



Soil ascomycetes from Spain. XIV. The *Chaetomiaceae* of La Palma (Canary Islands)

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Abstract: The Canary Islands, located in the Atlantic Ocean within the Macaronesian biogeographic region, consist of seven main islands alongside numerous smaller ones of volcanic origin, representing the southernmost region of Spain. This archipelago shows a variety of microclimates and ecological settings, encompassing from laurisilva cloud forests to montane pine forests and deserts, responsible for diverse flora and fauna rich in endemism. Despite considerable research focused on the biodiversity of plant and animal life, knowledge regarding fungi, particularly micromycetes, remains comparatively limited. Building on our ongoing investigation of soil-borne ascomycetes of the Canary Islands, initiated several decades ago, we collected samples from the southern region of La Palma Island. At the laboratory, these samples were processed using different semi-selective techniques aimed at isolating ascomycetes, such as the Warcup's soil plate method, the activation of soil dormant ascospores with 5 % acetic acid, and *ToKaVa* hair baiting method. After a phenotypic characterization, subsequent molecular identification of the fungal strains was conducted through amplification and sequencing of the Internal Transcribed Spacer (ITS) and the domains D1-D2 of the Large Subunit (LSU) regions of nuclear ribosomal DNA, and fragments of the RNA polymerase II second largest subunit (*rpb2*), β -tubulin (*tub2*) and translation elongation factor 1- α (*tef*) genes. Preliminary taxonomic assignment was carried out using BLAST searches, followed by phylogenetic studies for precise taxonomic delimitation. Among the identified members of the *Chaetomiaceae*, noteworthy taxa include *Achaetomium aegilopsis*, *Canariomyces arenarius*, *Carteria arctostaphyli*, *Ovatospora senegalensis*, *Parathielavia kuwaitensis*, *Pseudohumicola alba*, and *P. glauca*, representing the first documented occurrences in volcanic soils. Furthermore, the discovery encompasses the description of three new genera (*Oidiosporium*, *Phaeohyphomyces* and *Steirochaetomium*) and nine new species (*Botryotrichum pseudomurorum*, *Canariomyces asexualis*, *Carteria canariensis*, *Oidiosporium botulisporum*, *Phaeohyphomyces canariensis*, *Pseudohumicola cinnamobrunnea*, *P. intercalispora*, *P. variispora* and *Steirochaetomium canariensis*) within this fungal family. These findings underscore the significance of volcanic soils of La Palma Island as reservoirs of novel micromycetes, particularly emphasizing the prevalence of *Chaetomiaceae* members as revealed by the applied isolation methodologies.

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INTRODUCTION

The Canary Islands consist of seven main islands alongside with several smaller ones, islets, and rocks situated in the Atlantic Ocean, approximately 100 km off the northwest coast of Africa. This Spanish archipelago, located within the Macaronesian biogeographic region (Carracedo & Troll 2021, http://data.europa.eu/eli/dec_impl/2024/449/oj, accessed on 4 April 2024), is characterized by its volcanic origin, resulting in distinctive landscapes marked by steep mountain slopes and lava flows. The islands experience low seasonal temperature variations, minimal precipitation, and predominantly dry conditions. In terms of topography and geomorphology, Lanzarote and Fuerteventura (the easternmost islands) are characterized by low, rocky, and arid terrain with xeric shrub vegetation. In contrast, the remaining Canary Islands are mountainous, with elevations exceeding 2000 meters above sea level (m.a.s.l.) and are home to extensive forests

of conifers and laurisilva cloud forests. These unique characteristics strongly influence the distribution and diversity of biological components across various habitats (Fernández *et al.* 1978, European Environment Agency 2004).

In the northwest of the Canary archipelago lies the island of La Palma, characterized by rugged terrain consisting of ravines, mountain ranges, volcanoes, and forests. The island has a triangular shape, with its widest side in the northern part, spanning a surface area of 708 km² and reaching its highest point at the Roque de los Muchachos, towering at 2426 m.a.s.l. La Palma is particularly exposed to marine air systems influenced by the Canary Current, resulting in a Mediterranean subtropical climate. Summers are dry and hot, with average temperatures surpassing 22 °C, while winters are humid and rainy, featuring mild temperatures (Köppen-Geiger climate type Csa). The island's inland areas experience a more humid climate, fostering lush laurisilva cloud forests at its centre (<https://www.aemet.es/es/serviciosclimaticos/>



datosclimatologicos/valoresclimatologicos#tab2, accessed on 21 February 2024). Its geomorphology divides it into two, offering great qualitative richness and extraordinary landscape diversity. On the one hand, the oldest materials from the North of the island, which have been subjected for a long time to the action of climatic and biological phenomena, have created deep, fertile soils rich in natural conditions. On the other hand, in the South of the island, of recent volcanism, the soils are thin, stony, poor and of low fertility (Porrás Martín *et al.* 1985, European Environment Agency 2004, Cabildo La Palma 2011).

The flora and fauna of the island of La Palma, despite the eruption of the Cumbre Vieja volcano in 2021, have been minimally affected by this natural event. As a result, the island maintains a high biodiversity and remains rich in endemic species. Its plant communities range from the tabaibal-cardonal scrubland to the summit scrub, encompassing laurel forests and Canary Island pine forests, along with numerous species of plants, invertebrates, and vertebrates. Notable examples include the big-headed Teneguía (*Cheirolophus junonianus*), the summit pansy (*Viola palmensis*), and the pininana (*Echium pininana*), as well as various arthropods – particularly beetles – molluscs, reptiles, bats, and birds. Among these are the La Palma subspecies of the Tenerife lizard (*Gallotia galloti palmae*), the unique Canary long-eared bat (*Plecotus teneriffae*), the red-billed chough (*Pyrrhocorax pyrrhocorax barbarus*), and the endemic laurel forest pigeons (*Columba bollii* and *Columba junoniae*). However, as previously mentioned, both the presence and diversity of flora and fauna is significantly reduced in the southern part of the island due to its geomorphological features as well the meteorological conditions (<http://rerb.oapn.es/red-espanola-de-reservas-de-la-biosfera/reservas-de-la-biosfera-espanolas/mapa/la-palma/descripcion-general>; <https://www.biodiversidadcanarias.es/biota/especie/F01516>, accessed on 20 February 2024).

Among the soil micromycetes of the Canary Islands, only a few studies have been conducted (von Arx 1984, Beltrán-Tejera *et al.* 2009, Zachow *et al.* 2009, Hernández-Restrepo *et al.* 2017), but only one of them (von Arx 1984) mention the finding of a new species, *Canariomyces notabilis*, as well as other members of the family *Chaetomiaceae*, i.e. *Achaetomium*, *Chaetomidium*, *Chaetomium* and *Thielavia*, despite the identification at species level has not been mentioned. Fungal species recorded from the Canary Islands, as well as their geographic distribution and source, can be found in different freely available online databases (<https://www.biodiversidadcanarias.es/biota/>, accessed 14 August 2024, https://www.inaturalist.org/observations?nelat=29.463514&nelng=-13.31543&place_id=any&subview=map&swlat=27.425414&swlng=-18.391113&taxon_id=48250&verifiable=any, accessed 14 August 2024) but also printed checklists (Beltrán-Tejera *et al.* 2009, Arechavaleta *et al.* 2010).

Therefore, the main objective of our study was to further investigate the biodiversity of soil ascomycetes in the soils of La Palma, focusing on the family *Chaetomiaceae* of the Canary Islands, due to the high prevalence found. We used both general and semi-selective techniques for their isolation and applied a taxonomic polyphasic approach for their phylogenetic placement and identification.

MATERIALS AND METHODS

Sampling sites

Fourteen samples of soils were collected in 2008 from three sites near the village of Fuencaliente (Los Canarios) in the South of La Palma Island: San Antonio volcano (Ca2, Ca6), Teneguía volcano (Ca1, Ca5, Ca8, Ca10–Ca14), and the Fuencaliente lighthouse (Ca3, Ca4, Ca7, Ca9).

Isolation of the soil-borne fungi

Samples of approximately 100 g of the topmost layer of soil, devoid of organic matter, were collected and placed in sterile polyethylene bags, and sealed with rubber bands. These samples were stored at room temperature until shipment to our laboratory in suitable containers via postal mail. Upon arrival, the samples underwent processing using various isolation techniques by duplicate. Each sample was incubated at both 25 °C and 37 °C. The cultivation of samples was performed using the Warcup's soil plate method (Warcup 1950) on glycerol agar 18 % (G18; Rodríguez-Andrade *et al.* 2019) and ascospore agar (AA; Adams 1949). Also, dormant ascospores in soil samples were "activated" by 5 % acetic acid according to Stchigel *et al.* (2001). Finally, the *ToKaVa* hair baiting method was used to recover keratinophilic ascomycetes (Vanbreuseghem 1952). Fungal structures were transferred using sterile disposable hypodermic needles and syringes (tuberculin/insulin type) to 50-mm-diam. disposable Petri dishes containing oatmeal agar (OA; Samson *et al.* 2010). The dishes were then incubated at 25 °C under a 12-h dark cycle, alternating with 12 h of cool white, fluorescent light. This process was repeated until a pure culture was obtained. Strains of interest were deposited in the culture collection at the Faculty of Medicine (FMR, Reus, Spain) in three different forms: slant cultures on OA and potato dextrose agar (PDA; Hawksworth *et al.* 1996) under a layer of sterile liquid paraffin; OA blocks (where the strain had grown) immersed in sterile water in caramel-coloured self-sealing vials; and lyophilized. Holotypes and culture ex-types of the novel fungal taxa were deposited in the Westerdijk Fungal Biodiversity Institute (CBS; Utrecht, The Netherlands). The names and descriptions were deposited in MycoBank (<https://www.mycobank.org/>).

Phenotypic characterization of the fungal strains

Fungal strains were inoculated onto OA and PDA in 90-mm-diam. sterile disposable Petri dishes and then incubated at 25 °C under a 12-h dark cycle, alternating with 12-h of cool white, fluorescent light (Wang *et al.* 2022). The cultures were examined weekly under a dissecting microscope for up to 3 mo to observe the development of reproductive structures. These structures were processed in the same manner as previously described and mounted on a drop of lactic acid as a mounting medium, between a slide and a coverslip. Subsequently, they were observed and measured using an Olympus BH-2 bright field microscope equipped with an eyepiece scale (Olympus Corporation, Tokyo, Japan). For isolates of particular interest, the morphology of both vegetative and reproductive structures was studied in detail

using the slide culture technique according to Riddell (1950) and Wang *et al.* (2022), which involved inoculating OA and/or potato carrot agar (PCA; Langeron & Vanbreuseghem 1952) agar blocks of 1 cm². These cultures were then incubated for 2–14 wk at 25 °C in wet chambers. Subsequently, coverslips were transferred onto slides with a drop of lactic acid as a mounting medium for observation under a bright field microscope. Digital images of the samples were captured using a DeltaPix Infinity X camera attached to the Zeiss Axio Imager M1 microscope (Oberkochen, Germany), employing Nomarski interference contrast (DIC) and phase contrast (PC) condensers. Image editing was performed using Adobe Photoshop CS6 v. 13.0 (Adobe Systems, San Jose, CA, USA). Culture characteristics and micromorphology were observed at 25 °C on malt extract agar (MEA; Reiss, 1972), OA, PCA, PDA, and corn meal agar (CMA; Benham, 1931), from 1–4 wk, following the methods described by Wang *et al.* (2022). Cardinal temperatures were determined by incubating the inoculated PDA plates at 5, 12, 15, 20, 25, 30, 35, 37, 40, and 45 °C for 1 wk. Colony colour notations were referenced from (Kornerup & Wanscher 1978).

DNA extraction, amplification, and sequencing

The fungal strains were inoculated onto PDA and incubated for 1–2 wk at 25 °C. Subsequently, the aerial mycelium and fruiting structures were removed by scraping with a sterile scalpel, and DNA was extracted using the FastDNA kit protocol (Bio; Vista, CA, USA), supplemented with 50 mg of 425–600 µm size-fractionated glass beads and acid-washed [Sigma, Madrid, Spain], with a FastPrep-24™ instrument (Thermo Savant, Holbrook, NY, USA). DNA quantification was performed using a NanoDrop 2000 instrument (Thermo Scientific, Madrid, Spain). To facilitate molecular phylogenetic analysis and identification, partial sequences of five nuclear loci were amplified: ITS, LSU, *rpb2*, *tub2* and *tef*. The primers used for the amplification of these loci – ITS (White *et al.* 1990), LSU (Kurtzman & Robnett 1997, Vilgalys & Hester 1990), *rpb2* (Liu, Whelen, & Hall 1999), *tub2* (O'Donnell & Cigelnik 1997, Woudenberg *et al.* 2009), and *tef* (Rehner & Buckley 2005) – are listed in Table S1.

The amplification reactions were conducted using the EmeraldAmp® GT PCR Master Mix (Takara Bio Inc., Saint-Germain-en-Laye, France) following the manufacturer's instructions for a reaction volume of 25 µL. Each reaction tube contained 5 pmol of each primer and 50 ng of template DNA. Amplification was performed using the MyCycler™ Thermal Cycler (Bio-Rad, Feldkirchen, Germany). The initial denaturation step was set at 95 °C for 5 min, followed by 35 cycles of denaturation at 95 °C for 30 s, annealing at temperatures specified in Table S1 for 30 s, and extension at 72 °C for 30 s, with a final extension step at 72 °C for 7 min. The amplicons were sequenced bidirectionally using the same primer pair employed for amplification at Macrogen Spain (Macrogen Inc., Madrid, Spain). Consensus sequences were generated using SeqMan software v. 7.0.0 (DNASTar Lasergene, Madison, WI, USA) and subsequently deposited in GenBank.

Phylogenetic inference

Preliminary molecular identification of the fungal strains involved comparing each gene sequence with those available in the National Centre for Biotechnology Information (NCBI) database (Altschul *et al.* 1990) using the Basic Local Alignment Search Tool (BLAST; <https://blast.ncbi.nlm.nih.gov/Blast.cgi>, accessed on 21 February 2024). The ITS sequences were employed to confirm the strain assignment to the family *Chaetomiaceae*, while *rpb2* and *tub2* sequences were utilized for identification at the genus and species level (Wang *et al.* 2016a, b, 2019a, b, 2022, Alves *et al.* 2022, Oliveira *et al.* 2023). For the phylogenetic analysis, the nucleotide sequences were aligned using the ClustalW (Thompson *et al.* 1994) application of the MEGA (Kumar *et al.* 2016) computer program and manually adjusted using the same software platform. Phylogenetic reconstructions were made by maximum likelihood (ML) and Bayesian inference (BI) with RAxML (Stamatakis 2014) in CIPRES web (<https://www.phylo.org/>) (Miller *et al.* 2012) and MrBayes v. 3.2.6 (Ronquist *et al.* 2012), respectively, for each locus and all loci together after comparing the tree topology. The best substitution model for each gene matrix was estimated using MrModelTest v. 2.3.25 (Nylander 2004). For ML analyses, nearest-neighbor interchange was used as the heuristic method for tree inference. Support for internal branches was assessed by 1000 ML bootstrapped pseudoreplicates. Bootstrap support (BS) of ≥ 70 % was considered significant (Felsenstein 1985, Degnan 2016). For BI analyses, Markov chain Monte Carlo (MCMC) (Metropolis & Ulam 1949) sampling was carried out with four million generations, with samples taken every 1000 generations. The 50 % majority rule consensus trees and posterior probability values (PP) were calculated after removing the first 25 % of the resulting trees for burn-in. A PP value of ≥ 0.95 was considered statistically significant (Money 2016, Yang 2016). The nucleotide sequences generated during the development of our study, as well as those retrieved from the NCBI databases to build the phylogenetic tree, are listed in Table 1. To construct the multilocus phylogenetic tree, sequences from 92 ingroups were utilized. The selection of sequences from the NCBI databases was based on percentage similarity (using the BLAST search tool), with a minimum cutoff of 85 % for *rpb2* and 80 % for *tub2*, compared to the sequences generated in this study. Additionally, the phylogenetic analysis included sequences from two outgroups, *Sordaria equicola* CBS 146992 and *Neurospora tetraspora* CBS 178.33. The alignment has been deposited in Zenodo (<https://zenodo.org/>; doi: 10.5281/zenodo.10948357).

