3	0.24 ± 0.01, 0.27, 0.22	0.24 ± 0.01, 0.27, 0.22	0.23 ± 0.01, 0.26, 0.20	0.27 ± 0.01, 0.29, 0.26
HL	3.34 ± 0.12, 3.64, 3.12	3.38 ± 0.12, 3.59, 3.22	3.42 ± 0.12, 3.59, 3.17	3.50 ± 0.09, 3.59, 3.33
HL/HW	0.67 ± 0.02, 0.71, 0.64	0.67 ± 0.01, 0.69, 0.65	0.66 ± 0.01, 0.69, 0.64	0.65 ± 0.01, 0.66, 0.64
HW	5.01 ± 0.14, 5.20, 4.73	5.05 ± 0.17, 5.36, 4.73	5.15 ± 0.16, 5.46, 4.84	5.35 ± 0.17, 5.62, 5.04
IDL	2.61 ± 0.08, 2.70, 2.44	2.75 ± 0.09, 2.96, 2.60	2.80 ± 0.08, 3.02, 2.60	2.80 ± 0.10, 2.91, 2.60
IDU	2.97 ± 0.12, 3.12, 2.70	3.04 ± 0.10, 3.17, 2.91	3.09 ± 0.08, 3.22, 2.86	3.26 ± 0.08, 3.38, 3.12
IDU/IDL	1.14 ± 0.04, 1.22, 1.08	1.11 ± 0.03, 1.17, 1.07	1.10 ± 0.02, 1.14, 1.07	1.16 ± 0.03, 1.21, 1.13
IOD	1.00 ± 0.04, 1.07, 0.94	1.00 ± 0.03, 1.05, 0.95	0.98 ± 0.04, 1.09, 0.91	1.10 ± 0.03, 1.15, 1.06
IOD/OOD	1.38 ± 0.09, 1.53, 1.23	1.32 ± 0.05, 1.43, 1.21	1.30 ± 0.07, 1.45, 1.17	1.36 ± 0.07, 1.47, 1.25
LL	1.34 ± 0.05, 1.43, 1.27	1.40 ± 0.06, 1.46, 1.27	1.37 ± 0.06, 1.50, 1.27	1.38 ± 0.05, 1.46, 1.30
LL/LW	0.84 ± 0.03, 0.88, 0.80	0.85 ± 0.03, 0.92, 0.80	0.84 ± 0.03, 0.90, 0.78	0.81 ± 0.03, 0.85, 0.76
LW	1.61 ± 0.04, 1.69, 1.53	1.64 ± 0.07, 1.76, 1.50	1.63 ± 0.05, 1.72, 1.56	1.71 ± 0.05, 1.79, 1.63
MTL	7.03 ± 0.44, 8.00, 6.00	7.74 ± 0.36, 8.24, 7.20	7.74 ± 0.36, 8.24, 7.20	8.08 ± 0.77, 9.36, 6.96
MTW	5.97 ± 0.19, 6.24, 5.60	6.23 ± 0.26, 6.72, 5.60	6.39 ± 0.26, 7.12, 6.00	6.37 ± 0.19, 6.64, 6.08
MTW/MTL	0.85 ± 0.04, 0.95, 0.77	0.81 ± 0.05, 0.93, 0.73	0.83 ± 0.07, 1.07, 0.74	0.79 ± 0.07, 0.90, 0.69
OCED	0.32 ± 0.02, 0.35, 0.29	0.34 ± 0.01, 0.35, 0.31	0.34 ± 0.01, 0.35, 0.31	0.34 ± 0.02, 0.38, 0.33
OOD	0.72 ± 0.03, 0.77, 0.68	0.76 ± 0.02, 0.79, 0.72	0.76 ± 0.03, 0.80, 0.69	0.81 ± 0.03, 0.86, 0.76
SCL	4.33 ± 0.22, 4.78, 3.95	4.58 ± 0.23, 4.94, 4.16	4.47 ± 0.25, 4.94, 4.00	4.87 ± 0.25, 5.20, 4.47
TSCW	5.33 ± 0.22, 5.77, 4.94	5.58 ± 0.25, 5.98, 5.20	5.75 ± 0.31, 6.24, 5.10	5.73 ± 0.21, 5.98, 5.30
TSCW/SCL	1.23 ± 0.05, 1.31, 1.15	1.22 ± 0.08, 1.40, 1.10	1.29 ± 0.08, 1.41, 1.11	1.18 ± 0.05, 1.28, 1.13
WL	9.93 ± 0.35, 10.72, 9.36	10.23 ± 0.40, 10.96, 9.52	10.36 ± 0.47, 10.88, 9.20	10.69 ± 0.37, 11.28, 10.24

APPENDIX 3. Mean, standard deviation, maximum and minimum value of all continuous variables of the three species for males.

