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Article

The sweat bees from Fernando de Noronha Archipelago, Brazil (Hymenoptera: Halictidae)

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Abstract: The sweat bees from Fernando de Noronha Archipelago are presented and illustrated herein. The species recorded are *Augochlora* (*Augochlora*) *laevipyga* (Kirby, 1890), *Augochlora* (*Augochlora*) sp., new record, and *Lasioglossum* (*Dialictus*) *atripyga* (Kirby, 1890). The Kirby species are redescribed based on recently collected specimens, including the first illustration of the male terminalia. The unidentified species is also shortly characterized.
Keywords: *Augochlora; Dialictus; Halictinae; Lasioglossum; oceanic islands fauna.*

Halictídeos do arquipélago de Fernando de Noronha (Hymenoptera: Halictidae)

Resumo: Os halictídeos do Arquipélago de Fernando de Noronha são aqui apresentados e ilustrados. As espécies registradas são *Augochlora* (*Augochlora*) *laevipyga* (Kirby, 1890), *Augochlora* (*Augochlora*) sp., novo registro, e *Lasioglossum* (*Dialictus*) *atripyga* (Kirby, 1890). As espécies descritas por Kirby são redescritas com base em espécimes recentemente coletados, incluindo a primeira ilustração das terminálias dos machos. A espécie não identificada também é resumidamente caracterizada.
Palavras-chave: *Augochlora; Dialictus; Halictinae; Lasioglossum; fauna de ilhas oceânicas.*

Introduction

Brazil has extraordinary biodiversity distributed in different types of environments and/or biomes throughout its vast territory, which includes a set of five oceanic islands poorly known in terms of insects diversity, but with many endemic species (Mohr et al. 2009). The best known among Brazilian oceanic islands in terms of its insect fauna is Fernando de Noronha, an equatorial South Atlantic archipelago located c. 360 km away from the nearest Brazilian coastline. Since the early 18th century when the archipelago was transformed into a penal colony for almost 200 years, a large part of the native vegetation was devastated while exotic plants and animals were introduced to serve as food (Teixeira et al. 2003, Serafini et al. 2010, Rafael et al. 2020).

Nevertheless, there are only a few studies including the entomological fauna in Fernando de Noronha (see Rafael et al. 2020). Of these, only three reported the presence of sweat bees (Halictidae). The first, Kirby (1890), described two species currently considered as valid, *Augochlora* (*Augochlora*) *laevipyga* (Kirby, 1890) and *Lasioglossum* (*Dialictus*) *atripyga* (Kirby, 1890) (Augochlorini and Halictini tribes, respectively). Several years later, Alvarenga (1962) collected specimens of these two species. After nearly six decades, Rafael et al. (2020) performed the most extensive collection effort in this archipelago, and these two species were once again collected, and additionally *Augochlora* (*Augochlora*) sp., one unidentified species, shortly characterized below, thereby increasing the species of sweat bees in Fernando de Noronha to three.

Considering that both genera are highly diverse and widely distributed in the New World (Michener 2007, Gibbs 2011, Lepeco & Gonçalves 2020), and that the original descriptions were relatively generic and brief, this work may support future taxonomic revisions for the genera in order to provide better understanding of the taxonomic status of these species. In addition, housing specimens in some essential and accessible collections will be equally crucial, as very few specimens have been sampled until now.

Material and Methods

The Brazilian oceanic archipelago of Fernando de Noronha (3º45′S to 3º57′S; 32º19′W to 32º41′W) has an estimated age ranging between 8–9 to 12 Ma and is entirely volcanic in its origin (Lopes & Ulbrich 2015), never having been connected to the mainland. The archipelago has a tropical climate with an annual temperature ranging from 23.5 ºC to 31.5 ºC (IBAMA 1990). The total land area is 18.4 km², of which 16.9 km² is the main island, and the remaining area is distributed among 20 smaller islets, of which Rata Island is the largest with 0.8 km² (Lopes & Ulbrich 2015, Rafael et al. 2020).

This work results from a research project which performed exhaustive samplings in Fernando de Noronha Archipelago with passive samplings methods such as Malaise interception traps and less exhaustive using active sweeping. Details about the sampling effort, methods, collection period, and the sampled points are detailed in the material and methods of Rafael et al. (2020). In addition to the collecting effort described in Rafael et al. (2020), there was an additional collection to observe the peridomestic areas of the urban places, with a concentrated effort in the urban gardens, carried out in November 2021.

Morphological terminology follows Michener (2007) in general lines except for the propodeal triangle, referred to here as the metapostnotum (Brothers 1976). The format for the redescription follows that of Gibbs (2011). The measurements of the specimens were performed from selecting the smallest and largest specimens observed. Label information from separate labels is segregated by double slashes "//". Typographic errors from labels were corrected, and the corrections were identified with square brackets "[ ]". Some color descriptions diverged from those of the original description, probably due to the different lighting devices used here, so there was a need to transcribe the originally described color between brackets "{ }". Photomicrographs were prepared using a Leica M205C stereomicroscope coupled with a Leica DFC295 and a Leica Application Suite V4.1 Interactive Measurements, Montage.