RESULTS

Phylogenetic analysis

Bayesian inference and ML analysis showed a similar tree topology, with congruent results for each individual gene. However, LSU and ITS displayed a limited support for members of this family, consistent with a previous report

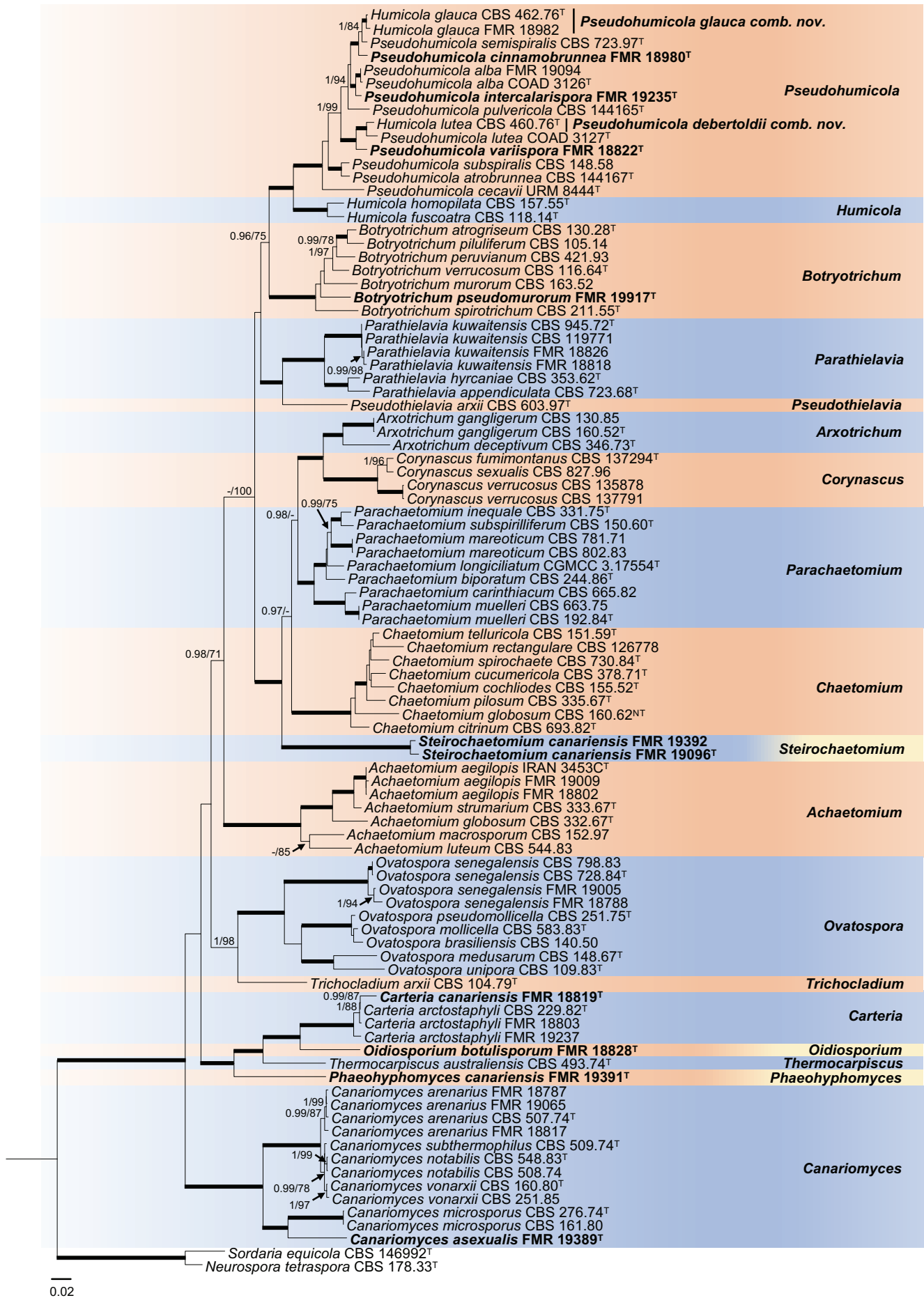


Fig. 1. Maximum likelihood of the tree obtained from the concatenated ITS-LSU-*rpb2-tub2* (3215 bp) alignment of the nucleotide sequences from our strains and those retrieved from the GenBank. Bayesian posterior probabilities (PP) ≥ 0.95 and the RAxML bootstrap support values (BS) $\geq 70\%$ are presented at the nodes (PP/BS). Thickened branches indicate full support (PP = 1 and BS = 100 %). The new species and combinations are indicated in **bold**. ^T represents the ex-type strain of the species. ^{NT} represents the ex-neotype strain of the species.

(Wang *et al.* 2019a, b, 2022). The multilocus phylogenetic tree constructed with four molecular markers ITS-LSU-*rpb2*-*tub2* (Fig. 1) was based on 3215 positions, including gaps (631 bp for ITS, 851 bp for LSU, 857 bp for *rpb2*, and 876 bp for *tub2*). The concatenated alignment is available in Zenodo, doi: 10.5281/zenodo.10948357.

The phylogenetic tree (Fig. 1) revealed 18 well-supported main clades, within which we identified several fungal strains belonging to the family *Chaetomiaceae*. The identified species, listed in alphabetical order, include: *Achaetomium aegilopsis* (FMR 18802 and FMR 19009), *Canariomyces arenarius* (FMR 18787, FMR 18817 and FMR 19065), *Carteria arctostaphyli* (FMR 18803 and FMR 19237), *Humicola glauca* (FMR 18982), *Ovatospora senegalensis* (FMR 18788 and FMR 19005), *Parathielavia kuwatitensis* (FMR 18826 and FMR 18818), and *Pseudohumicola alba* (FMR 19094) (Table 1; Fig. 1).

Additionally, the strains FMR 18822, FMR 18980, and FMR 19235 were identified as new species of the genus *Pseudohumicola*; FMR 19917, FMR 19389, and FMR 18819, as new species of the genera *Botryotrichum*, *Canariomyces* (*Can.*), and *Carteria*, respectively. The strains FMR 19096 and FMR 19392 were placed within a newly established

monospecific genus, *Steirochaetomium* (*St.*). Furthermore, FMR 18828 and FMR 19391 were classified as two new genera, *Oidiosporium* (*Oid.*) and *Phaeohyphomyces* (*Phaeoh.*), respectively.

Moreover, based on our phylogenetic analysis, new taxonomic combinations will be proposed for *H. glauca* and *H. lutea*. Accordingly, the new taxa and new combinations are described below.

TAXONOMY

Botryotrichum pseudomurorum Sastoque, Cano & Stchigel, *sp. nov.* MycoBank MB 847932. Fig. 2.

Etymology: From Greek *ψεύδο-* (*pseudo-*), false, because the morphological resemblance to *Botryotrichum murorum*.

Typus: Spain, Canary Islands, La Palma, Fuencaliente (Los Canarios), from soil near the lighthouse, 15 Jul. 2008, coll. M. Caldach & A.M. Stchigel, isol. A.P. Sastoque (**holotype** CBS H-25345, culture ex-type FMR 19917 = CBS 149965).

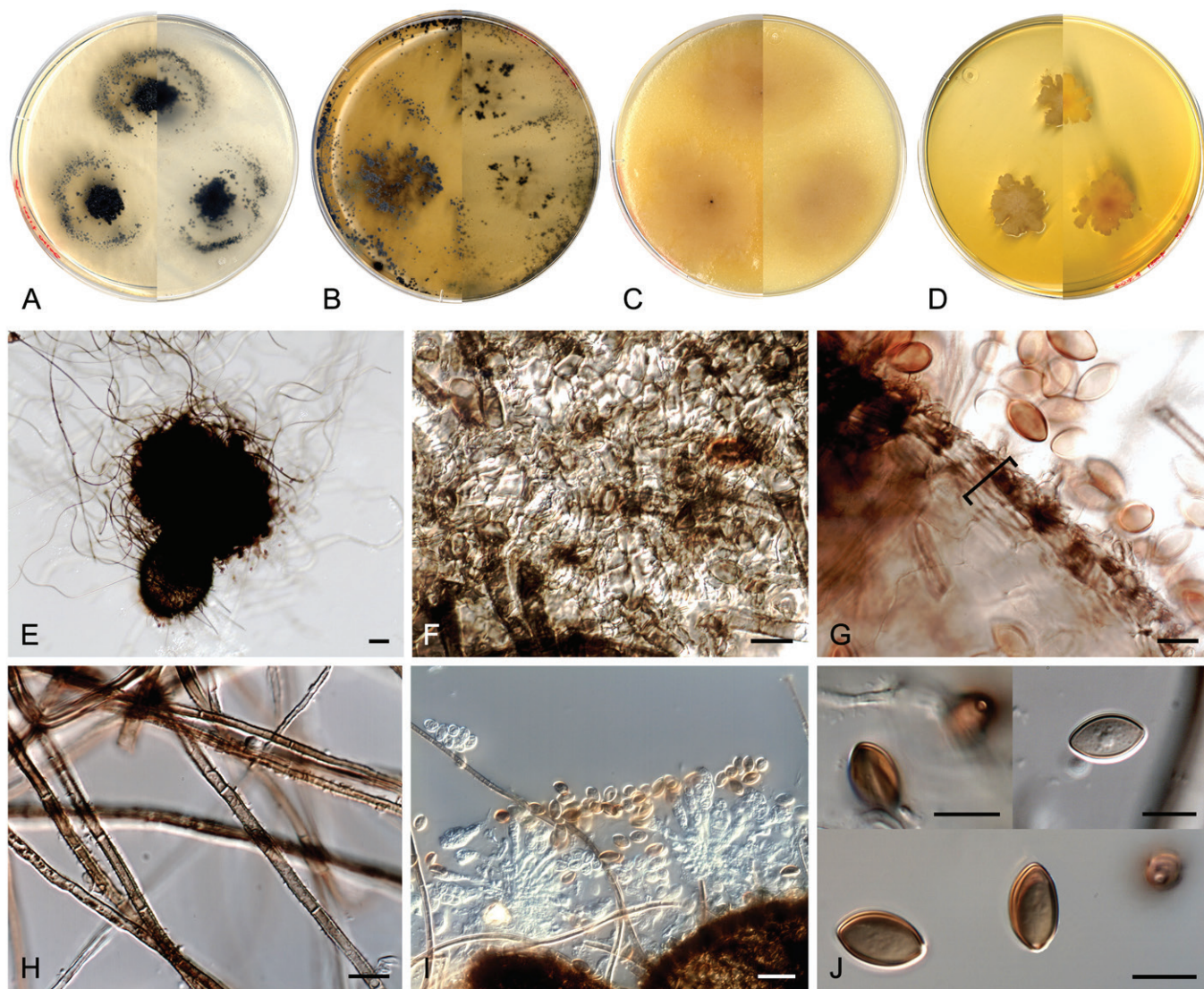


Fig. 2. *Botryotrichum pseudomurorum* CBS 149965. **A–D.** Colonies on PCA, OA, CMA, MEA (4-wk-old; 25 °C; surface, left; reverse, right). **E.** Mature ascomata. **F.** Detail of the peridium. **G.** Detail of the ascomata wall, indicating the peridial layers (black line). **H.** Verrucose upper part of the terminal hairs. **I.** Asci and ascospores. **J.** Ascospores showing the variation of the cell wall thickness (as longitudinal striations) and the apical germ pore. Scale bars: E = 50 µm; F–I = 10 µm.



On oatmeal agar after 4 wk at 25 °C: Mycelium scarce, mostly aerial, composed of septate, branching, smooth- and thin-walled, subhyaline to brown, 0.5–3 µm wide hyphae. Ascomata superficial, solitary to aggregate, smoke grey to olivaceous grey under reflected light, with greenish setae, ostiolate, neck absent, globose, subglobose, ovoid, or barrel-shaped, 30–105 × 20–100 µm (Fig. 2E). Peridial wall translucent, greenish-brown to olivaceous brown, but opaque and nearly black around the ostiole (of up to 30 µm diam.) and medium brown at the base, 3–4-layered, 7–12 µm thick, outer layer of textura intricata, inner layers composed of flattened, translucent polygonal cells of 5–15 µm diam. (Figs. 2F,G); terminal hairs abundant around the ostiole, septate, straight, undulate and verrucose at the upper part (Fig. 2H), pointed or circinate at the apex, greenish-brown to olivaceous grey, mostly up to three times longer than the ascomata diameter, 5–7.5 µm wide at the base, branching; lateral hairs straight, septate, greenish brown to olivaceous grey, up to 150 µm long, covered with cup-shaped ornamentations specially at the base, pointed or rounded at the tip (Fig. 2E). Asci unitunicate, fasciculate, clavate to fusiform, spore-bearing part 36–51 × 13–20 µm, stalks 16–25 µm long, with 8 irregularly-arranged or biseriate ascospores, evanescent before ascospores become mature (Fig. 2I). Ascospores unicellular, pale pinkish brown when young, brown but irregularly coloured (varying the intensity of colour) when mature, smooth-walled, but with slight irregularity in wall thickness, broadly fusiform, (12–)13–14(–15) × (7–)7.5–8(–8.5) × 7–8 µm, attenuated at both ends, with a germ pore at one end (Fig. 2J). Asexual morph not seen.

Culture characteristics (after 7 d at 25 °C): Colonies on PCA 8–9 mm diam., flat, circular, and expansive; margin filamentous, slightly- and irregularly undulate; surface yellowish grey (4B2) with black (6F3) ascomatal covered

by almond green (28E3) terminal hairs and scarce white (4A1) aerial mycelium in the central area; soluble pigment absent; reverse nougat (5D3) and marble white (5B2) margins. Colonies on OA 30–31 mm diam., flat, circular, and expansive; margin entire and regular; surface golden blonde (4C4) with scarce white (3A1) erect aerial mycelium; soluble pigment absent; reverse greyish yellow (4C5). Colonies on CMA 18–19 mm diam., flat, circular, and expansive; margin filamentous and lobulated to irregular; surface without aerial mycelium camel (6D4) and yellowish white (3A2) margins; soluble pigment absent; reverse light brown (6D5). Colonies on MEA 14–15 mm diam., flat to slightly convex; margin entire and irregularly-lobulated; surface golden blonde (5C4) with floccose white (5A1) aerial mycelium and pale yellow (3A3) margins without aerial hyphae; yellow soluble pigment; reverse butter yellow (4A5) and yellowish white (3A2) margins. Culture iconography after 4 wk of incubation on PCA, OA, CMA and MEA (Fig. 2A–D, respectively). Minimum, optimum and maximum temperature of growth on PDA after 7 d: 5 °C, 20 °C and 35 °C, respectively.

Notes: *Botryotrichum pseudomurorum* was placed in the fully-supported clade corresponding to the species of the genus *Botryotrichum* (B.), but in a separate branch flanked by *Botryotrichum murorum* CBS 163.52 and *Botryotrichum spirotrichum* CBS 211.55 (Fig. 1). *Botryotrichum pseudomurorum* differs from *Botryotrichum murorum* by the larger ascomata (160–320 × 150–270 µm in *B. murorum*), and the verrucose and longer terminal hairs (usually over four times longer than ascomata (up to 3 mm long). Additionally, *B. pseudomurorum* is distinguished by the production of a yellow soluble pigment on MEA, a characteristic not described for *B. murorum* (Corda 1837, Wang *et al.* 2016a). While most *Botryotrichum* spp. have been reported from dung, air, wood or soil, they have not been specifically isolated from volcanic

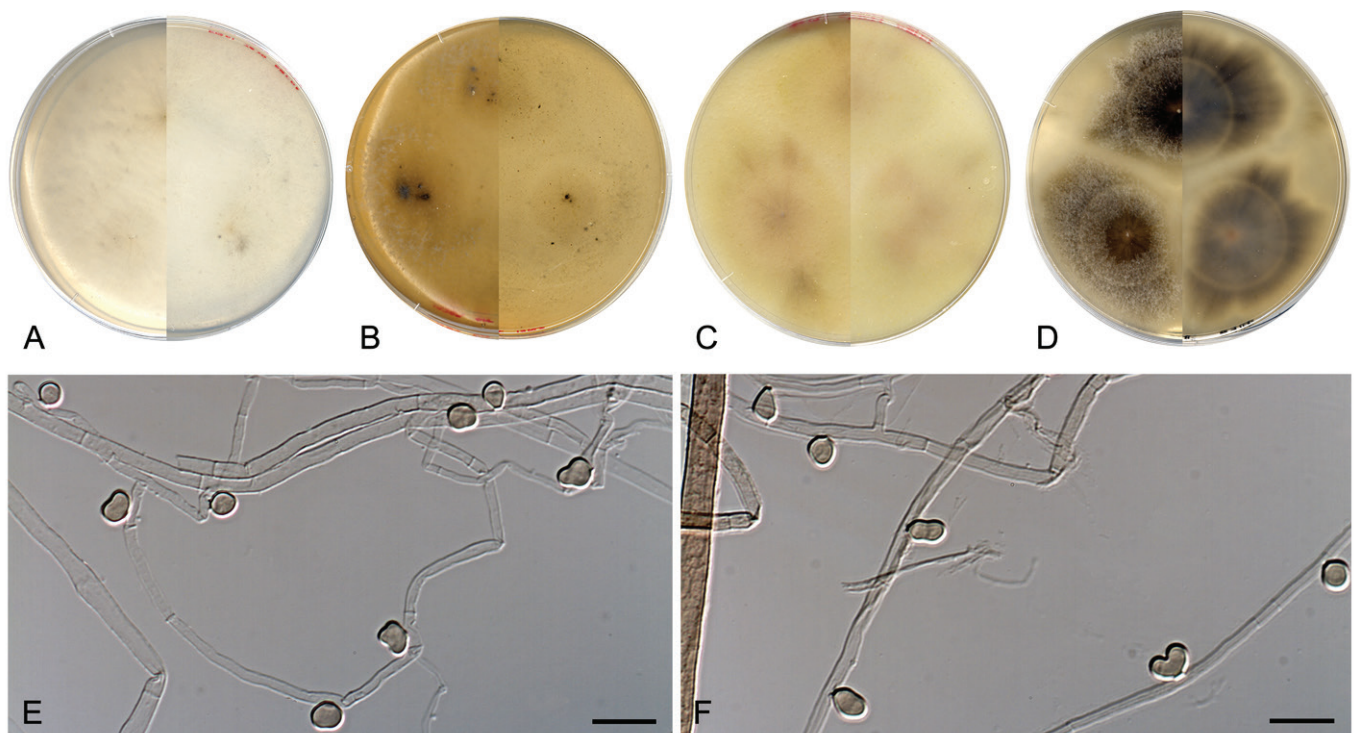


Fig. 3. *Canariomyces asexualis* CBS 149966. A–D. Colonies on PCA, OA, CMA, MEA (4-wk-old; 25 °C; surface, left; reverse, right). E, F. Conidia sessile, 1-celled, solitary and widely variable in shape. Scale bars = 10 µm.

soils as the case of *B. pseudomurorum* (Wang *et al.* 2016a, https://wi.knaw.nl/fungal_table, accessed on 21 February 2024). Like *B. murorum*, *B. piluliferum*, *B. spirotrichum* and *B. verrucosum*, which are mesophiles and have an optimal growing temperature of 20–30 °C (Corda 1837, Pugh *et al.* 1964, Domsch *et al.* 1980, von Arx 1985, Asgari & Zare 2011), *B. pseudomurorum* exhibit a rapid growth between 5 and 35 °C. However, *B. verrucosum* shows slow growing at 37 °C, indicating a less thermotolerance than the former species (Pugh *et al.* 1964). Since *B. pseudomurorum* was isolated using the ToKaVa technique, suggesting the ability to use the keratin as source of nutrients by enzymatic digestion, further tests are required to confirm this assumption.