males	***quadrifasciata* - mainland (n = 5)**	***maderae* - Madeira Island (n = 11)**	***maderae* - Porto Santo (n = 18)**	***teneriffensis* - Canary Islands (n = 9)**
in mm	**mean ± SD, max, min**	**mean ± SD, max, min**	**mean ± SD, max, min**	**mean ± SD, max, min**
BL	13.78 ± 0.64, 14.72, 13.12	13.99 ± 0.56, 15.04, 13.04	13.96 ± 0.59, 14.96, 13.04	13.62 ± 0.72, 15.20, 12.80
BL/WL	1.94 ± 0.10, 2.03, 1.81	1.88 ± 0.07, 1.98, 1.72	1.84 ± 0.09, 2.06, 1.70	1.77 ± 0.11, 2.00, 1.65
CLL	1.25 ± 0.05, 1.30, 1.17	1.30 ± 0.06, 1.43, 1.20	1.29 ± 0.06, 1.43, 1.17	1.26 ± 0.07, 1.37, 1.17
CLL/CLW	0.56 ± 0.02, 0.59, 0.54	0.55 ± 0.02, 0.59, 0.52	0.55 ± 0.02, 0.58, 0.49	0.54 ± 0.02, 0.58, 0.51
CLW	2.24 ± 0.09, 2.34, 2.11	2.35 ± 0.10, 2.54, 2.21	2.35 ± 0.07, 2.47, 2.21	2.35 ± 0.07, 2.47, 2.24
CU2d	0.26 ± 0.04, 0.31, 0.23	0.29 ± 0.04, 0.37, 0.23	0.28 ± 0.02, 0.33, 0.24	0.29 ± 0.03, 0.34, 0.23
CU2p	0.47 ± 0.03, 0.50, 0.43	0.43 ± 0.03, 0.48, 0.38	0.44 ± 0.03, 0.52, 0.39	0.48 ± 0.02, 0.52, 0.46
CU2P/CU2D	1.82 ± 0.25, 2.18, 1.52	1.49 ± 0.20, 1.76, 1.19	1.59 ± 0.23, 2.00, 1.25	1.70 ± 0.16, 2.00, 1.52
EL	2.82 ± 0.04, 2.86, 2.76	2.87 ± 0.19, 3.38, 2.65	2.86 ± 0.08, 3.07, 2.76	2.88 ± 0.11, 3.02, 2.70
EL/EW	2.00 ± 0.11, 2.12, 1.89	2.17 ± 0.18, 2.57, 1.90	2.03 ± 0.12, 2.25, 1.86	1.95 ± 0.08, 2.11, 1.86
EW	1.41 ± 0.06, 1.46, 1.35	1.33 ± 0.14, 1.61, 1.09	1.41 ± 0.08, 1.51, 1.25	1.48 ± 0.07, 1.61 1.40
FL1	0.46 ± 0.03, 0.49, 0.41	0.46 ± 0.02, 0.50, 0.43	0.45 ± 0.02, 0.50, 0.41	0.44 ± 0.03, 0.48, 0.41
FL2	0.24 ± 0.02, 0.26, 0.22	0.21 ± 0.01, 0.27, 0.22	0.23 ± 0.02, 0.27, 0.20	0.28 ± 0.01, 0.30, 0.27
FL3	0.36 ± 0.01, 0.37, 0.34	0.37 ± 0.01, 0.39, 0.34	0.38 ± 0.02, 0.41, 0.33	0.43 ± 0.02, 0.45, 0.39
HL	3.06 ± 0.06, 3.12, 2.96	3.18 ± 0.16, 3.54, 2.96	3.19 ± 0.09, 3.38, 3.02	3.10 ± 0.13, 3.28, 2.96
HL/HW	0.67 ± 0.01, 0.69, 0.67	0.68 ± 0.02, 0.70, 0.64	0.69 ± 0.02, 0.71, 0.65	0.65 ± 0.01, 0.66, 0.63