Institutional acronyms used in the sections on the material examined are: **CZMA**, Coleção Zoológica do Maranhão da Universidade Estadual do Maranhão, Caxias, Maranhão, Brazil; **INPA**, Coleção de Invertebrados do Instituto Nacional de Pesquisas da Amazônia, Manaus, Amazonas, Brazil; **MNRJ**, Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil; **MZUSP**, Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil; **NHMUK**, Natural History Museum, London, United Kingdom; **UFRPE**, Universidade Federal Rural de Pernambuco, Pernambuco, Brazil. The type specimens of the two identified species are currently deposited in the NHMUK and were examined through photographs available on the institution's website (Natural History Museum 2014).

The collecting activities were approved by the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) under the license number 62.821.

Results

Halictid specimens, distributed in three species, were collected during nine months using interception traps and during short periods using sweeping. The extensive collection effort over a long period and sampling a large area on the main island, in addition to the sporadic collection on the Rata Island, resulted in the collection of two previously known species from the archipelago described by Kirby (1890), *Augochlora* (*Augochlora*) *laevipyga* (four specimens) and *Lasioglossum* (*Dialictus*) *atripyga* (639 specimens), and additionally one unidentified species is being recorded for the first time, *Augochlora* (*A.*) sp., based on seven specimens.

The amount collected indicates that both *Augochlora* species should be treated as extremely rare species on the archipelago.

Augochlora (*Augochlora*) *laevipyga* (Kirby, 1890)

(Figures 1–2)

Halictus laevipyga Kirby, 1890: 542.

Augochlora laevipyga: Cockerell, 1909: 314 [taxonomic notes]; Alvarenga, 1962: 25 [Fernando de Noronha checklist].

Augochlora (*Augochlora*) *laevipyga*: Moure et al. 2007: 764 [catalog]; Rafael et al. 2020: 19 (Fernando de Noronha checklist).

Halictus alternipes Kirby, 1890: 542 [synonymized by Cockerell, 1909].

Diagnosis. Females can be recognized by the coloration pattern: integument dark metallic bluish-green. Apical surface of head notably dark brown, almost black, and blue reflections restricted to paraocular and supraclypeal areas and lateral areas of clypeus (Fig. 1b).