Canariomyces asexualis Sastoque, Stchigel & Cano, *sp. nov.* MycoBank MB 847933. Fig. 3.

Etymology: From Latin *a-*, without, *-sexus-*, sex, and *-alis*, quality of, because the fungus lacks of sexual reproduction.

Typus: **Spain**, Canary Islands, La Palma, Fuencaliente (Los Canarios), from soil of Teneguía volcano, 15 Jul. 2008, coll. M. Caldusch & A.M. Stchigel, isol. A.P. Sastoque (**holotype** CBS H-25249, culture ex-type FMR 19389 = CBS 149966).

On oatmeal agar after 4 wk at 25 °C: *Mycelium* abundant, mostly aerial, septate, branching, smooth- and thin-walled hyphae when hyaline to subhyaline but granulose when pigmented, 1–4.5 µm wide, often coiled. *Conidiogenous cells* integrated to the hyphae, monoblastic, producing sessile conidia. *Conidia* 1-celled, solitary, arising laterally on the hyphae, subhyaline to olivaceous brown, smooth- and thin-walled, obovoid, pyriform, broadly fusiform, subglobose, ellipsoidal, clavate or heart-shaped, 3–6 × 2.5–4 µm (Fig. 3E, F). *Sexual morph* not observed.

Culture characteristics (after 7 d at 25 °C): Colonies on PCA 35–36 mm diam., flat and circular; margin filamentous; surface natural (4B3) without aerial hyphae and with grey (3E1) radiate superficial mycelium; soluble pigment absent; reverse beige (4B3) and pale yellow in the centre (4A3). Colonies on OA 39–40 mm diam., flat, circular, and expansive; margin filamentous; surface beige (4B3) to golden (4C6) without aerial mycelium; soluble pigment absent; reverse uncoloured to golden (4C6). Colonies on CMA 22–23 mm diam., flat, circular, and expansive; margin filamentous; surface without aerial mycelium, champagne (4B4) in the central area with radiate soot brown (5F5) superficial mycelium and uncoloured margins; soluble pigment absent; reverse sepia (5E4). Colonies on MEA 34–35 mm diam., flat and circular; margin entire; surface with hair brown (5F2) superficial mycelium radiated, sparse floccose white (5A1) aerial mycelium just in the centre and natural (4B3) margins; soluble pigment absent; reverse like surface. Culture iconography after 4 wk of incubation on PCA, OA, CMA and MEA (Fig. 3A–D, respectively). Minimum, optimum and maximum temperature of growth on PDA after 7 d: 12 °C, 35 °C and 40 °C, respectively.

Notes: *Canariomyces asexualis* was placed in a fully supported terminal clade together with *Canariomyces microsporus* CBS 276.74 and CBS 161.80, but in a separate

branch as a distinct species (Fig. 1). *Canariomyces asexualis* lacks a sexual morph and differs morphologically from *Canariomyces microsporus* in the size and shape of conidia (*Can. microsporus* produces obovoid to clavate conidia, measuring 4–10.5 × 2–3.5 µm, whereas *Can. asexualis* forms obovoid, pyriform, broadly fusiform, subglobose, ellipsoidal, clavate, or heart-shaped conidia, measuring 3–6 × 2.5–4 µm) (Mouchacca 1973, Wang *et al.* 2019a).

Carteria canariensis Sastoque, Cano & Stchigel, *sp. nov.* MycoBank MB 847723. Fig. 4.

Etymology: The epithet *canariensis* refers to the Canary Islands, due to the geographic origin of the fungus.

Typus: **Spain**, Canary Islands, La Palma, Fuencaliente (Los Canarios), from soil of Teneguía volcano, 15 Jul. 2008, coll. M. Caldusch & A.M. Stchigel, isol. A.P. Sastoque (**holotype** CBS H-25242, culture ex-type FMR 18819 = CBS 149955).

On oatmeal agar after 4 wk at 25 °C: *Mycelium* scarce, mostly aerial, composed of septate, branching, smooth- and thin-walled, subhyaline to reddish brown, 1–2 µm wide hyphae. *Ascomata* superficial, solitary to aggregated, often covered by aerial mycelium, non-ostiolate, dark brown in reflected light, spherical or subspherical, rarely oblate, 29–65 µm diam. (Fig. 4E, F); *peridial wall* thin, one-layered, brown to reddish-brown, semi-translucent, of textura epidermoidea (Fig. 4G). *Asci* 8-spored, subglobose, ellipsoidal, or obovate, 10–16 × 10–15 µm, without visible stalks, soon evanescent (Fig. 4H). *Ascospores* irregularly-arranged within the asci, 1-celled, dark brown when mature, smooth- and thin-walled, ellipsoidal, (7–)8–9(–10) × (4–)4.5–5(–5.5) µm, attenuated at both ends, occasionally flattened at one side, with a subapical germ pore (Fig. 4I). *Asexual morph* not observed.

Culture characteristics (after 7 d at 25 °C): Colonies on PCA 8–9 mm diam., circular, flat; margin entire and regular; surface grey (28D1) to greyish green (28F4), with velvety white (5A1) aerial mycelium in the central area, and natural (4B3) colour at the margins; soluble pigment absent; reverse grey (28D1) to greenish grey (28F2), with yellowish white margins (4A2). Colonies on OA 6–7 mm diam., flat, circular; margins entire and regular; surface brownish grey (5C2) and black (6F3) at the centre; soluble pigment absent; reverse uncoloured. Colonies on CMA 6–7 mm diam., flat, circular; margins entire and regular; surface black (6F3) at the centre, surrounded by olive brown (4E4) halo, with yellowish white (3A2) margins; soluble pigment absent; reverse greyish brown (5F3) coloured. Colonies on MEA 11–12 mm diam., flat and circular; margin entire and regular; surface brownish grey (5F2) with scarce dust (5D2) aerial mycelium, surrounded by a grey (5F1) circle and with cream (4A3) margins; soluble pigment present, yellowish; reverse dark grey (1F1) at the centre, surrounded by a sepia (4F4) halo, with yellowish white (4A2) margins. Culture iconography after 4 wk of incubation on PCA, OA, CMA and MEA (Fig. 4A–D, respectively). Minimum, optimum and maximum temperature of growth on PDA after 7 d: 12 °C, 25 °C and 35 °C, respectively.

Notes: *Carteria canariensis* formed a well-supported terminal branch (0.99 PP/82 % BS) as a different species



in the monospecific clade of *Carteria* (Fig. 1), differing from *C. arctostaphyli* by the production of shorter asci (10–16 × 10–15 µm vs 14–18.5 × 11.5–16 µm in *C. arctostaphyli*), ascospores with a typical subapical germ pore (terminal in *C. arctostaphyli*), and the production of a yellowish soluble pigment on MEA (not reported for *C. arctostaphyli*) (Wang *et al.* 2019a).

Oidiosporium Sastoque, Cano & Stchigel, **gen. nov.** MycoBank MB 850913.

Etymology: From Latin *ovum*-, egg, *-idium*-, a diminutive suffix, and *-sporium*, spore, because the fungus produces thallic conidia similar to those of the order *Erysiphales* (= oidia).

Type species: *Oidiosporium botulisporum* Sastoque, Cano & Stchigel

Mycelium abundant, composed of hyaline to brown or reddish-brown, septate, branched, smooth- and thin- to moderately thick-walled hyphae when pigmented, often coiled. **Conidiophores** absent. **Conidia** holothallic, aseptate, hyaline or brown to reddish-brown, smooth- and thin-walled

to moderately thick-walled, guttulate, subglobose, ellipsoidal, broadly fusiform, barrel-shaped or sausage-shaped, flattened at both ends but without visible scars, formed by remodelling of pre-existing hyphae sections, secession schizolytic, produced in short to long chains.

Oidiosporium botulisporum Sastoque Cano & Stchigel, **sp. nov.** MycoBank MB 847921. Fig. 5.

Etymology: From Latin *botulus*-, sausage, and *-spora*, spore, because the shape of the thallic conidia.

Typus: **Spain**, Canary Islands, La Palma, Fuencaliente (Los Canarios), isolated from soil of Teneguía volcano, 15 Jul. 2008, coll. *M. Caldach* & *A.M. Stchigel*, isol. *A.P. Sastoque* (**holotype** CBS H-24247, culture ex-type FMR 18828 = CBS 149964).

On oatmeal agar after 4 wk at 25 °C: **Mycelium** abundant, composed of hyaline to brown or reddish-brown, septate, branched, smooth- and thin- to moderately thick-walled hyphae when pigmented, 1–4.5 µm wide, often coiled (Fig. 5F). **Conidiophores** absent. **Conidia** holothallic, aseptate, hyaline or brown to reddish-brown, smooth- and thin-walled

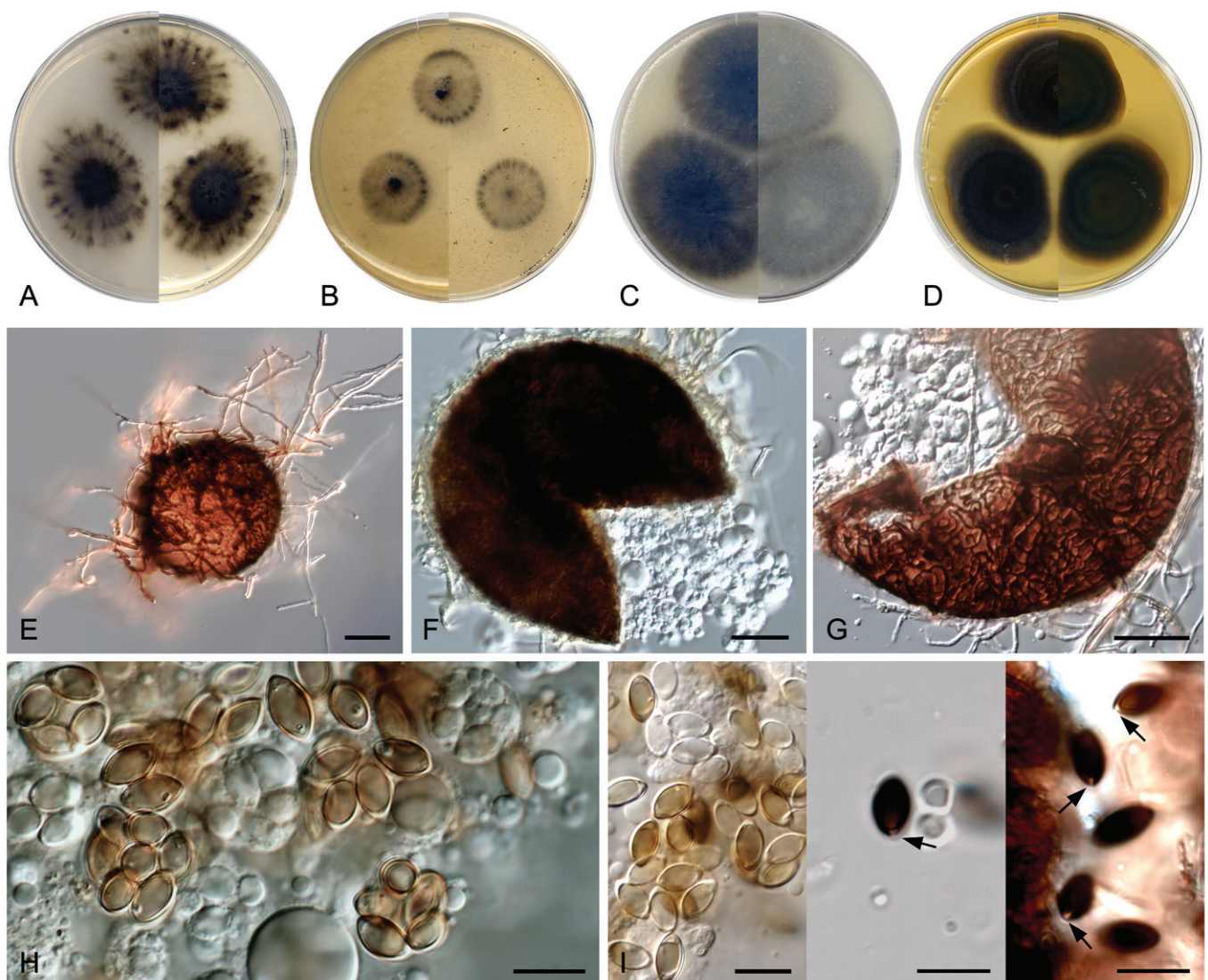


Fig. 4. *Carteria canariensis* CBS 149955. **A–D.** Colony on PCA, OA, CMA, MEA (4-wk-old; 25 °C; surface, left; reverse, right). **E, F.** Non-ostiolate ascomata. **G.** Peridium with *textura epidermoidea*. **H.** Asci and ascospores. **I.** Young and mature ascospores with a subapical germ pore (black arrows). Scale bars: E–G = 25 µm; H, I = 10 µm.

Table 1. Geographical origin and source of the fungal strains, and the accession numbers of the loci used for building the phylogenetic trees. The nucleotide sequences generated during the development of this work are in **bold**. New species and combinations are indicated in **bold**.

Taxon	Strains ¹	Geographic origin	Source	GenBank accession numbers					Reference
				ITS	LSU	<i>rpb2</i>	<i>tub2</i>	<i>tef</i>	
<i>Achaetomium aegilopsis</i>	IRAN 3453C ^T	Iran	Seed of <i>Aegilops triuncialis</i>	NR_172742	MT568844	—	MT568852	—	Mehrabi <i>et al.</i> (2020)
	FMR 19009	Spain	Soil of Teneguía volcano	OZ016249	OZ016250	OZ016283	OZ016284	—	This study
	FMR 18802	Spain	Soil of San Antonio volcano	OZ016251	OZ016252	OZ016285	OZ016286	—	This study
<i>Achaetomium globosum</i>	CBS 332.67 ^T	India	<i>Tamarindus indica</i> , rhizosphere	NR_157458	MH870682	KM655441	KX976911	—	Wang <i>et al.</i> (2016a)
<i>Achaetomium luteum</i>	CBS 544.83	Pakistan	<i>Rosa</i> sp., stem	KX976572	KX976697	KX976795	KX976913	—	Wang <i>et al.</i> (2016a)
<i>Achaetomium macrosporum</i>	CBS 152.97	India	Leaf litter	KX976573	KX976698	KX976796	KX976914	—	Wang <i>et al.</i> (2016a)
<i>Achaetomium strumarium</i>	CBS 333.67 ^T	India	Soil	NR_144811	NG_056954	KC503254	AY681238	—	Cai <i>et al.</i> (2006)
<i>Arxotrichum deceptivum</i>	CBS 346.73 ^T	USA	Dung of pack rat	MK919276	MK919276	MK919332	MK919390	—	Wang <i>et al.</i> (2022)
<i>Arxotrichum gangligerum</i>	CBS 130.85	Canada	Dung of rabbit	MK919278	MK919278	MK919334	MK919392	—	Wang <i>et al.</i> (2022)
	CBS 160.52 ^T	USA	Wood sample	MH856977	MH868498	MK919333	MK919391	—	Wang <i>et al.</i> (2022)
<i>Botryotrichum atrogriseum</i>	CBS 130.28 ^T	The Netherlands	Dung of rabbit	NR_147666	KX976714	KX976813	KX976931	—	Wang <i>et al.</i> (2016a)
<i>Botryotrichum murorum</i>	CBS 163.52	USA	Unknown	KX976591	KX976716	KX976815	KX976933	—	Wang <i>et al.</i> (2016a)
<i>Botryotrichum peruvianum</i>	CBS 421.93	Cuba	Air	KX976596	KX976721	KX976820	KX976938	—	Wang <i>et al.</i> (2016a)
<i>Botryotrichum piluliferum</i>	CBS 105.14	Unknown	Unknown	KX976598	KX976723	KX976822	KX976940	—	Wang <i>et al.</i> (2016a)
<i>Botryotrichum pseudomurorum</i>	CBS 149965 ^T (FMR 19917)	Spain	Soil of Fuencaliente lighthouse	OZ001674	OZ001675	OZ001714	OZ00171	—	This study
<i>Botryotrichum spirotrichum</i>	CBS 211.55 ^T	USA	Dung of deer	NR_147667	NG_067362	KX976825	KX976943	—	Wang <i>et al.</i> (2016a)
<i>Botryotrichum verrucosum</i>	CBS 116.64 ^T	UK	Salt-marsh soil, mature dunes	NR_168165	LT993567	LT993486	LT993648	—	Wang <i>et al.</i> (2019b)
<i>Canariomyces arenarius</i>	CBS 507.74 ^T	Egypt	Desert soil	NR_103575	KM655383	KM655438	MK926898	MN078433	Wang <i>et al.</i> (2019a)
	FMR 18787	Spain	Soil of Teneguía volcano	OZ016253	OZ016254	OZ016287	OZ016288	OZ016289	This study
	FMR 19065	Spain	Soil of Teneguía volcano	OZ016255	OZ016256	OZ016290	OZ016291	OZ016292	This study
	FMR 18817	Spain	Soil of Fuencaliente lighthouse	OZ016257	OZ016258	OZ016293	OZ016294	OZ016295	This study
<i>Canariomyces asexualis</i>	CBS 149966 ^T (FMR 19389)	Spain	Soil of Teneguía volcano	OZ001676	OZ001677	OZ001716	OZ001717	OZ001718	This study
<i>Canariomyces microsporus</i>	CBS 276.74 ^T	Egypt	Desert soil	NR_165201	NG_067407	MK876760	JN709484	MN078437	Wang <i>et al.</i> (2019a)
	CBS 161.80	Japan	<i>Thymus</i> sp., leaf	MK926800	MK926800	MK876761	MK926900	—	Wang <i>et al.</i> (2019a)
<i>Canariomyces notabilis</i>	CBS 548.83 ^T	Spain	<i>Phoenix canariensis</i> , litter	NR_165232	NG_069797	MK876763	MK926902	MN078432	Wang <i>et al.</i> (2019a)
	CBS 508.74	Egypt	Desert soil	MK926803	KM655384	KM655439	MK926903	MN078431	Wang <i>et al.</i> (2019a)

Table 1. (Continued).