HW	4.53 ± 0.13, 4.68, 4.32	4.68 ± 0.21, 5.25, 4.42	4.64 ± 0.14, 4.99, 4.47	4.77 ± 0.19, 4.99, 4.47
IDL	2.32 ± 0.07, 2.39, 2.24	2.47 ± 0.13, 2.76, 2.29	2.41 ± 0.11, 2.55, 2.13	2.47 ± 0.06, 2.55, 2.39
IDU	2.63 ± 0.05, 2.70, 2.60	2.76 ± 0.17, 3.17, 2.55	2.73 ± 0.08, 2.91, 2.65	2.78 ± 0.08, 2.91, 2.70
IDU/IDL	1.14 ± 0.03, 1.16, 1.09	1.12 ± 0.05, 1.17, 0.98	1.14 ± 0.07, 1.37, 1.04	1.13 ± 0.03, 1.17, 1.06
IOD	0.87 ± 0.04, 0.91, 0.81	0.91 ± 0.06, 1.06, 0.84	0.90 ± 0.04, 0.95, 0.84	0.94 ± 0.02, 0.99, 0.92
IOD/OOD	1.36 ± 0.08, 1.45, 1.25	1.36 ± 0.07, 1.47, 1.24	1.35 ± 0.07, 1.45, 1.21	1.36 ± 0.06, 1.45, 1.26
LL	1.21 ± 0.04, 1.27, 1.17	1.27 ± 0.05, 1.37, 1.20	1.25 ± 0.05, 1.37, 1.17	1.24 ± 0.07, 1.33, 1.14
LL/LW	0.84 ± 0.03, 0.87, 0.80	0.87 ± 0.03, 0.93, 0.83	0.87 ± 0.04, 0.93, 0.80	0.83 ± 0.03, 0.87, 0.80
LW	1.44 ± 0.04, 1.50, 1.40	1.46 ± 0.07, 1.59, 1.37	1.44 ± 0.04, 1.53, 1.37	1.49 ± 0.07, 1.59, 1.40
MTL	7.25 ± 0.24, 7.52, 6.96	8.84 ± 0.58, 7.68, 6.08	6.72 ± 0.50, 7.84, 6.08	6.77 ± 0.46, 7.28, 6.00
MTW	5.23 ± 0.15, 5.44, 5.04	5.58 ± 0.54, 6.96, 4.96	5.52 ± 0.29, 6.08, 5.20	5.86 ± 0.33, 6.16, 5.04
MTW/MTL	0.72 ± 0.03, 0.75, 0.68	0.82 ± 0.06, 0.91, 0.74	0.82 ± 0.04, 0.90, 0.75	0.87 ± 0.07, 1.00, 0.79
OCED	0.32 ± 0.01, 0.34, 0.30	0.33 ± 0.01, 0.35, 0.31	0.33 ± 0.01, 0.35, 0.31	0.33 ± 0.01, 0.34, 0.33
OOD	0.64 ± 0.02, 0.65, 0.60	0.67 ± 0.03, 0.75, 0.64	0.67 ± 0.03, 0.71, 0.62	0.69 ± 0.03, 0.73, 0.64
SCL	3.90 ± 0.05, 3.95, 3.85	4.18 ± 0.35, 5.10, 3.74	4.06 ± 0.24, 4.47, 3.74	4.06 ± 0.22, 4.37, 3.59
TSCW	4.85 ± 0.12, 4.99, 4.68	5.15 ± 0.33, 5.82, 4.78	5.21 ± 0.21, 5.67, 4.84	5.21 ± 0.18, 5.46, 4.89
TSCW/SCL	2.03 ± 0.03, 2.06, 2.00	2.17 ± 0.18, 2.65, 1.95	2.10 ± 0.13, 2.33, 1.95	2.11 ± 0.11, 2.27, 1.87
WL	8.90 ± 0.56, 9.52, 8.24	9.31 ± 0.50, 10.40, 8.80	9.48 ± 0.44, 10.40, 8.80	9.61 ± 0.35, 10.00, 8.88