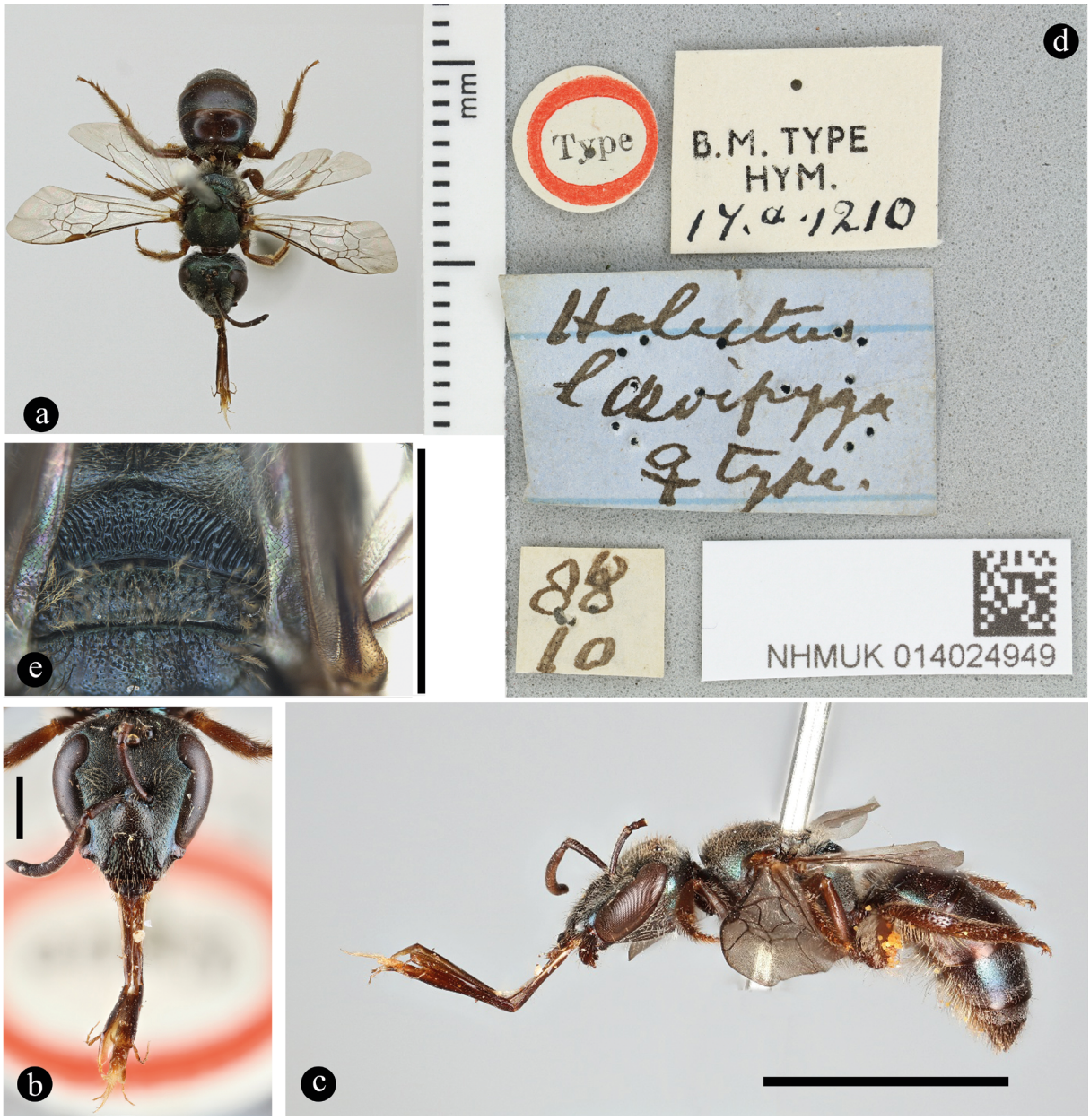

Figure 1. Female of *Augochlora* (*Augochlora*) *laevipyga* (Kirby, 1890). a–d, Type. a) dorsal habitus; b) head, frontal view; c) lateral habitus; d) Type labels; e) metapostnotum, dorsal view (figs. a and c, scale bar = 5 mm; figs. b and e, scale bar = 1 mm;); Photos credits a–d: Natural History Museum.

Redescription. FEMALE: Body length 8 mm {*10 mm*}; head length 2.2 mm; head width 2.1 mm; forewing length 5.5 mm.

Coloration. Integument dark metallic bluish-green {*head and thorax dark green, slightly bronzed*} (Figs. 1a–c and e). Apical surface of head dark brown, almost black, blue reflections restricted to paraocular and supraclypeal areas and lateral areas of clypeus. Mandible brown, apical third slightly yellowish. Antenna, brownish on ventral surface of flagellum. Tegula translucent brownish. Wing membrane hyaline, venation dark brown. Legs dark brown to ferruginous {*black*}. {*Abdomen shining, shading into violet at the extremity of the segments*}. Terga with translucent dark brown apical margins on T1–T4, sterna brownish.

Pubescence. Mainly white, inner surface of tibiae and tarsi with golden bristles. Head almost entirely covered by branched setae (1.5 OD) with subappressed tomentum. Clypeus covered by spaced simple hairs and supraclypeal, lower paraocular, and hypostomal areas without subappressed tomentum. Posterior margin of scutellum with long brown branched setae (3.5 OD). Mesepisternum, metanotum, and lateral and posterior surfaces of propodeum with dense plumose hairs (2–3 OD), metapostnotum glabrous. Anterior margin of T1 with long plumose hairs (2 OD), disc of T1 and T2 with very short simple setae, lateral bands longer (2 OD); T3–T5 with sparse short erect setae (1.5 OD) with short plumose hairs subappressed; T6 covered with long setae. Metasomal sterna covered with very long branched setae (4.5 OD), longer on S2–S4.

Surface sculpture. Face densely and minutely punctate. Clypeus punctate, punctures large and weak, loosely imbricate in between. Mesosoma densely fine punctured, slightly spaced on mesoscutellum. Metapostnotum strongly rugoso-carinulate (Fig. 1e). Metasomal terga evenly microsculptured and with very fine sparse punctation.