Taxon	Strains1	Geographic origin	Source	GenBank accession numbers					Reference
				ITS	LSU	rpb2	tub2	tef	
<i>Canariomyces subthermophilus</i>	CBS 509.74 ^T	Egypt	Desert soil	NR_145164	NG_069765	MK876764	MK926904	MN078436	Wang et al. (2019a)
<i>Canariomyces vonarxii</i>	CBS 160.80 ^T	Sudan	<i>Hibiscus</i> sp., dried flower	MK926805	MK926805	MK876765	MK926905	MN078435	Wang et al. (2019a)
<i>Carteria arctostaphyli</i>	CBS 251.85	Nigeria	Unknown	MK926806	MK926806	MK876766	MK926906	MN078434	Wang et al. (2019a)
	CBS 229.82 ^T	Switzerland	<i>Arctostaphylos uva-ursi</i>	MF952433	MK926807	MK876767	MK926907	—	Wang et al. (2019a)
	FMR 18803	Spain	Soil of Teneguia volcano	OZ016271	OZ016272	OZ016234	OZ016235	—	This study
<i>Carteria canariensis</i>	FMR 19237	Spain	Soil of Teneguia volcano	OZ016273	OZ016274	OZ016236	OZ016237	—	This study
	CBS 149955 ^T (FMR 18819)	Spain	Soil of Teneguia volcano	OZ001678	OZ001679	OZ001719	OZ001720	—	This study
<i>Chaetomium citrinum</i>	CBS 693.82 ^T	Japan	Rice-field soil	NR_144863	NG_069789	KT214691	KT214764	—	Wang et al. (2019b)
<i>Chaetomium cochliodes</i>	CBS 155.52 ^T	Unknown	Dung of animal	NR_151835	NG_069672	KF001811	KC109772	—	Wang et al. (2016b)
<i>Chaetomium cucurmericola</i>	CBS 378.71 ^T	Turkey	Unknown	NR_144858	KT214610	KT214680	KT214756	—	Wang et al. (2016b)
<i>Chaetomium globosum</i>	CBS 160.62 ^{NT}	Germany	Compost	NR_144851	NG_069699	KT214666	KT214742	—	Wang et al. (2016b)
<i>Chaetomium pilosum</i>	CBS 335.67 ^T	Australia	Grain of <i>Triticum aestivum</i>	NR_144862	NG_069734	FJ666387	KT214763	—	Wang et al. (2016b)
<i>Chaetomium rectangulare</i>	CBS 126778 ^T	Iran	Leaf of <i>Hordeum vulgare</i>	MH864225	HM365239	KT214688	HM365285	—	Wang et al. (2016b)
<i>Chaetomium spirochaete</i>	CBS 730.84 ^T	USA	Unknown	NR_144823	NG_069804	KF001819	JN256191	—	Wang et al. (2016b)
<i>Chaetomium telluricola</i>	CBS 151.59 ^T	UK	Soil	NR_144859	KT214613	KT214685	KT214759	—	Wang et al. (2016b)
<i>Corynascus fumimontanus</i>	CBS 137294 ^T	USA	Forest soil	LK932694	LK932706	MK919347	MK919405	—	Wang et al. (2016b)
<i>Corynascus sexualis</i>	CBS 827.96	India	Soil	MK919295	MK919295	MK919352	MK919409	—	Wang et al. (2022)
<i>Corynascus verrucosus</i>	CBS 137791	USA	Soil	LK932699	LK932704	LK932732	—	—	(Marin-Felix et al. 2015)
<i>Humicola fuscoatra</i>	CBS 135878	USA	Soil	LK932695	LK932705	MK919354	MK919411	—	Wang et al. (2022)
	CBS 118.14 ^T	Norway	Soil	NR_163527	MH866152	KX976882	KX977017	—	Wang et al. (2016a)
	CBS 157.55 ^T	Norway	Filter paper in soil	MH857425	KM655364	KM655399	LT993663	—	Wang et al. (2019b)
<i>Neurospora tetraspora</i>	CBS 178.33 ^T	Canada	<i>Lagopus</i> sp., dung	NR_077163	NG_068996	DQ470932	AY681212	—	(Cai et al. 2006)
<i>Oidiosporium botulisporum</i>	CBS 149964 ^T (FMR 18828)	Spain	Soil of Teneguia volcano	OZ014599	OZ014600	OZ016228	OZ016229	—	This study
<i>Ovatospora brasiliensis</i>	CBS 140.50	India	Moist jute cloth	KX976683	KX976781	KX976896	KX977031	—	Wang et al. (2016a)
<i>Ovatospora medusarum</i>	CBS 148.67 ^T	Zaire	Soil	KX976684	KX976782	KX976897	KX977032	—	Wang et al. (2016a)
<i>Ovatospora mollicella</i>	CBS 583.83 ^T	USA	Dung of spotted skunk	KX976685	KX976783	KX976898	KX977033	—	Wang et al. (2016a)
<i>Ovatospora pseudomollicella</i>	CBS 251.75 ^T	India	Air	NR_147680	KX976784	KX976899	KX977034	—	Wang et al. (2016a)

Table 1. (Continued).

Taxon	Strains1	Geographic origin	Source	GenBank accession numbers					Reference
				ITS	LSU	rpb2	tub2	tef	
<i>Ovatospora senegalensis</i>	CBS 798.83	Israel	Dung of gazelle	KX976688	KX976786	KX976901	KX977036	—	Wang <i>et al.</i> (2016a)
	CBS 728.84 ^T	Senegal	Plant remains	NR_147681	KX976785	KX976900	KX977035	—	Wang <i>et al.</i> (2016a)
	FMR 18788	Spain	Soil of Fuencaliente lighthouse	OZ016265	OZ016266	OZ016263	OZ01626	—	This study
	FMR 19005	Spain	Soil of Teneguía volcano	OZ001680	OZ001681	OZ001721	OZ001722	—	This study
<i>Ovatospora unipora</i>	CBS 109.83 ^T	Egypt	Soil	NR_147682	NG_069274	KX976902	KX977037	—	Wang <i>et al.</i> (2016a)
<i>Parachaetomium biporatum</i>	CBS 244.86 ^T	Spain	Soil	MK919303	MK919303	MK919360	MK919417	—	Wang <i>et al.</i> (2022)
<i>Parachaetomium carinthiacum</i>	CBS 665.82	Japan	<i>Thymus</i> sp.	MH861536	MK919299	MK919356	MK919413	—	Wang <i>et al.</i> (2022)
<i>Parachaetomium inaequale</i>	CBS 331.75 ^T	Ukraine	Soil	NR_178150	MK919306	MK919363	MK919420	—	Wang <i>et al.</i> (2022)
<i>Parachaetomium longiciliatum</i>	CGMCC 3.17554 ^T	China	Soil	NR_157442	KP336823	KT149497	KP336872	—	Zhang <i>et al.</i> (2017)
<i>Parachaetomium mareoticum</i>	CBS 781.71	Israel	Dung of gazelle	MH860352	—	MZ342993	MZ343032	—	Wang <i>et al.</i> (2022)
	CBS 802.83	Israel	Dung	MZ334723	JX280715	MZ342997	MZ343036	—	Wang <i>et al.</i> (2022)
<i>Parachaetomium muelleri</i>	CBS 663.75	Turkey	Unknown	MK919301	MK919301	MK919358	MK919415	—	Wang <i>et al.</i> (2022)
	CBS 192.84 ^T	Pakistan	Decayed twig	MK919300	MK919300	MK919357	MK919414	—	Wang <i>et al.</i> (2022)
<i>Parachaetomium subspirilliferum</i>	CBS 150.60 ^T	Russia	Soil	NR_156254	NG_067367	MK919369	MK919426	—	Wang <i>et al.</i> (2022)
<i>Parathielavia appendiculata</i>	CBS 723.68 ^T	India	Leaf of <i>Punica granatum</i>	NR_165588	MK926827	MK876788	MK926927	—	Wang <i>et al.</i> (2019a)
<i>Parathielavia hyrcaniae</i>	CBS 353.62 ^T	Iran	Sand dune soil	NR_145189	MH869771	KX976908	KX977043	—	Wang <i>et al.</i> (2016a)
<i>Parathielavia kuwaitensis</i>	CBS 119771	China	Soil	MK926829	MK926829	MK876790	MK926929	—	Wang <i>et al.</i> (2019a)
	CBS 945.72 ^T	Kuwait	Desert soil	NR_166001	NG_067400	KX976909	KX977044	—	Wang <i>et al.</i> (2016a)
	FMR 18826	Spain	Soil of Teneguía volcano	OZ016259	OZ016260	OZ016296	OZ016297	—	This study
<i>Phaeohyphomyces canariensis</i>	FMR 18818	Spain	Soil of Teneguía volcano	OZ016261	OZ016262	OZ016298	OZ016299	—	This study
	CBS 151045 ^T (FMR 19391)	Spain	Soil of Fuencaliente lighthouse	OZ026876	OZ026877	OZ026880	OZ026881	—	This study
<i>Pseudohymenochaeta alba</i>	FMR 19094	Spain	Soil of Teneguía volcano	OZ016277	OZ016278	OZ016240	OZ016241	—	This study
	COAD 3126 ^T	Brazil	Air from a cave	ON989662	ON979681	ON995382	ON988189	—	Oliveira Condé <i>et al.</i> (2023)
<i>Pseudohymenochaeta atrobrunnea</i>	CBS 114167 ^T	China	Garden soil	LT993570	LT993570	LT993489	LT993651	—	Wang <i>et al.</i> (2019b)
<i>Pseudohymenochaeta cinnamobrunnea</i>	CBS 150900 ^T (FMR 18980)	Spain	Soil of Teneguía volcano	OZ016267	OZ016268	OZ016230	OZ016231	—	This study



Table 1. (Continued).

Taxon	Strains1	Geographic origin	Source	GenBank accession numbers					Reference
				ITS	LSU	rpb2	tub2	tef	
<i>Pseudohumicola debertoldii</i>	CBS 460.76 ^T (FMR 20616)	Italy	Quercus forest soil	MH860994	MH872765	OZ016246	MH444288	—	Wang <i>et al.</i> (2019b)
<i>Pseudohumicola glauca</i>	CBS 462.76 ^T (FMR 19938)	Italy	Soil nematode-infested	MH444273	OZ016244	OZ016245	MH444286	—	Wang <i>et al.</i> (2019b)
<i>Pseudohumicola</i> <i>intercalispora</i>	FMR 18982	Spain	Soil of Teneguía volcano	OZ016279	OZ016280	OZ016242	OZ016243	—	This study
<i>Pseudohumicola lutea</i>	CBS 149962 ^T (FMR 19235)	Spain	Soil of Teneguía volcano	OZ001682	OZ001683	OZ001723	OZ001724	—	This study
	COAD 3127 ^T	Brazil	Air from a cave	ON989663	ON979682	ON995383	ON988190	—	Oliveira Condé <i>et al.</i> (2023)
<i>Pseudohumicola pulvericola</i>	CBS 144165 ^T	Mexico	Dust	LT993592	LT993592	LT993511	LT993673	—	Wang <i>et al.</i> (2019b)
<i>Pseudohumicola semispiralis</i>	CBS 723.97 ^T	Unknown	Filter paper	LT993597	MH874274	LT993516	LT993678	—	Wang <i>et al.</i> (2019b)
<i>Pseudohumicola subspiralis</i>	CBS 148.58	China	Leaf fragments in soil	LT993599	LT993599	LT993518	LT993680	—	Wang <i>et al.</i> (2019b)
<i>Pseudohumicola variispora</i>	CBS 149960 ^T (FMR 18822)	Spain	Soil of Teneguía volcano	OZ001684	OZ001685	OZ001725	OZ001726	—	This study
<i>Pseudothielavia arxii</i>	CBS 603.97 ^T	Chile	Soil	NR_165589	MK926830	MK876791	MK926930	—	Wang <i>et al.</i> (2019a)
<i>Sordaria equicola</i>	CBS 146992 ^T	Namibia	<i>Equus zebra hartmannae</i> , dung	NR_173047	MZ064492	MZ078202	MZ078267	—	Crous <i>et al.</i> (2021)
<i>Steirochaetomium canariensis</i>	CBS 150903 ^T (FMR 19096)	Spain	Soil of Teneguía volcano	OZ016269	OZ016270	OZ016232	OZ016233	—	This study
<i>Thermocarpiscus australiensis</i>	FMR 19392	Spain	Soil of Teneguía volcano	OZ016247	OZ016248	OZ016281	OZ016282	—	This study
	CBS 493.74 ^T	Australia	<i>Leipoa ocellata</i> , nesting material	AJ271590	KM655378	KM655419	MZ343024	—	Wang <i>et al.</i> (2022)
<i>Trichocladium arxii</i>	CBS 104.79 ^T	USA	Dung of kangaroo-rat	MH861178	MH872947	KM655420	LT993712	—	Wang <i>et al.</i> (2019b)

¹CBS, Westerdijk Fungal Biodiversity Institute, fungal and yeast collection (Utrecht, The Netherlands). CGMCC, China General Microbiological Culture Collection Centre (Beijing, China). COAD, Coleção Octávio Almeida Drummond, Universidade Federal de Viçosa (Viçosa, Brazil). FMR, Faculty of Medicine-Reus culture collection (Reus, Spain). IRAN...C, Iranian Fungal Culture Collection, Iranian Research Institute of Plant Protection (Tehran, Iran). T Ex-type strain. NT Ex-neotype strain.

to moderately thick-walled, guttulate, subglobose, ellipsoidal, broadly fusiform, barrel-shaped or sausage-shaped, $8\text{--}23 \times 4\text{--}8 \mu\text{m}$, flattened at both ends but without visible scars, formed by remodelling of pre-existing hyphae sections, secession schizolytic (Fig. 5G), produced in short to long chains (Fig. 5F–H).

Culture characteristics (after 7 d at 25 °C): Colonies on PCA 11–13 mm diam., flat and circular; margin filamentous and regular; surface sand (4B3) with a thin layer of greyish brown (6F3) aerial hyphae in the central area and yellowish white (4A2) margins; soluble pigment absent; reverse pale yellow (4A3) and light yellow in the centre (4A4). Colonies on OA 27–28 mm diam., flat and circular; margin filamentous and regular; surface champagne (4B4) with sparse dark grey (6F3), radiated and superficial mycelium and pale yellow (4A3) margins; soluble pigment violet brown (10F6) after 10 wk (Fig. 6E); reverse like surface. Colonies on CMA 13–14 mm diam., flat and circular; margin filamentous and regular; surface black (6F3) with sparse brownish grey (6F2) aerial mycelium and olive green (2F6) margins; soluble pigment absent; reverse greyish brown (5F3). Colonies on MEA 15–16 mm diam., flat and circular; margin filamentous and regular; surface with a thin layer of pearl white (3B1) and short aerial mycelium; reverse with olive grey (2F2) margins. Culture iconography after 4 wk of incubation on PCA, OA, CMA and MEA (Fig. 5A–D, respectively). Minimum, optimum and maximum temperature of growth on PDA after 7 d: 15 °C, 25 °C and 37 °C, respectively.

Notes: *Oidiosporium botulisporum* was placed in a fully supported clade close to the type species of the genera *Carteria* and *Thermocarpiscus*, but as a distinct genus (Fig. 1). The new genus differs from the latter two by producing an asexual morph consisting of chains of holothallic conidia,

whereas *C. arctostaphyli* and *T. australiensis* lack asexual morphs (Wang *et al.* 2019a, 2022).

Phaeophyphomyces Sastoque, Stchigel & Cano, **gen. nov.** MycoBank MB 850891.

Etymology: From Greek *φαίο-*, dun-coloured, *-υφές-*, hyphae, and *-μύκης*, fungus, because the fungus produces brown verrucose hyphae as the sole remarkable morphological feature.

Type species: *Phaeophyphomyces canariensis* Sastoque, Stchigel & Cano

Colonies remaining sterile. Mycelium abundant, consisting in septate, branched, smooth-walled to verrucose or tuberculate, thin- to thick-walled, hyaline to reddish brown hyphae, whose cells swelling with the age.

Phaeophyphomyces canariensis Sastoque, Stchigel & Cano, **sp. nov.** MycoBank MB 850892. Fig. 6.

Etymology: The epithet *canariensis* refers to the Canary Islands, due to the geographic origin of the fungus.

Typus: **Spain**, Canary Islands, La Palma, Fuencaliente (Los Canarios), from soil near the lighthouse, 15 Jul. 2008, coll. *M. Caldach* & *A.M. Stchigel*, isol. *A.P. Sastoque* (**holotype** CBS H-25348, culture ex-type FMR 19391 = CBS 151045).