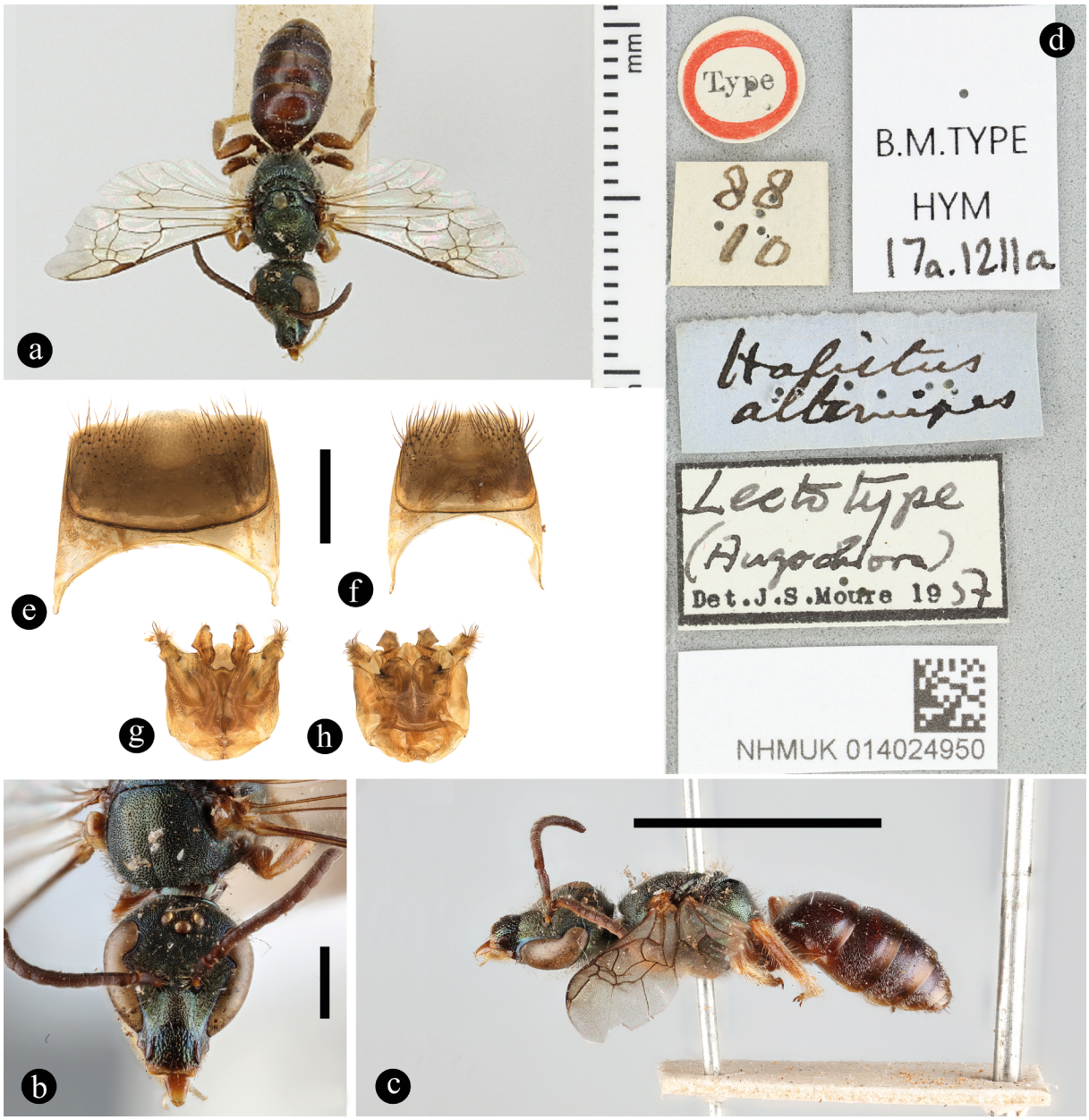

Figure 2. Male of *Augochlora* (*Augochlora*) *laevipyga* (Kirby, 1890). a–d, Type. a) dorsal habitus; b) head, frontal view; c) lateral habitus; d) Type labels; e) metasomal sternum 5; f) metasomal sternum 6; g) genital capsule, dorsal view; h) genital capsule, ventral view (figs. a and c, scale bar = 5 mm; fig. b, scale bar = 1 mm; figs. e–h scale bar = 0.5 mm); Photos credits a–d: Natural History Museum.

Structure. Ocellocular distance 2.5 OD. Gena broad, approximately 1.5 wider than compound eyes in lateral view. Mandible bidentate. Epistomal angle acute, strongly protruding over clypeus. Preoccipital carina lamellate, lamella expanded near post gena. Hypostomal carina not projected anteriorly. Metapostnotum slightly longer than metanotum. S1 with slight longitudinal median ridge.

MALE. Similar to female except as follows: body length 7.8–8.1 mm {*11 mm*}; head length 2.1–2.3 mm; head width 1.8–2 mm; forewing length 4.3–5 mm. Integument in general less darkened, metallic reflections more evident (Figs. 2a–c). Clypeus with yellow apical stripe. Tibiae and basitarsi yellowish. Punctures on mesoscutellum more spaced leaving large, polished areas on disc. Clypeus distinctly longer than wide, pronounced, giving an elongated aspect to head. Slight median longitudinal depression on mesoscutellum. Male terminalia structures as in Figure 2 (e–h).

Type material (examined through photographs). BRAZIL: Fern. Nor. [Fernando de Noronha], 88 10 [label verse] // Type // *Halictus laevipyga* ♀ type // B.M. Type 14.a.1210 // NHMUK 014024949 (Holotype ♀, NHMUK); Fern. Nor. [Fernando de Noronha], 88 10 [label verse] // Type // *Halictus alternipes* // B.M. Type 17a.1211a // NHMUK 014024950 // Lectotype (*Augochlora*) Det. J.S.Moure, 1957 (Syntype ♂, NHMUK).

Additional material examined. BRAZIL: Pernambuco, Arquipélago de Fernando de Noronha, Capim-Açu, 3°51′17″S, 32°26′26″W, 7-21.viii.2019, Malaise grande, J.A.Rafael, F.Limeira-de-Oliveira, L.C.Castro (1♀, INPA); *idem* Trilha Golfinhos, 7-22.vii.2019 (1♂, INPA); *idem* 9-23.vi.2019 (1♂, MNRJ); *idem* Trilha do Sancho, 12-27.ii.2020, Malaise pequena (1♂, CZMA).

Biological notes. A bee's nest was found during the search for insects in a rotten trunk and carried to the laboratory of the Universidade Federal Rural de Pernambuco, where one adult specimen of *A. laevipyga* emerged. It is now known that this species nests in rotten wood.

Remarks. Kirby (1890) described two *Halictus* species, presently in the genus *Augochlora*, from Fernando de Noronha; *A. laevipyga* based on a female specimen, and *A. alternipes* based on both sexes. According to Kirby (1890), *A. alternipes* appeared to be "closely allied to *A. laevipyga*". In studying the types of these species in the NHMUK, Cockerrel (1909) synonymized both and since then they have been treated as synonymous (Moure et al. 2007). This species is quite difficult to be collected in the archipelago, and has not been observed in flowers yet. Only four specimens were collected in a restricted area in the more preserved flora of the south coast island.

Augochlora (*Augochlora*) sp.