On potato dextrose agar after one year at 25 °C: Mycelium abundant composed of septate, hyaline to reddish brown (Fig. 6E), branched, smooth- to verrucose or tuberculate due to the evagination of the cell wall, thin- to thick-walled, $0.5\text{--}1 \mu\text{m}$ wide hyphae, whose cells swollen through age reaching $4\text{--}16$

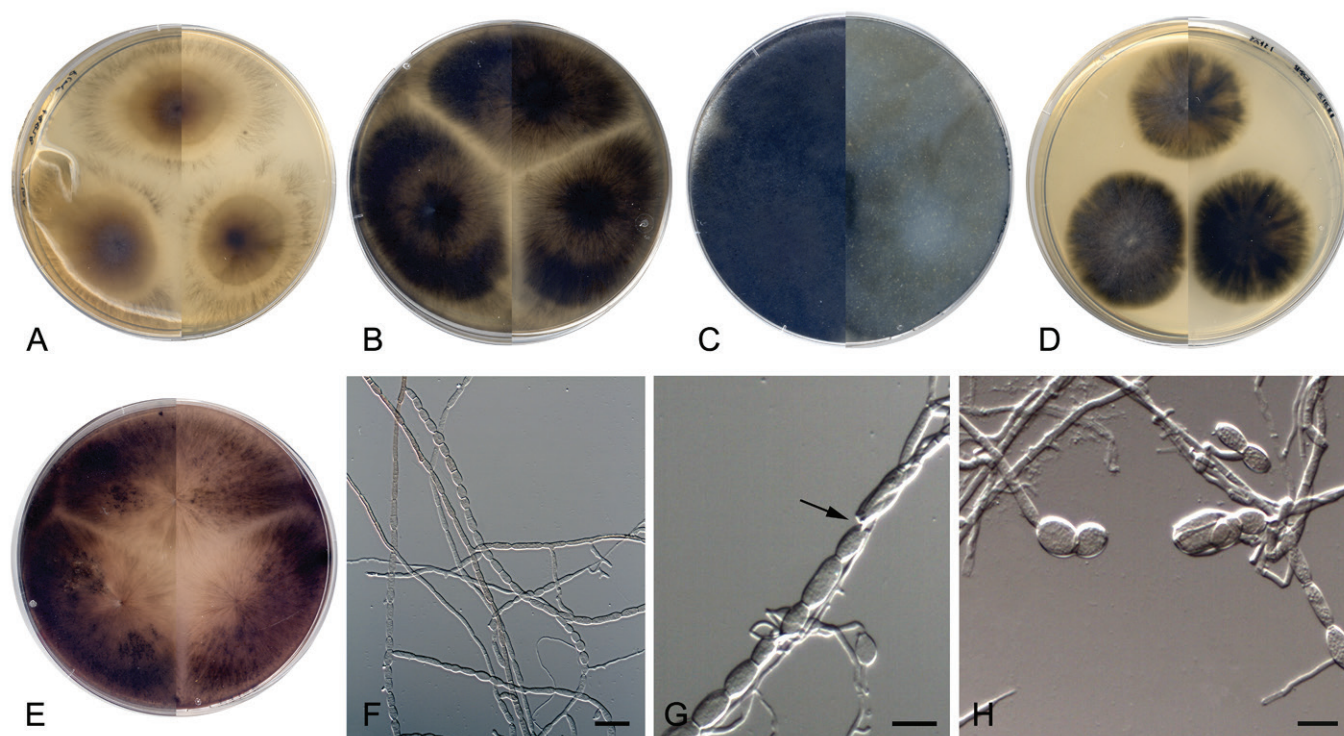


Fig. 5. *Oidiosporium botulisporum* CBS 149964. **A–D.** Colonies on PCA, OA, CMA, MEA (4-wk-old; 25 °C; surface, left; reverse, right). **E.** Colonies on OA with soluble pigment violet-brown after 10 wk. **F.** Chains of holothallic conidia. **G, H.** Disarticulation of conidia with schizolytic secession (black arrow). Scale bars: F = 25 μm , G, H = 10 μm .



µm wide (Fig. 6F). *Phaeophyphomyces canariensis* differs from its closest phylogenetic species, *Thermocarpiscus australiensis*, based on nucleotide sequence alignment of four concatenated loci (deposited in Zenodo, doi: 10.5281/zenodo.10948357), in the deletions on: ITS positions: 116 (C), 117 (C), 118 (A), 119 (T), 120 (C), 121 (G), 180 (A), 209 (T), 426 (G), 439 (G), 459 (T), 473 (A), 496 (C), 497 (A), 517 (G), 552 (T), 553 (G), 554 (A), 555 (A), 556 (G), 582 (T); LSU positions: 667 (A), 663 (A), 679 (A), 685 (A), 688 (A), 1179 (A); *rpb2* position: 2331 (T); *tub2* positions: 2392 (T), 2393 (T), 2394 (T), 2395 (T), 2396 (T), 2397 (C), 2398 (C), 2399 (G), 2400 (T), 2401 (C), 2402 (C), 2403 (A), 2404 (C), 2405 (C), 2451 (T), 2655 (G), 2656 (G), 2667 (G), 2765 (A), 2769 (C), 2770 (G), 2888 (T), 2926 (A), 2991 (C), 2993 (T), 2994 (G).

Culture characteristics (after 7 d at 25 °C): Colonies on PCA reaching 2–2.5 mm diam., flat, circular and restricted; margins filamentous and regular; surface grey (5E3), with a sparse, floccose white (5E1) aerial mycelium, which is absent at the margins; soluble pigment absent; reverse pale grey (1B1). Colonies on OA reaching 1.5–2 mm diam., flat, circular, and restricted; margins filamentous and regular; surface bronze (5E5) coloured with a white (5A1) sparse aerial mycelium; soluble pigment absent; reverse bronze (5E5). Colonies on CMA reaching 2–2.5 mm diam., flat and circular; margins filamentous and regular; surface uncoloured with a floccose white (4A1) aerial mycelium at the centre; soluble pigment absent; reverse uncoloured. Colonies on MEA reaching 3–4 mm diam., flat and circular; margins entire and regular, surface brown (5E4), with a white (5A1) floccose aerial mycelium, which is absent at the margins; soluble pigment absent; reverse dark blonde (5D4). Culture iconography after 4 wk of incubation on PCA, OA, CMA and MEA (Fig. 6A–D, respectively). Minimum, optimum and maximum temperature of growth on PDA after 7 d: 20 °C, 25 °C and 30 °C, respectively.

Notes: *Phaeophyphomyces canariensis* was placed in a fully supported clade close to *T. australiensis*, but as a different genus (Fig. 1). This fungus lacks fertile structures but is molecularly easily distinguishable from the rest of the *Chaetomiaceae* based on the sequences of phylogenetically informative molecular markers. Using the BLAST search tool, the closest hits the *rpb2* sequence was *Arcopilus megasporus* CBS 127650 [GenBank MZ342971; identities = 732/832 (87.98 %), four gaps (0 %)] and *T. australiensis* CBS 493.74 [GenBank KM655419; identities = 751/857 (87.63 %), no gaps]. Using the *tub2* sequence, it was *T. australiensis* CBS 493.74 [GenBank MZ343024; identities = 440/549 (80.15 %), 26 gaps (4 %)].

Pseudohumicola cinnamobrunnea Sastoque, Cano & Stchigel, *sp. nov.* MycoBank MB 847930. Fig. 7.

Etymology: From Latin *cinnamomum*-, cinnamon, *-brunneae*, brown, due to the colour of the conidia.

Typus: **Spain**, Canary Islands, La Palma, Fuencaliente (Los Canarios), isolated from soil of Teneguía volcano, 15 Jul. 2008, coll. M. Caldusch & A.M. Stchigel, isol. A.P. Sastoque (**holotype** CBS H-25248, culture ex-type FMR 18980 = CBS 150900).

On potato carrot agar after 2 wk at 25 °C: Mycelium composed of somatic hyphae hyaline, septate, branched, forming several spirals, smooth- and thin-walled, 1–2 µm wide. *Conidiophores* undifferentiated. *Conidiogenous cells* integrated to the vegetative hypha. *Conidia* holoblastic and 1-celled, solitary or less frequently in chains of two, sessile (Fig. 7E), on short conical denticles or on short (sometimes subglobose or obovoid) side branches from the hyphae (Fig. 7F, G), smooth- and thick-walled, covered by mucilaginous and dark brown substance, becoming verrucose to reticulate

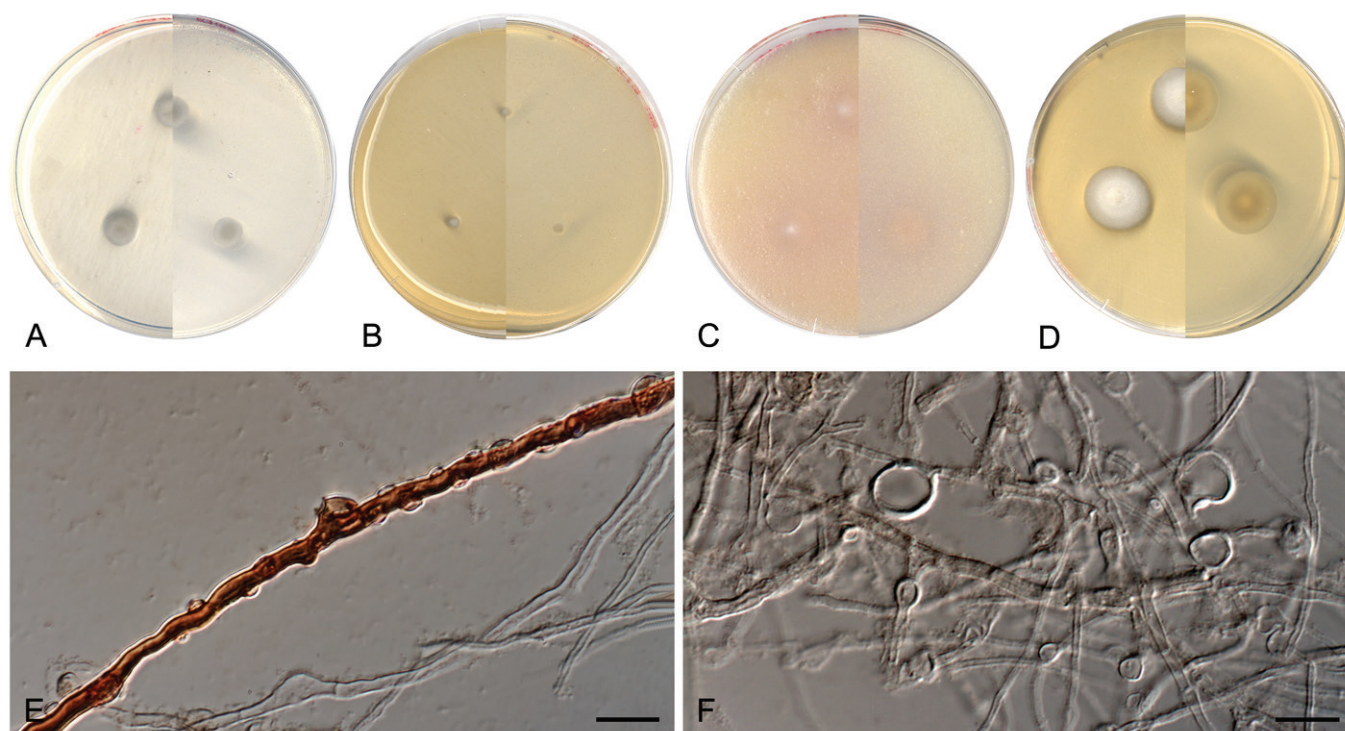


Fig. 6. *Phaeophyphomyces canariensis* CBS 151045. **A–D.** Colonies on PCA, OA, CMA, MEA (4-wk-old; 25 °C; surface, left; reverse, right). **E.** Hyphae smooth- to verrucose, thin-walled, hyaline to reddish-brown. **F.** Hyphae becoming swollen with the age. Scale bars = 10 µm.

when old, sometimes intercalary (holothallic), then 1–2-celled, pale olivaceous brown to brown, globose, subglobose, obovoid, pyriform, less frequently ovoid, obpyriform or ellipsoidal, (4–)7–9(–10) × (5–)8–10(–12) μm (Fig. 7E–G). Acremonium-like *synasexual morph* and *sexual morph* not observed.

Culture characteristics (after 7 d at 25 °C): Colonies on PCA 46–47 mm diam., circular and flat; margin filamentous and regular; surface showing white (4A1) aerial mycelium and grey (5B1) bottom only in the central area, surrounded by a cream (4A3) zone and yellowish white (4A2) margins; soluble pigment absent; reverse yellowish grey (4B2) in the centre, grey (5B1) and yellowish white margins (4A2). Colonies on OA 37–40 mm diam., flat, circular, and expansive; margin filamentous and regular; surface uncoloured with scarce floccose greyish white (4B1) aerial hyphae in the centre; soluble pigment absent; reverse uncoloured. Colonies on CMA 40–45 mm diam., circular and flat; margin filamentous and regular; surface hair brown (5E4) with scarce white (8A1) aerial hyphae in the centre, margins yellowish white (4A2); soluble pigment absent; reverse bronze (5E5). Colonies on MEA 45–46 mm diam., flat and circular; margin filamentous and slightly undulated; surface yellowish grey (4B2) with scarce and floccose white (8A1) aerial hyphae in the centre, surrounded by a pastel red (8A5) halo and pale yellow (4A2) margins; reverse light-yellow (4A4) in the centre, cream (4A3) and pale yellow (4A2) margins. Culture iconography after 2 wk of incubation on PCA, OA, CMA and MEA (Fig. 7A–D, respectively). Minimum, optimum and maximum temperature of growth on PDA after 7 d: 12 °C, 30 °C and 45 °C, respectively.

Notes: *Pseudohumicola cinnamobrunnea* was located as a distinct species in a fully supported terminal clade together

the ex-type strains of *Humicola glauca* CBS 462.76 and *Pseudohumicola semispiralis* CBS 723.97 (0.99 PP/94 % BS; Fig. 1). *Pseudohumicola cinnamobrunnea* differs from *Pseudohumicola semispiralis* by lacking a sexual morph (chaetomium-like in *P. semispiralis*) and by the production pale olivaceous brown to brown sessile to stalked conidia (hyaline to olivaceous sessile conidia in *P. semispiralis*) (Udagawa & Cain 1969, Wang *et al.* 2019b).

Pseudohumicola debertoldii Sastoque, Cano & Stchigel, *nom. nov.* MycoBank MB 853457. Fig. 8.

Replaced synonym: *Humicola lutea* De Bert., *Canad. J. Bot.* **54**: 2759. 1976, non *Pseudohumicola lutea* T.O. Condé *et al.* 2023

Etymology: In honour of Marco de Bertoldi, an Italian mycologist who also isolated this fungus.

Typus: Italy, Sardinia, Sassari, soil from *Quercus* sp. forest, 1969, coll. and isol. *M. de Bertoldi* (**lectotype** designated here CBS H-25748, MBT 10026333, culture ex-type CBS 460.76 = FMR 20616).

On potato carrot agar after 2 wk at 25 °C: Mycelium abundant, composed of hyaline, septate, branched, smooth- and thin-walled, 1–3 μm wide hyphae. *Conidiophores* absent. *Conidiogenous cells* integrated to the hyphae. *Conidia* mostly holoblastic, mostly unicellular, rarely 1-septate, solitary or in clusters, sessile or on short conical denticles or on short side branches, smooth- and thin-walled at first, becoming verruculose and thick-wall with the age, occasionally intercalary (holothallic) (Fig. 8E), sub-hyaline to brown, globose, subglobose, oblate, ellipsoid, obovoid, pyriform, ovoid, fusiform or cylindric, (4–)7–11(–13) × (4–)7–12(–13) μm , mostly truncated at one end, or at both ends (if intercalary),

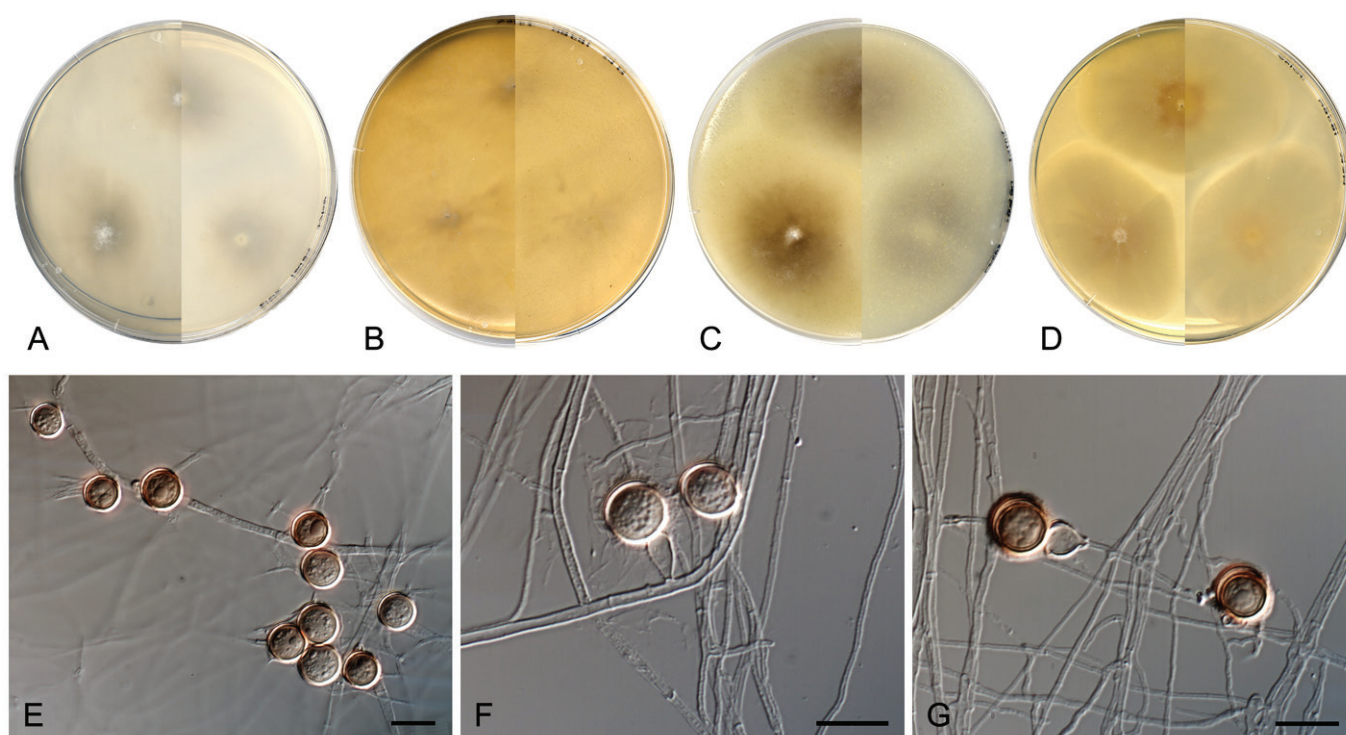


Fig. 7. *Pseudohumicola cinnamobrunnea* CBS 150900. **A–D.** Colonies on PCA, OA, CMA, MEA (2-wk-old; 25 °C; surface, left; reverse, right). **E.** Conidia single cell, aseptate, sessile. **F, G.** Conidia single cell on short subglobose or obovoid side branches from the hyphae. Scale bars = 10 μm .



secession rhexolytic (Fig. 8E). *Acremonium*-like synasexual morph present; *conidiophores* reduced to a *conidiogenous cell*; *conidiogenous cell* phialidic, arising on (discrete) or integrated to (adelophialides) the hyphae, hyaline, simple or 1-branched, flask-shaped (monophialides) or v-shaped (polyphialides) (Fig. 8F), $3\text{--}12 \times 1\text{--}3 \mu\text{m}$, mostly ventricose at the base and with a long neck that tapers progressively towards the apex; *conidia* enteroblastic, hyaline, formed basipetally in chains, unicellular, obovoid, $2\text{--}4 \times 1\text{--}2 \mu\text{m}$, truncated at the base and rounded at the apex (Fig. 8F).

Culture characteristics (after 7 d at 25 °C): Colonies on PCA 28–30 mm diam., flat and circular; margins entire and regular, brown (5F3) at the centre with radiated stripes showing sparse white (5A1) aerial mycelium at the centre; soluble pigment absent; reverse greyish brown (5E3) at the centre, with radiated dark brown (5F3) stripes and margins uncoloured. Colonies on OA 32–33 mm diam., flat, circular, and expansive; margins filamentous and regular; surface uncoloured, with a floccose white (4A1) aerial mycelium at the centre; soluble pigment absent; reverse uncoloured, cream (4B3) at the centre. Colonies on CMA 25–27 mm diam., flat, circular, and expansive; margins entire and regular; surface sepia (4F4), with a scarce white (5A1) floccose mycelium at the centre, and greyish green (30E5) superficial spots, margins uncoloured; soluble pigment absent; reverse dark green (30F5) at the centre. Colonies on MEA 27–28 mm diam., flat and circular; margins entire and regular; surface dark brown (5E4) with a white (5A1) floccose mycelium at the centre, and margins cream (4B3); soluble pigment absent; reverse similar than the surface. Culture iconography after 2 wk of incubation on PCA, OA, CMA and MEA (Fig. 8A–D, respectively). Minimum, optimum and maximum temperature of growth on PDA after 7 d: 5 °C, 30 °C and 40 °C, respectively.

Notes: *Humicola lutea* CBS 460.76 was placed in the same fully supported clade as *P. lutea* COAD 3127, being consequently transferred to the genus *Pseudohumicola* as *P. debertoldii* (Fig. 1). *Pseudohumicola debertoldii* differs from *P. lutea* by the production of unicellular, rarely 1-septate conidia, smooth- and thin-walled at first, becoming verruculose and thick-wall with the age, with intercalary (holothallic) conidia, $(4\text{--})7\text{--}11\text{--}(13) \times (4\text{--})7\text{--}12\text{--}(13) \mu\text{m}$ and the production of an *acremonium*-like synasexual morph, in contrast to *P. lutea*, which produces lateral and terminal, single-cell, thick- but smooth-walled conidia, $(7.5\text{--})10.8\text{--}11.8\text{--}(14.5) \times (7.2\text{--})10.4\text{--}11.2\text{--}(12) \mu\text{m}$ and lacking an *acremonium*-like synasexual morph (Oliveira *et al.* 2023).

Pseudohumicola glauca (De Bert.) Sastoque, Stchigel & Cano, **comb. nov.** MycoBank MB 853458. Fig. 9.

Basionym: *Humicola glauca* De Bert., *Canad. J. Bot.* **54**: 2757. 1976.

Typus: Italy, nematode-infested soil, 1970, coll. and isol. *M. de Bertoldi* (**lectotype** designated here CBS H-7238, MBT 10026348, culture ex-type CBS 462.76 = MUCL 19429 = FMR 19938).

On potato carrot agar after 2 wk at 25 °C: Mycelium composed of hyaline, septate, branched, smooth- and thin-walled, 1–2 μm wide hyphae. *Conidiophores* absent. *Conidiogenous cells* integrated to the hyphae. *Conidia* holoblastic, unicellular, solitary, sessile or on short conical denticles or on short side branches (Fig. 9E), less frequently in short chains or forming few-celled clusters (Fig. 9F), or intercalary (holothallic; Fig. 9F), smooth- and thick-walled, covered by a mucilaginous and dark brown substance, becoming verrucose to reticulate when old, pale olivaceous brown to brown, globose,

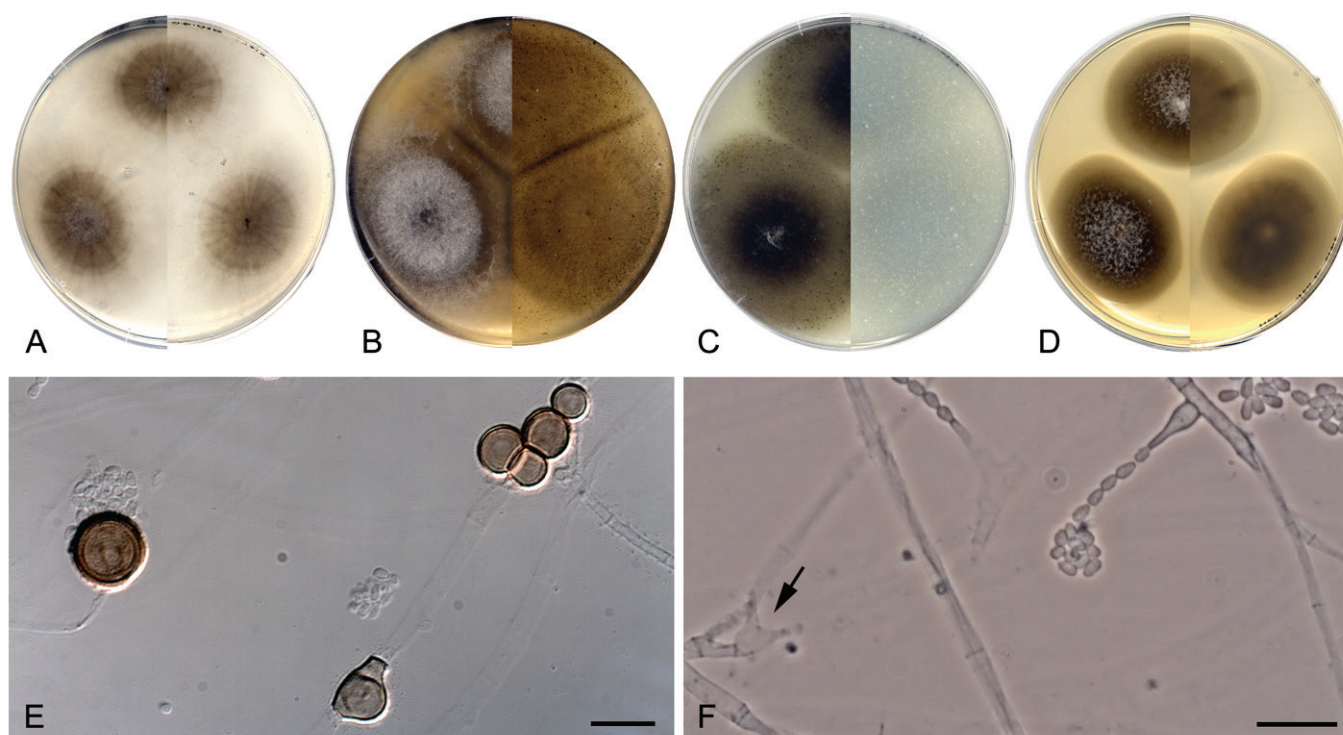


Fig. 8. *Pseudohumicola debertoldii* CBS 460.76. **A–D.** Colony on PCA, OA, CMA, MEA (2-wk-old; 25 °C; surface, left; reverse, right). **E.** Brown, holoblastic, sessile or on short denticles (DIC). **F.** Mono- and poly-phialides (black arrow) and conidia in chains (PC). Scale bars = 10 μm .

subglobose, oblate, ellipsoid, obovoid, piriform, occasionally ovoid or cylindric, (4–)7–8(–9) × (4–)8–10(–15) µm (Fig. 9E, F). Acremonium-like *synasexual morph* and *sexual morph* not observed.

Culture characteristics (after 7 d at 25 °C): Colonies on PCA 30–31 mm diam., flat and circular; margins filamentous and regular; surface chocolate (6F4) at the centre, with a white (6A1) aerial mycelium, margins yellowish white (4A2); soluble pigment absent; reverse dark brown (6F2) at the centre, surrounded by a chocolate (6F4) halo, margins yellowish-white (4A2). Colonies on OA 37–39 mm diam., flat and circular and expansive; margins filamentous and regular; surface dark brown (5F8), with a floccose white (4B1) aerial mycelium at the centre, margins cream (4B3); soluble pigment absent; reverse dark brown (5F8) at the centre, marble-white (5B2) at the margins. Colonies on CMA 31–34 mm diam., flat and circular; margins filamentous and regular; surface dark brown (5F5) at the centre, with a scarce white (5A1) aerial mycelium, margins yellowish white (4A2) to uncoloured; soluble pigment absent; reverse similar in colour than the surface. Colonies on MEA 35–36 mm diam., flat and circular; margins filamentous and regular; surface brown (5E5) with a floccose white (8A1) aerial mycelium at the centre, margins yellowish white (4A2); reverse cream (4A3) but brown (5E4) at the centre. Culture iconography after 2 wk of incubation on PCA, OA, CMA and MEA (Fig. 9A–D, respectively). Minimum, optimum and maximum temperature of growth on PDA after 7 d: 15 °C, 30 °C and 37 °C, respectively.

Additional material examined: **Spain**, Canary Islands, La Palma, Fuencaliente (Los Canarios), isolated from Teneguía volcano soil, 15 Jul. 2008, coll. *M. Caldach & A.M. Stchigel*, isol. *A.P. Sastoque* (culture FMR 18982 = CBS 150904).

Notes: *Humicola glauca* CBS 462.76 was placed close to *P. semispiralis* CBS 723.97 (Fig. 1), and consequently transferred to the genus *Pseudohumicola*. *Pseudohumicola glauca* differs from *Pseudohumicola semispiralis* by lacking a sexual morph and by the size and shape of conidia [globose, subglobose, oblate, ellipsoid, obovoid, piriform, occasionally ovoid or cylindric, (4–)7–8(–9) × (4–)8–10(–15) µm in *P. glauca* vs globose to oblate, sometimes ovoid, (8.5–)9–11 µm diam. in *P. semispiralis*] (Udagawa & Cain 1969, Wang *et al.* 2019b).

Pseudohumicola intercalarispora Sastoque, Stchigel & Cano, **sp. nov.** MycoBank MB 847821. Fig. 10.

Etymology: From Latin *intercalaris*-, intercalary, and *-spora*, spore, due to the presence of holothallic intercalary conidia.

Typus: **Spain**, Canary Islands, La Palma, Fuencaliente (Los Canarios), from soil of Teneguía volcano, 15 Jul. 2008, coll. *M. Caldach & A.M. Stchigel*, isol. *A.P. Sastoque* (**holotype** CBS H-25245, culture ex-type FMR 19235 = CBS 149962).

On potato carrot agar after 2 wk at 25 °C: Mycelium composed of hyaline, septate, branched, smooth- and thin-walled, 1–2.5 µm wide hyphae, often forming spirals (Fig. 10E). *Conidiophores* undifferentiated. *Conidiogenous cells* integrated to the vegetative hypha. *Conidia* mostly holoblastic and 1-celled, solitary or less frequently in chains of two, sessile, on short conical denticles or on short side branches from the hyphae (Fig. 10E,F), smooth- and thick-walled, covered by mucilaginous and dark brown substance, becoming verrucose to reticulate when old (Fig. 10F), sometimes intercalary (holothallic) (Fig. 10F), then 1-celled, pale olivaceous brown to brown with dark brown walls,

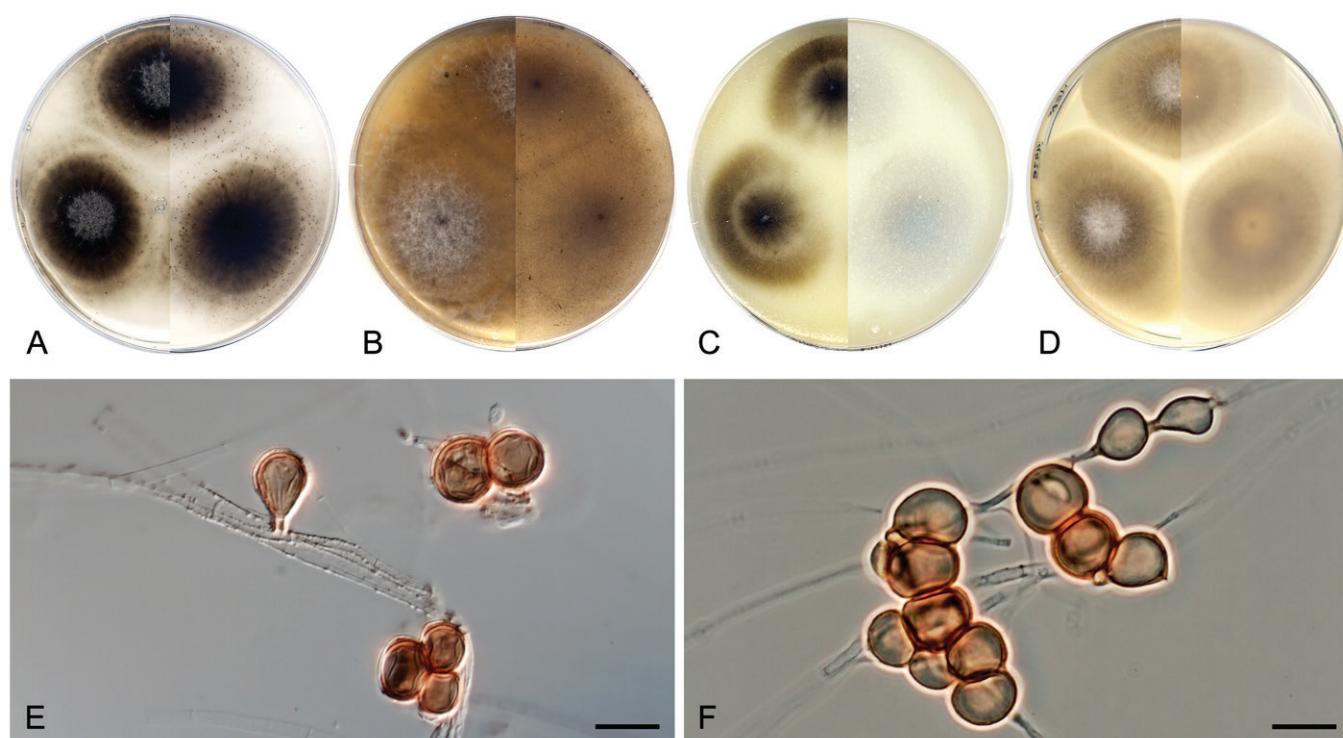


Fig. 9. *Pseudohumicola glauca* CBS 462.76. **A–D.** Colonies on PCA, OA, CMA, MEA (2-wk-old; 25 °C; surface, left; reverse, right). **E.** Conidia single cell, aseptate, sessile or on short denticles (DIC). **F.** Conidia solitary or on short chains (PC). Scale bars = 10 µm.



globose, subglobose, obovoid, pyriform, less frequently ovoid, obpyriform or ellipsoidal, $(4-)7-9(-10) \times (4-)7-10(-11) \mu\text{m}$ (Fig. 10E, F). Acremonium-like *synasexual morph* and *sexual morph* not observed.