(Figures 3–4)

Material examined. BRAZIL: Pernambuco, Arquipélago de Fernando de Noronha, Boldró, 3°51′02″S, 32°25′28″W, 16-19.xi.2021, Varredura, T. Mahlmann *Leg*. (3♀♀ and 4♂♂, INPA).

Remarks. This unidentified species could be interpreted as one of the synonym names above (*A. laevipyga* (Kirby, 1890) or *A. alternipes* (Kirby, 1890)). However, it can be easily distinguished by its smaller body size (about 5 mm) (versus 8–10 mm in *A. laevipyga*); by a head with a less elongated appearance (Fig. 3a) (versus head distinctly elongated in *A. laevipyga* (Fig. 1b)), by the notably greener metallic color (Figs. 3a–c) (versus dark metallic bluish-green in *A. laevipyga*, (Figs. 1a–c and e)) and by the male terminalia (Figs. 4d–g) (versus Figs. 2e–h of *A. laevipyga*). Due to these differences we herein consider it as a distinct species. *Augochlora* sp., as opposed to *A. laevipyga*, was only observed and collected in the peridomestic areas of the archipelago, in the central area of the main island visiting ornamental flowers such as Jetirana (*Merremia aegyptia* (L.) Urb.) (Fig. 5a), and it also seems to be an uncommon species. All specimens are being retained at the INPA collection for additional studies.

Lasioglossum (*Dialictus*) *atripyga* (Kirby, 1890)

(Figures 6–7)

Halictus atripyga Kirby, 1890: 543; Cockerell, 1909: 315 [taxonomic notes].

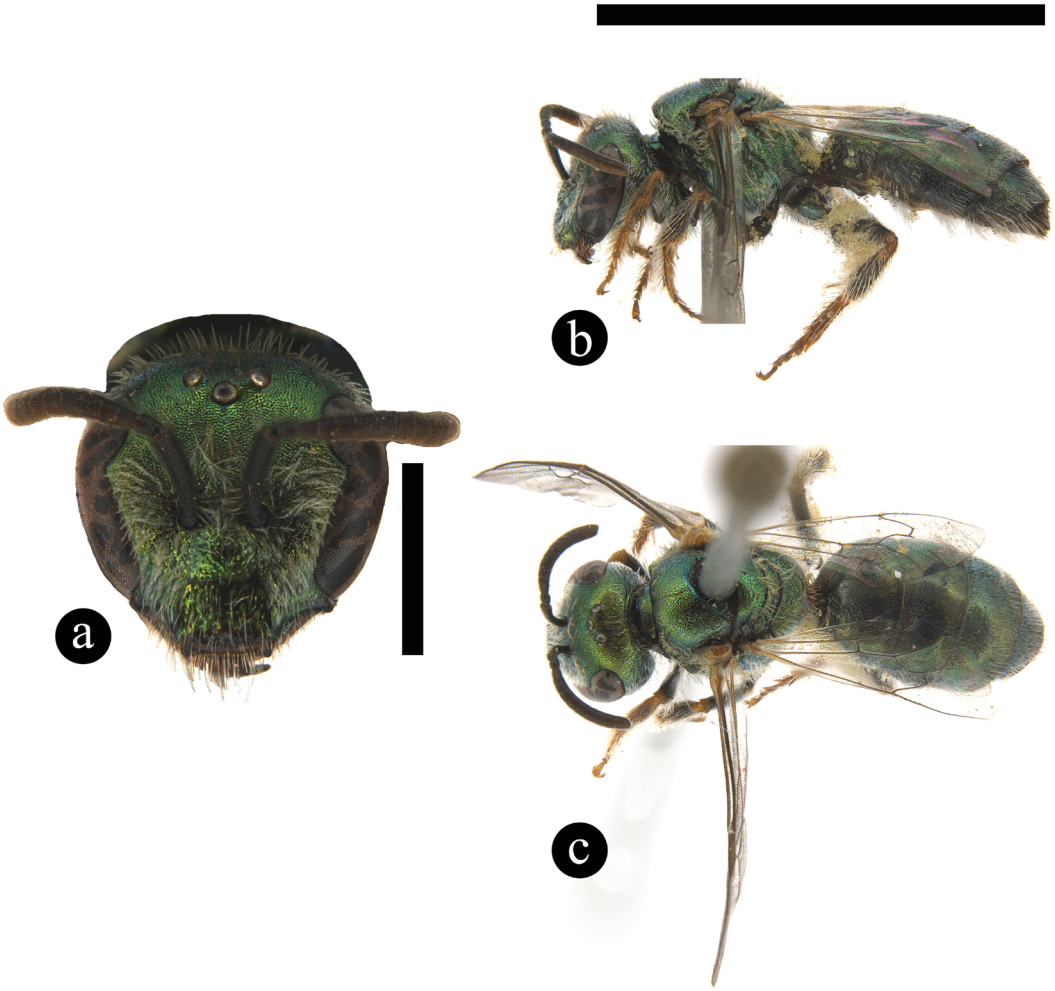

Figure 3. Female of *Augochlora* (*Augochlora*) sp. a) head, frontal view; b) lateral habitus; c) dorsal habitus (fig. a, scale bar = 1 mm; figs. b–c scale bar = 5 mm).