Culture characteristics (after 7 d at 25 °C): Colonies on PCA 20–30 mm diam., circular and flat; margin filamentous, regular to lobulated; surface showing white (6A1) aerial mycelium in the central area, surrounded by a brownish-grey (6F2) circle and with yellowish-white (4A2) narrow or wide margins; soluble pigment absent; reverse brownish-grey (6F2) to brown (6E5) with yellowish-white margins (4A2). Colonies on OA 29–33 mm diam., flat, circular, and expansive; margin filamentous and regular; surface with scarce and floccose grey (6E1) aerial hyphae only in the centre, bottom brownish grey (5F2) and margins bronze (5E5) without aerial hyphae; soluble pigment absent; reverse greyish brown (5F3) and margins hair brown (5E4). Colonies on CMA 22–23 mm diam., circular and flat; margin filamentous and regular; surface chocolate (6F4) with floccose greyish white (6B1) aerial hyphae in the central area, around and margins brown (5F6); soluble pigment absent; reverse chocolate (6F4) in the centre and wide tobacco (5F6) margins. Colonies on MEA 28–30 mm diam. after 7 d at 25 °C; flat and circular; margin entire and regular; surface brownish orange (6C3) with white (6A1) aerial hyphae in the centre, sand (4B3) and with yellowish-white (4A2) margins; soluble pigment absent; reverse pale orange (6A3) in the centre, surrounded by greyish-orange (5B3) and margins orange-white (5A2). Culture iconography after 2 wk of incubation on PCA, OA, CMA and MEA (Fig. 10A–D, respectively). Minimum, optimum and maximum temperature of growth on PDA after 7 d: 12 °C, 30 °C and 37 °C, respectively.

Notes: *Pseudohumicola intercalarispora* was placed as a distinct species in a basal branch of a well-supported clade (1 PP/99 % BS) including *Pseudohumicola alba* COAD 3126 (Fig. 1). *Pseudohumicola intercalarispora* differs from *P. alba* by the presence of abundant intercalary conidia (absent in *P. alba*) and by the absence of an phialidic *synasexual morph* (present in *P. alba*) as well as the shape and size of humicola-like conidia [globose, subglobose, obovoid, pyriform, less frequently ovoid, obpyriform or ellipsoidal, $(4-)7-9(-10) \times (4-)7-10(-11) \mu\text{m}$ in *P. intercalarispora* and globose to subglobose or obovoid, with a truncated base, $(8.3-)9.6-10.4(-12.6) \times (7.0-)8.8-9.6(-10.4) \mu\text{m}$ in *P. alba*] (Oliveira *et al.* 2023).

Pseudohumicola variispora Sastoque, Cano & Stchigel, *sp. nov.* MycoBank MB 847751. Fig. 11.

Etymology: From Latin *variis-*, diverse, and *-spora*, spore, due to the morphological variability of the conidia.

Typus: Spain, Canary Islands, La Palma, Fuencaliente (Los Canarios), isolated from soil of Teneguía volcano, 15 Jul. 2008, coll. M. Caldach & A.M. Stchigel, isol. A.P. Sastoque (**holotype** CBS H-25244, culture ex-type FMR 18822 = CBS 149960).

On potato carrot agar after 4 wk at 25 °C: Mycelium abundant, composed of hyaline, septate, branched, smooth- and thin-walled, 0.5–3 μm wide hyphae. *Conidiophores* undifferentiated. *Conidiogenous cells* integrated to the vegetative hypha. *Conidia* mostly holoblastic and 1-celled, solitary, sessile, on short conical denticles or on short side branches from the hyphae (Fig. 11E), smooth- and thick-

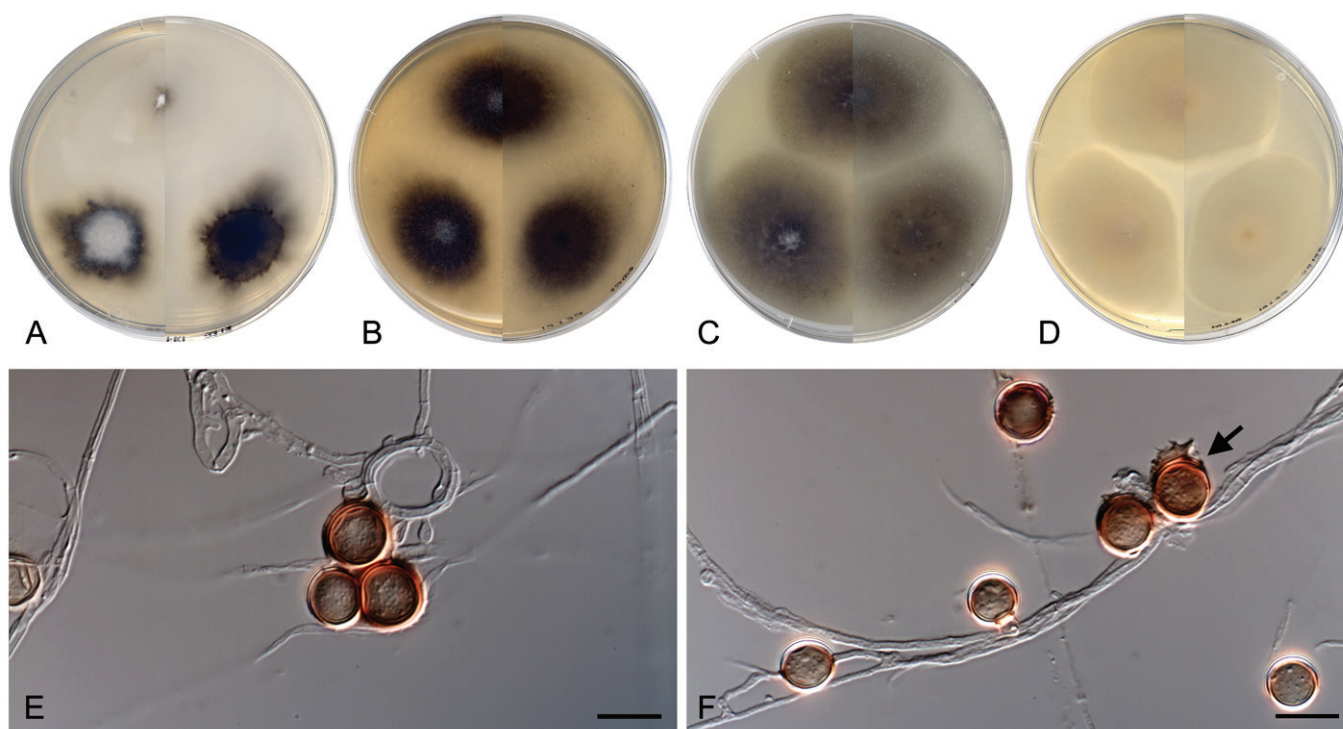


Fig. 10. *Pseudohumicola intercalarispora* CBS 149962. **A–D.** Colonies on PCA, OA, CMA, MEA (2-wk-old; 25 °C; surface, left; reverse, right). **E.** Hypha forming spirals. **F.** Conidia sessile or on short denticles or intercalary, and sometimes covered by dark brown mucilaginous substance (black arrow). Scale bars = 10 μm .

walled, covered by mucilaginous and dark brown sheath, becoming verruculose when old (Fig. 11E, J), rarely 2–3-celled, sometimes generating secondary conidia to form short chains (2–3-celled) (Fig. 11E–H), occasionally intercalary (holothallic), then 1–2-celled (Fig. 11I), brown, globose, subglobose, oblate, ellipsoid, obovoid, piriform, occasionally ovoid or cylindric, (3–)7–8(–9) × (4–)7–10(–15) µm, mostly truncated at the base or at both ends (when intercalary), secession rhexolytic (Fig. 11E–J). Acremonium-like *synasexual morph* and *sexual morph* not observed.

Culture characteristics (after 7 d at 25 °C): Colonies on PCA 9–12 mm diam., circular and flat; margin lobulated to irregular; surface showing white (4A1) aerial mycelium in the central area, surrounded by a black (4F1) superficial area and with cream (4B3) margins; soluble pigment absent; reverse black (4F2) to smoke brown (4F1) with yellowish white margins (4A2). Colonies on OA 28–30 mm diam., flat, circular and expansive; margin entire and regular; surface dry, opaque, with floccose white (6A1) aerial hyphae only in the central area, margins cream (4A3) without aerial hyphae and chocolate (6F4) short, radiated lines at the bottom; soluble pigment absent; reverse yellowish brown (5F8) in

the centre with short radiated lines and margins yellowish-white (3A2). Colonies on CMA 11–14 mm diam., circular and flat; margin entire and regular; surface canary yellow (2B7) with scarce greyish white (4B1) aerial hyphae in the centre, margins uncoloured; soluble pigment absent; reverse greyish yellow (2B5). Colonies on MEA 17–18 mm diam., flat and circular; margin filamentous and undulated; surface light yellow (3A5) in the centre to cream (4A3) without aerial hyphae; soluble pigment absent; reverse butter-yellow (4A5) in the centre and margins cream (4A3). Culture iconography after 2 wk of incubation on PCA, OA, CMA and MEA (Fig. 11A–D, respectively). Minimum, optimum and maximum temperature of growth on PDA after 7 d: 12 °C, 30 °C and 40 °C, respectively.

Notes: *Pseudohumicola variispora* was placed in a fully supported clade close to *P. lutea* COAD 3127 and *P. debertoldii* CBS 460.76, but as a different species in a basal branch (Fig. 1). *Pseudohumicola variispora* differs from *P. lutea* by presence of 2–3-celled sessile conidia and 1–2-celled intercalary conidia, and by the formation of thick-walled verrucose conidia in *P. variispora*, while *P. lutea* does not produce intercalary conidia, the conidia are

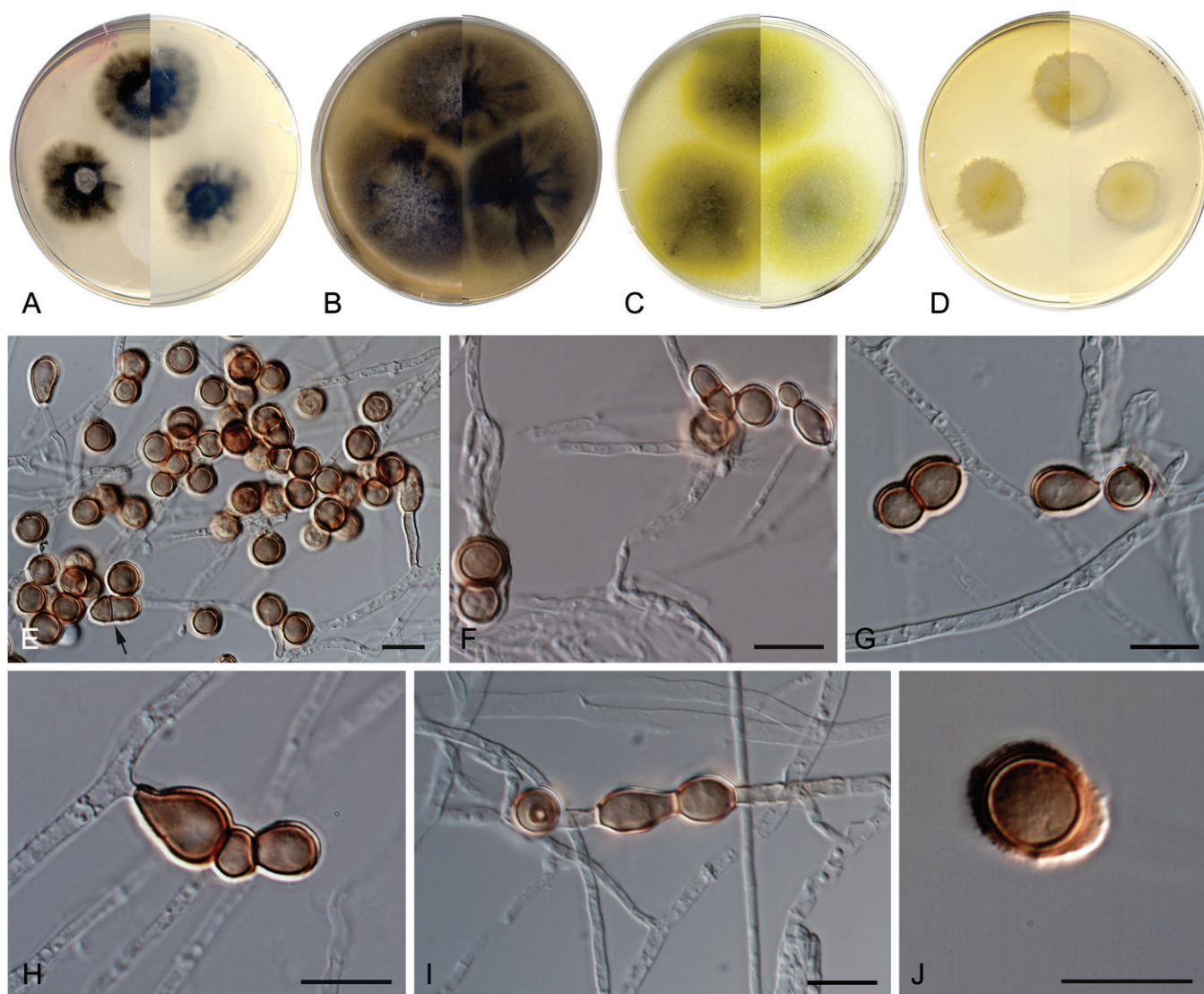


Fig. 11. *Pseudohumicola variispora* CBS 149960. **A–D.** Colonies on PCA, OA, CMA, MEA (2-wk-old; 25 °C; surface, left; reverse, right). **E–G.** Conidia 1–2-celled, septate (black arrow) and forming secondary conidia. **H.** Conidia in short chains. **I.** Intercalary conidia. **J.** Conidia covered by mucilaginous, dark brown sheath. Scale bars = 10 µm.



unicellular and thick but smooth-walled (Oliveira *et al.* 2023). *Pseudohumicola variispora* differs from *P. debertoldii* in having lateral, terminal and intercalary 2–3-celled conidia covered by mucilaginous and dark brown sheath, and sometimes produces secondary conidia to form short chains (2–3-celled) and does not present an acremonium-like asexual morph.

Steirochaetomium Sastoque, Stchigel & Cano, **gen. nov.** MycoBank MB 849839.

Etymology: From Greek *στεῖρος* (*steiros*-), sterile, because the fungus does not produce fertile structures.

Type species: *Steirochaetomium canariensis* Sastoque, Stchigel & Cano

Mycelium mostly aerial, abundant, composed of septate, branching, smooth- and thin-walled, hyaline and pigmented hyphae. **Chlamydospores**, hyaline, vacuolated, smooth- and slightly thick-walled, globose, subglobose or barrel-shaped, in chains. **Sexual morph** not observed.

Steirochaetomium canariensis Sastoque, Stchigel & Cano **sp. nov.** MycoBank MB 849840. Fig. 12.

Etymology: *canariensis*, from Canary Islands (Spain), due to the geographic origin of the fungus.

Typus: **Spain**, Canary Islands, La Palma, Fuencaliente (Los Canarios), isolated from soil of Teneguía volcano, 15 Jul. 2008, coll. *M. Caldusch* & *A.M. Stchigel*, isol. *A.P. Sastoque* (**holotype** CBS H-25347, culture ex-type FMR 19096 = CBS 150903).

On oatmeal agar after 3 mo at 25 °C: **Mycelium** mostly aerial, abundant, composed of septate, branching, smooth-

and thin-walled, hyaline to brown hyphae, 1–2 µm wide. **Chlamydospores**, hyaline, smooth- and slightly thick-walled, globose, subglobose or barrel-shaped, 11–19 × 7–13 µm, in chains, with several big lipid vacuoles (Fig. 12E, F). **Sexual morph** not observed.

Culture characteristics (after 7 d at 25 °C): Colony on PCA 28–29 mm diam., flat and circular; margin filamentous and regular; surface uncoloured with white (4A1) floccose aerial hyphae, sparse on the margins; soluble pigment absent; reverse uncoloured to white (4A1). Colonies on OA 25–27 mm diam., flat, circular, and expansive; margin filamentous and regular; surface greyish yellow (4B3) coloured with white (4A1) sparse aerial mycelium around and at the centre; soluble pigment absent; reverse uncoloured to greyish yellow (4B3). Colonies on CMA 31–32 mm diam., flat and circular; margin filamentous and regular; surface uncoloured with floccose white (4A1) aerial hyphae around at the centre; soluble pigment absent; reverse yellowish white (4A2). Colonies on MEA 40–41 mm diam., flat and circular; margin filamentous and regular; surface greyish yellow (4B3), with white (4A1) floccose aerial mycelium, sparse on the margins; soluble pigment absent; reverse greyish yellow (4B3). Culture iconography after 5 wk of incubation on PCA, OA, CMA and MEA (Fig. 12A–D, respectively). Minimum, optimum and maximum temperature of growth on PDA after 7 d: 15 °C, 30–37 °C and 45 °C, respectively.

Additional specimens examined. **Spain**, Canary Islands, La Palma, Fuencaliente (Los Canarios), from soil of Teneguía volcano, 15 Jul. 2008, coll. *M. Caldusch* & *A.M. Stchigel*, isol. *A.P. Sastoque* (culture FMR 18932).

Notes: *Steirochaetomium canariensis* was located as a monospecific fully supported lineage related but different to the *Chaetomium* clade (Fig. 1). *Steirochaetomium*

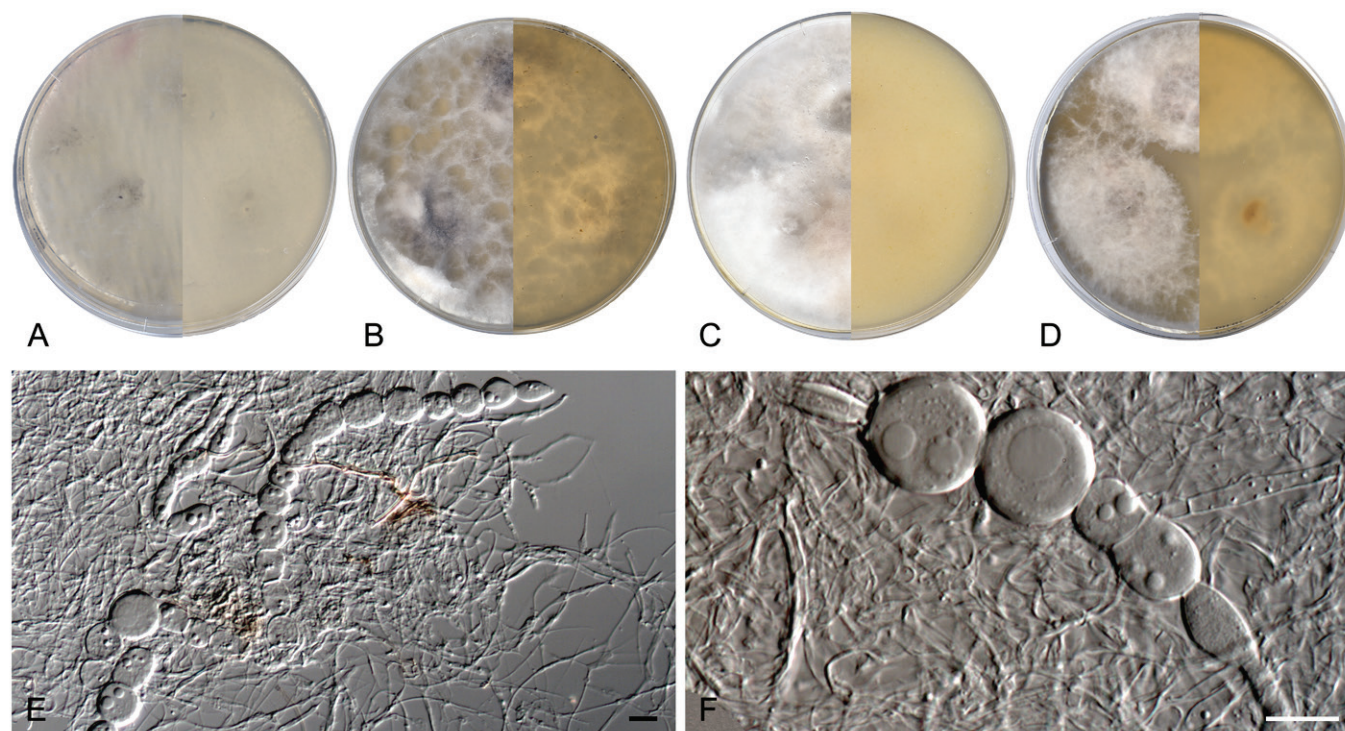


Fig. 12. *Steirochaetomium canariensis* CBS 150903. **A–D.** Colonies on PCA, OA, CMA, MEA (5-wk-old; 25 °C; surface, left; reverse, right). **E,** **F.** Chlamydospores with several lipid vacuoles, forming chains. Scale bars = 10 µm.

canariensis does not produce fertile structures. However, it forms big chlamydospores with several big lipid vacuoles, which have not been observed in *Arxotrichum*, *Corynascus*, *Chaetomium* and *Parachaetomium*. Moreover, it is easily molecularly distinguishable from the other genera of the family *Chaetomiaceae* (Wang *et al.* 2016a, 2019a, b, 2022). Based on a BLAST search of the NCBI's GenBank nucleotide database, the closest match using the *rpb2* sequence was *Parachaetomium mareoticum* [CBS 781.71, GenBank MZ342993; Identities = 598/688 (86.92 %), four gaps (0 %)]. Lastly, using the *tub2* sequence, the closest match was *Parachaetomium biporatum* [CBS 244.86, GenBank MK919417; identities = 427/521 (81.96 %), 23 gaps (4 %)].

DISCUSSION

The family *Chaetomiaceae*, established by Winter (1885) to place *Chaetomium* (Kunze & Schmidt 1817) as its type genus, comprises fungal taxa characterized by the production of superficial, ostiolate (perithecial) or non-ostiolate (cleistothecial) ascomata with a membranaceous ascomatal wall (peridium), usually covered with flexuous, undulate or coiled, verrucose or smooth hairs or setae, clavate, fusiform, cylindrical, or globose asci with or without stalks, but in all cases unitunicate and soon evanescent, lacking of apical structures, 4–8-spored, with no paraphysis within mature ascomata, and unicellular, brown to black, opaque or slightly translucent, smooth-walled, globose, ellipsoidal, lemon-shaped, quadrangular, fusiform or triangular ascospores with one or two germ pores, discharged across the ostiole as a dark cylindrical mass (cirrus) (von Arx *et al.* 1984, 1986, Mehrabi *et al.* 2020, Wang *et al.* 2022). In addition, some members of the family produce asexual morphs, consisting of conidia arising directly on the vegetative hyphae (holoblastic sessile conidia), on denticulate conidiogenous cells, or on more differentiated, hyaline or pigmented, branched or unbranched conidiophores (macronematous) with terminal or intercalary, monoblastic, sympodially polyblastic, phialidic or annellidic conidiogenous cells producing solitary, thin- or thick-walled, hyaline or pigmented, smooth to slightly roughened conidia, rarely produced in chains (Wang *et al.* 2016a, 2019b).

Members of the *Chaetomiaceae* have been isolated worldwide as saprobes on various substrates, including dung, seeds, paper, plants, straw, debris, soil (from desert, garden, dry pastures, crop fields, among others), compost, air and wood, as well as mycoparasites and human pathogens (Zhang *et al.* 2006, Violi *et al.* 2007, Marin-Felix *et al.* 2015, Ahmed *et al.* 2016, Wang *et al.* 2016a, b, 2022, Mehrabi *et al.* 2020, https://wi.knaw.nl/fungal_table, accessed on 4 February 2024), but few of them has been reported for Gran Canaria, such as *Canariomyces notabilis*, which was isolated from *Phoenix canariensis* (von Arx 1984, Cannon 1986, https://wi.knaw.nl/fungal_table, accessed on 4 February 2024). Several members are thermophilic (with an optimum temperature of growth between 40 and 50 °C, and a minimum temperature of growth above 20 °C) or thermotolerant (minimum temperature of growth below 20 °C and optimal growing starting from 35 °C) (Tansey & Jack 1975, Ellis 1981, Stchigel *et al.* 2000, de Oliveira *et al.* 2015, van den Brink *et al.* 2015, de Oliveira & Rodrigues 2019, Wang *et al.* 2022), i.e. species belonging to the genera *Achaetomium*, *Amesia*,

Humicola, *Melanocarpus*, *Mycothermus*, *Parachaetomium*, *Remersonia*, *Subramaniula*, *Thermocarpiscus*, *Thermocarpusella*, *Thermochaetoides*, *Thermothelomyces*, *Thermothielavioides*, and *Trichocladium*. This thermophilic/thermotolerant trait does not seem to be directly associated with the source of isolation, as most species have been isolated from common substrates where environmental conditions are favourable for their development (Dahiya *et al.* 2019, de Oliveira & Rodrigues 2019, Hutchinson *et al.* 2019).

Historically, the delimitation of genera and species belonging to the *Chaetomiaceae* was primarily based on the morphological traits of the sexual morph, as previously mentioned. However, it has become apparent over time that such morphological and developmental features are insufficient for this taxonomic task (Lee & Hanlin 1999, Asgari & Zare 2011). Recent studies on the family, employing a combination of ecological, molecular, and phenotypic traits, resulted in the allocation of all known fungal taxa into fifty genera so far (Wang *et al.* 2016a, 2019a, b, 2022). These studies challenge some of the morphological criteria previously used to distinguish genera within this family. For example, the presence or absence of ascomatal ostioles, as even within the same genus, both characters may be observed, as in *Botryotrichum* (Wang *et al.* 2016a).

In the present study, morphological characterization and a multilocus phylogenetic analysis based on ITS-LSU-*rpb2*-*tub2* nucleotide sequences allowed us to identify strains belonging to the *Chaetomiaceae* not previously reported for volcanic soils. These include *Achaetomium aegilopsis*, *Canariomyces arenarius*, *Carteria arctostaphyli*, *Pseudohumicola alba*, *Pseudohumicola glauca*, *Parathielavia kuwaitensis*, and *Ovatospora senegalensis* (Ames 1963, Mouchacca 1973, de Bertoldi 1976, Moustafa 1976, Asgari & Zare 2011, Wang *et al.* 2016a, 2019a, Oliveira *et al.* 2023, https://wi.knaw.nl/fungal_table, accessed on 4 March 2024). Additionally, this analysis led to the proposal of three new genera and nine new species for the science.

Botryotrichum piluliferum, designated as type species of that genus by Saccardo & Marchal (1885), is characterized by the production of perithecial ascomata with unbranched ascomatal hairs circinate at the end and mostly disposed around the ostiole, and of ellipsoid ascospores as well as of hyaline globose sessile conidia on loosely branched hyphae and on acrogenous prostrate branches (Saccardo & Marchal 1885, Daniels 1961, Alidadi *et al.* 2020). Currently, the genus comprises twenty-four species (www.indexfungorum.org/ accessed on 4 March 2024). *Botryotrichum pseudomurorum* is characterized by producing smoke grey to olivaceous grey ostiolate ascomata, verrucose terminal hairs, a yellowish soluble pigment on MEA, and growing up to 35 °C (Fig. 2).

The genus *Canariomyces* was introduced by von Arx (1984), with *C. notabilis* as the type species. This genus was placed within the *Chaetomiaceae* based on *tub2* and *tef* nucleotide sequences analysis (von Arx 1984, Wang *et al.* 2019a). *Canariomyces* currently comprises six species (<https://www.indexfungorum.org/>, accessed on 4 March 2024), isolated from various sources including soils (mostly from desertic areas), plants and human tissue (https://wi.knaw.nl/fungal_table, accessed on 4 March 2024). This genus produces both sexual and asexual morphs. The sexual morph is characterized by the production of dark brown, opaque, non-ostiolate, globose or subglobose, ascomata



often covered by subhyaline to brown hyphae, with textura angularis, or a transition to textura epidermoidea (authors' note), in surface view, the asci are obovoid, ellipsoidal, or subglobose, usually without visible stalks, soon evanescent, containing eight irregularly arranged, unicellular, dark brown when mature, ellipsoidal ascospores, with attenuated ends and a subapical or apical germ pore. The asexual morph consists of conidiogenous cells reduced to a hyphal cell, monoblastic, laterally producing conidia (sessile conidia; aleuroconidia), mostly solitary, subhyaline to dark brown, obovoid, pyriform or clavate, with a basal flattened scar (Wang *et al.* 2019a). *Canariomyces asexualis* (Fig. 3) forms smaller aleurioconidia than those of *Can. microsporus* (Wang *et al.* 2019a, https://wi.knaw.nl/fungal_table, accessed on 4 March 2024), displaying a variety of shapes including heart-shaped ones (Wang *et al.* 2022). Furthermore, the type species of this genus, *Can. notabilis*, was isolated from Gran Canaria Island on litter of *Phoenix canariensis* (von Arx 1984), *Can. asexualis* then being the second species reported for the Canary Islands.

Carteria is a monospecific genus within the *Chaetomiaceae*, established to accommodate a fungal strain (CBS 229.82) isolated from the shrub *Arctostaphylos uva-ursi* in Parsenn (Switzerland), and erroneously assigned to *Thielavia basicola* (Wang *et al.* 2019a). *Carteria canariensis* (Fig. 4) is characterized by the production of ascomata and asci smaller than those of *C. arctostaphyli*, and by the production of a yellowish soluble pigment on MEA. In our multilocus phylogenetic tree (Fig. 1), this genus was located in a fully-supported lineage together with *Thermocarpiscus australiensis* (formerly *Thielavia australiensis*; Wang *et al.* 2022)) and two new monospecific genera, *Oidiosporium* and *Phaeophyphomyces*, with *Oid. botulisporum* and *Phaeoh. canariensis* as their respective type species. *Oidiosporium botulisporum* (Fig. 5) is characterized by the production of chains of holothallic conidia by remodeling of sections of pre-existing hyphae, detaching from the hyphae by schizolytic secession. Then, *Oid. botulisporum* resembles *Mycothermus thermophilus* and *Batnamyces globulariicola*, but these also form intercalary, lateral or terminal chlamydospores (Tansey & Jack 1975, Wang *et al.* 2019b, 2022, Noumeur *et al.* 2020). On the other hand, *Phaeoh. canariensis* (Fig. 6) is a sterile fungus, being placed as an unequivocally new genus and species within the *Chaetomiaceae* based on the results of our phylogenetic analysis.

Pseudohumicola was established as a genus to accommodate some species of *Humicola* forming a separate lineage, and currently contains seven species (Alves *et al.* 2022, Wang *et al.* 2022, Oliveira *et al.* 2023). *Pseudohumicola* spp. have been isolated from soil, dust, dung, air, cave sediment, filter paper, litter and leaves (Alves *et al.* 2022, Wang *et al.* 2022, Oliveira *et al.* 2023, https://wi.knaw.nl/fungal_table, accessed on 4 March 2024). In our study, three new species of that genus were identified, all of them producing a humicola-like asexual morph, being isolated from soils surrounding the Teneguía volcano. *Pseudohumicola cinnamobrunnea* (FMR 18980; Fig. 7), *P. intercalispora* (FMR 19235; Fig. 10) and *P. variispora* (FMR 18822; Fig. 11) can be differentiated from the other species of the genus by the size and shape of the conidia, by the absence of an acromonium-like synasexual morph, and lacking a sexual morph. Notably, *P. variispora* (Fig. 9) produces 2–3-celled conidia, surrounded by a thick

verrucose sheath when old. These three new species are thermotolerant, growing between 12 °C and 45 °C, but with an optimal temperature of growth at 37 °C. Additionally, two species of *Humicola* described by de Bertoldi (1976), but considered as doubtful for that genus (de Bertoldi 1976, Wang *et al.* 2022, Oliveira *et al.* 2023), were transferred to the genus *Pseudohumicola* based on our multilocus phylogenetic tree (Fig. 1), and renamed as *Pseudohumicola debertoldii* (formerly *Humicola lutea*; CBS 460.76; Fig. 8) and *Pseudohumicola glauca* (formerly *Humicola glauca*; CBS 462.76; Fig. 9). The first species could not be renamed with its previous specific name because it was previously used to name other new species of *Pseudohumicola* (Oliveira *et al.* 2023).

Furthermore, the new monospecific genus *Steirochaetomium* (Fig. 12) was established based on the results of our phylogenetic analysis (Fig. 1), where it forms a fully supported basal branch within a terminal clade that includes the genera *Parachaetomium*, *Arxotrichum*, *Corynascus*, and *Chaetomium*. *Steirochaetomium canariensis* is mainly characterized by the production of large, globose, hyaline chlamydospores arranged in chains, the absence of fertile structures, and its high thermotolerance (growing up to 45 °C), and with an optimal temperature of growth between 30 and 37 °C. Although the presence of chlamydospores has been reported in species of the genera *Aporothielavia*, *Batnamyces*, *Mycothermus*, *Trichocladium*, and *Subramaniula*, these chlamydospores are typically pigmented and smaller than those observed in *St. canariensis* (Wang *et al.* 2019a, 2022, Noumeur *et al.* 2020).

These findings indicate that despite the predominantly volcanic and low-fertility soils in the southern region of La Palma, there is a significant presence of members of the family *Chaetomiaceae*. Furthermore, the thermophilic profiles observed in some of these species suggest that, in addition to geomorphology, the island's climate, topography, vegetation, and fauna diversity also play a crucial role in the development and distribution of these micromycetes.

CONCLUSIONS

The application of diverse isolation techniques allowed us to recover multiple taxa of the family *Chaetomiaceae* from volcanic soils collected near Fuencaliente village on La Palma Island (Canary Archipelago, Spain), with a particular focus on areas surrounding the Teneguía volcano. Using a polyphasic approach for fungal identification, we report not only the discovery of seven *Chaetomiaceae* species previously unreported in volcanic soils (*Achaetomium aegilopsis*, *Canariomyces arenarius*, *Carteria arctostaphyli*, *Ovatospora senegalensis*, *Parathielavia kuwaitensis*, *Pseudohumicola alba*, and *Pseudohumicola glauca*), but also the identification of three new genera (*Oidiosporium*, *Phaeophyphomyces*, and *Steirochaetomium*) and nine new species (*Botryotrichum pseudomurorum*, *Canariomyces asexualis*, *Carteria canariensis*, *Oidiosporium botulisporum*, *Phaeophyphomyces canariensis*, *Pseudohumicola cinnamobrunnea*, *Pseudohumicola intercalispora*, *Pseudohumicola variispora*, and *Steirochaetomium canariensis*). Additionally, *Humicola glauca* and *Humicola lutea* were reclassified in the genus *Pseudohumicola*. Regarding growth temperatures, while most strains were isolated at

25 °C, some exhibited thermotolerance (e.g., *Can. asexualis* and *St. canariensis*), whereas others were limited to growth up to 37 °C (e.g., *Oid. botulisporum*, *P. cinnamobrunnea*, *P. intercalarispora*, and *P. variispora*). Notably, *Botryotrichum pseudomurorum* and *Can. asexualis* demonstrated a broad temperature range for growth, from 5 °C to 35/40 °C, respectively. In conclusion, these findings highlight volcanic soils as an underexplored source of taxonomically significant micro-mycetes, particularly within the *Chaetomiaceae*.

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Declaration on conflict of interest. The authors declare that there is no conflict of interest.

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SUPPLEMENTARY MATERIAL

Table S1. List of primers and annealing temperatures used for amplification of gene targets.