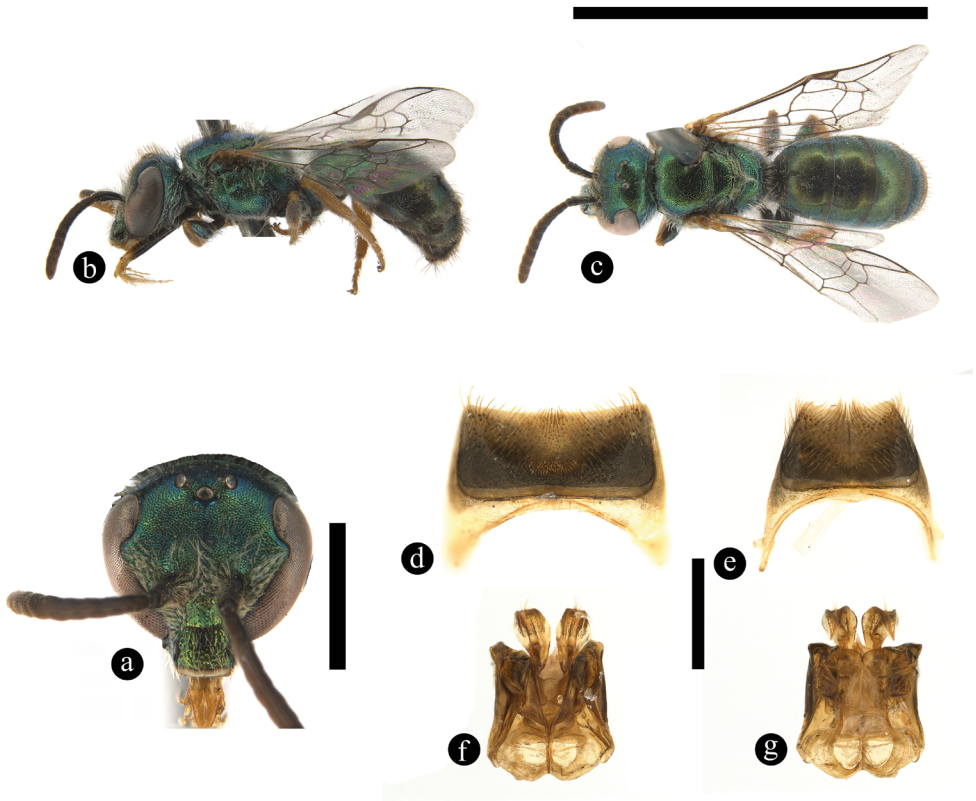

Figure 4. Male of *Augochlora* (*Augochlora*) sp. a) head, frontal view; b) lateral habitus; c) dorsal habitus; d) metasomal sternum 5; e) metasomal sternum 6; f) genital capsule, dorsal view; g) genital capsule, ventral view (fig. a, scale bar = 1 mm; figs. b–c scale bar = 5 mm; figs. d–g scale bar = 0.5 mm).

Figure 5. Sweat bees (Halictidae) visiting flowers in the Fernando de Noronha archipelago, Brazil. a) female of *Augochlora* (*Augochlora*) sp. on Jetirana (Convolvulaceae: *Merremia aegyptia* (L.) Urb.); b) female of *Lasioglossum* (*Dialictus*) *atripyga* on onze-horas (Portulacaceae: *Portulaca* sp.).

Dialictus (*Chloralictus*) *atripyga*; Alvarenga, 1962: 25 [Fernando de Noronha checklist].

Dialictus atripyga; Silveira et al. 2002: 185 [list, distribution]; Moure et al. 2007: 847 [catalog].

Lasioglossum (*Dialictus*) *atripyga*; Ascher & Pickering, 2015 [checklist]; Rafael et al. 2020: 19 (Fernando de Noronha checklist).

Diagnosis. Moderate-sized species (4.3–5.5 mm) with very singular coloration, mainly by the dull greenish bronzed body and yellowish brown on apical half of clypeus and pronotum and for the yellowish legs. Head rounded (length/width ratio about 1.1). Clypeus with depressed preapical fimbriae margin, laterally slightly projected at acute angle on each side.

Redescription. FEMALE: Body length 4.3–5.5 mm; head length 1.5–1.7 mm; head width 1.4–1.6 mm; forewing length 3.2–3.6 mm.

Coloration. Head and mesosoma largely dull greenish bronzed {*much bronzed*} (Figs. 6a–b, d–e). Mandible and apical half of clypeus yellowish brown. Antenna dark brown with basal third of scape and ventral surface of flagellum yellowish. Pronotum yellowish

with translucent spots on anterior surface of pronotal lobes. Tegula translucent yellowish. Wing membrane hyaline, venation dark brown, pterostigma yellowish. Legs yellowish, except meso and metatibia brownish and dark brown spot on external surface of distitarsi. Terga brownish without metallic reflections and with translucent apical margins on T1–T4; sterna yellowish.

Pubescence. Mainly white, inner surface of tibiae and tarsi with golden bristles. Body with moderately dense hairs, sparse on hypostomal area and disc of T1–T3. Head covered almost entirely by plumose hairs (1.5 OD) with subappressed tomentum. Apical half of clypeus hairless. Clypeus and supraclypeal area, lower paraocular, and hypostomal areas without subappressed tomentum. Setae on dorsobasal area of scape longer than diameter of scape. Metafemur with strong scopa. Propodeum with dense plumose hairs on lateral and posterior surfaces (2–2.5 OD). Disc of T1 and T2 with very short simple setae, lateral bands longer (2–3 OD); T2 and T3 basally and laterally with short plumose hairs; T3 with sparse long branched setae, branches very short; T4 with sparse long branched setae similar to T3 with dense short plumose hairs subappressed; T5 and T6 covered with long plumose hairs, longer on lateral bands. Metasomal sterna covered with long plumose hairs, longer on S2; S1–S3 with apical short fringe.

Surface sculpture. Face imbricate, punctation fine. Clypeus entirely microsculptured, apical half almost unpunctured. Mesoscutum and mesepisternum strongly microsculptured with very fine sparse punctures. Mesoscutellum microsculptured with very fine sparse punctures anteriorly and with two sparse sculptured dorsal areas on each side. Metapostnotum weakly rugoso-carinulate, medial carina nearly reaching posterior margin (Fig. 6e). Metasomal terga polished evenly microsculptured and unpuctured.

Structure. Head round (length/width ratio about 1.1). Ocellocular distance 1.5 OD. Gena broad, approximately 1.5 wider than compound eyes in lateral view. Frontal line carinate, ending 2.3 OD below median ocellus. Clypeus with depressed preapical fimbriae margin, laterally slightly projected at an acute angle on each side. Labrum with apical process narrow, dorsal keel present. Mandible simple with small angular notch on preapical upper margin. Pronotal dorsal ridge weakly carinate from lateral angle to lobe. Three submarginal cells, first longer than two others together. Inner metatibial spur pectinate with 4–5 branches, sometimes less and asymmetrical (3 on one side and 5 on other). Metapostnotum moderately elongate, about two times the metanotum length. Propodeum without oblique carina, weak lateral carina not reaching dorsal surface.

MALE. Even though it is more slender and has longer antennae (Figs. 7a–c), it is similar to the female except as follows: body length 4.0–5.2 mm; head length 1.2–1.5 mm; head width 1.3–1.5 mm; forewing length 2.9–3.4 mm. Tegula, wing venation and legs darker brown. Metasoma dark brown. Clypeus evenly hairy; propodeal pilosity shorter; pilosity on metasomal sterna S2–S5 shorter medially. Metapostnotum coarsely rugoso-carinulate. Gena narrowed, almost as wide as the compound eyes in lateral view; mandible simple; scape shorter and F1 almost as long as wide and about half length of F2; inner metatibial spur not pectinate. Male terminalia structures as in figure 7 (d–f).

Type material examined. BRAZIL: Fern. Nor. [Fernando de Noronha], 88 10 [label verse] // atri-pyga, 30 // Syntype ♀, *Halictus atripyga* Kirby, det. D. Notton, 2015 // BMNH(E) #971054 (Syntype ♀, NHMUK).

Additional material examined. BRAZIL: Arquip. [Arquipélago], Fernando de Noronha, 03°50′S, 32°24′W, several data along the nine months of collection. Material examined totaling 79 ♀♀ and 560 ♂♂ to be deposited equally among the Brazilian collaborating collections: INPA, CZMA, MNRJ, MZUSP and UFRPE.

Remarks. Extremely common and apparently quite abundant species on the island, having been widely collected and observed visiting flowers of several species of plants, such as onze-horas (*Portulaca* sp.)

Figure 6. Female of *Lasioglossum* (*Dialictus*) *atripyga* (Kirby, 1890). a–d, Type. a) head, frontal view; b) lateral habitus; c) Type labels; d) dorsal habitus; e) metapostnotum, dorsal view (figs. a and e, scale bar = 1 mm; figs. b and d, scale bar = 5 mm); Photos credits a–d: Natural History Museum.

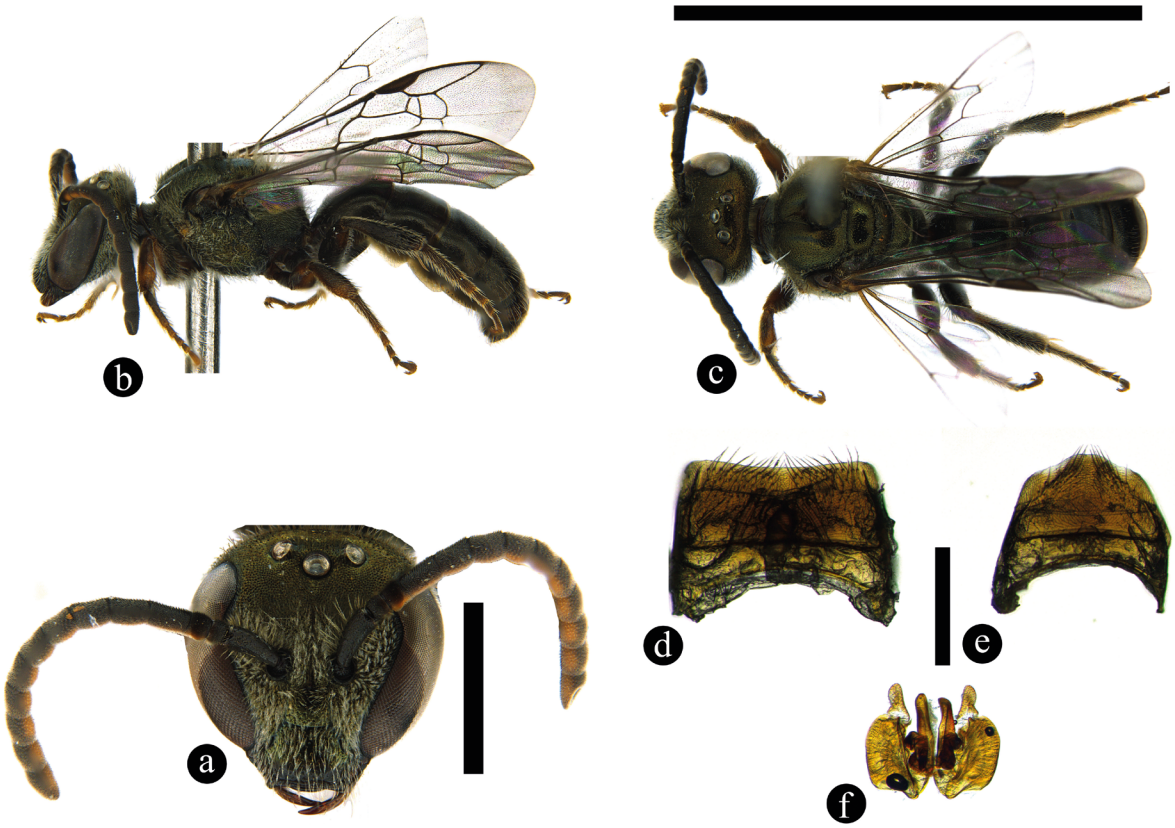

Figure 7. Male of *Lasioglossum* (*Dialictus*) *atripyga* (Kirby, 1890). a) head, frontal view; b) lateral habitus; c) dorsal habitus; d) metasomal sternum 5; e) metasomal sternum 6; f) genital capsule, dorsal view (fig. a, scale bar = 1 mm; figs. b–c scale bar = 5 mm; figs. d–f scale bar = 0.5 mm).

(Fig. 5b). Just like in *A. laevipyga*, the nesting behavior of this species has never been observed. However, a male specimen reported here was collected over a rotting wood, suggesting that this substrate might be explored for nesting. Michener (2007) states that a few species of *L.* (*Dialictus*) nest in rotting wood.

Discussion

Michener (2007) discussed the probable hypotheses of bee colonization on oceanic islands, commenting that the solitary to primitively social bees that nest in wood or stems are more likely to cross water barriers than those which nest in the ground, presumably because wood and stems containing nests are sometimes carried above water in floating islands of vegetation. However, he recognizes that the bee fauna of oceanic islands includes minute forms that nest in the soil, where dispersal presumably occurs by wind, at least for the small forms, whereas the larger ones probably came later and perhaps in some cases with the help of humans. We cannot be sure how or when exactly the colonization of the archipelago by insects began, but we agree with Carbonell (1996) that the Fernando de Noronha insect fauna is derived from the continental mainland, as these bees are common in the New World (Michener 2007, Gibbs 2011, Lepeco & Gonçalves 2020). The two described species are currently only recorded from Fernando de Noronha, an island with a low percentage of endemism (8%) for insects (Rafael et al. 2020).

Given the uncertainties about the biogeographical history of these two identified halictids, it is impossible to state when or how exactly these species appeared in the archipelago or whether these species can be found on the mainland. Nonetheless, more important than understanding how these species colonized the archipelago is to know when exactly this occurred, since isolation time of a population is decisive for evolution. Although it is impossible to precisely say when these species colonized the island, there are at least two possible and probable hypotheses. The first is related to the hypothesis of human intervention (i.e. boats, construction material such as earth and wood) in a recent period, probably between 1503 and 1890, corresponding to the period between the discovery of the island and the first record of the species, which could indicate living populations on the continent. The second is related to the hypothesis of earlier colonization (e.g., by wind or water as suggested by Michener 2007), wich could have favored the speciation process. Consequently, the chance that they are endemic is also greater.

According to Kirby (1890), *A. laevipyga*, cited as *A. alternipes*, "appears to be a very common" species; however, our results based on Malaise traps collection and sweeping, suggest that this species is not so common on the island.

Augochlora sp. is being recorded for the first time and it is possible that is a more recent introduction to the Fernando de Noronha archipelago.

The higher populational density of *L.* (*Dialictus*) *atripyga* probably has an economic impact on fruit culture activities on the main island. Kirby (1890) had already realized the importance of these bees for pollination on the island, when he declared that "these were taken in the flowers of the melons and the *Oxalis*, and play an important part in the fertilization of the flowers". These bees are commonly found in the most diverse pollination studies, whether for crops or in natural landscapes and some species of the subgenus are known to be generalists on bee-plant interaction networks (Kleinert & Gianinni 2012).

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Author Contributions

Thiago Mahlmann: was responsible for the identification and illustration of the species; contributed to data collection and manuscript preparation

Francisco Limeira-de-Oliveira: contributed to data collection and manuscript preparation.

José Albertino Rafael: contributed to data collection and manuscript preparation.

Conflicts of Interest

The authors declares that they have no conflict of interest related to the publication of this manuscript.

Ethics

This study did not involve human beings and/or clinical trials that should be approved by one Institutional Committee.

Data Availability

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