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RESEARCH ARTICLE

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A New Species and Three New Records Belonging to *Mucorales* and *Mortierellales* from Korea

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ABSTRACT

During an investigation of fungi of the orders *Mucorales* and *Mortierellales* in Korea, a new *Backusella* species, *Backusella terrestris* sp. nov., and three new records, *Entomortierella sugadairana*, *Mucor nederlandicus*, and *Poitrasia circinans*, were found in soil and freshwater samples. All species are described based on morphological and molecular evidence. *Backusella terrestris* is characterized by globose or subglobose sporangiospores, a variable (globose, subglobose, oval, or oblong) columellae, chlamydospore production, and a maximum growth temperature of 34 °C. The distinct characteristics of the new species and their closely related species are discussed. An identification key to the *Backusella* species of Korea is also presented.

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1. Introduction

Mucorales is the largest order of *Mucoromycotina*, comprising 16 families and 57 genera [1–3]. The members of *Mucorales* are often isolated from soil, food products, herbivore dung, and invertebrates [3–7]. *Mucorales* contains several species reported as therapeutic agents for mucormycosis in humans [1]. Furthermore, several species have been used for the industrial production of organic acids, enzymes, and fermented foods [8–10].

The genus *Backusella* (*Mucoromycotina*, *Mucorales*) was first established by Hesseltine and Ellis in 1969, with *B. circina* J.J. Ellis & Hesselt. as the type species. *Backusella* species are characterized by the formation of curved sporangiophores when young and erect when mature [11]. Lateral, uni- and/or multi-spored pedicellate and persistent-walled sporangiola may arise from long sporangiophores [11, 12]. These species mainly inhabit soil, leaf litter, dung, and invertebrates [3, 6, 7, 13–15]. Currently, 40 species of this genus have been recorded in Index Fungorum (www.indexfungorum.org; accessed on October 12, 2024). However, only nine species have been reported from South Korea [3, 15].

The genus *Mucor* (*Mucoromycotina*, *Mucorales*) was first described by Fresenius [16], with *M. mucedo* L.: Fries as the type species. *Mucor* species are known to be saprophytes that are usually isolated from soil, water, food products, human clinical specimens, insect, and dung [6, 17–21]. These species have important industrial applications due to their ability to produce a wide range of metabolites and enzymes [9, 22, 23]. However, several members of the *Mucor circinelloides* complex have been identified as pathogens that cause mucormycosis, an angio-invasive fungal infection and can lead to host death, in humans and animals [19, 24]. A total of 98 *Mucor* species have been identified [25], of which 38 have been reported from Korea [3].

The genus *Poitrasia* (*Mucoromycotina*, *Mucorales*) was first described by Kirk [26], with *P. circinans* (H. Nagan. & N. Kawak.) P.M. Kirk as the type species. This genus is characterized by the production of zygospores with a smooth zygosporangial wall and a striate zygospore wall, which are brown and borne between tong-like suspensors [26]. Currently, this genus only comprises the type species *Poitrasia circinans* (www.indexfungorum.org; accessed on September 10, 2024), which is found in soil [6].

Mortierellales is the largest order of the subphylum *Mortierellomycotina*. Currently, this order contains only one family, *Mortierellaceae*, comprising 14 genera and over 100 species [27, 28]. The members of this order are found in various habitats, including soil, freshwater, and bat dung [27–31]. *Mortierellales*

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spp. have attracted considerable interest as industrial lipid producers. For example, *Mortierella* spp. can accumulate large amounts of unusual lipids containing polyunsaturated fatty acids (PUFAs) [23]. *Mortierella alpina* is a producer of arachidonic acid (ARA) and an ingredient in infant formula [32]. Many *Mortierella* species have been found in agricultural soils, where they are associated with promoting plant growth and litter decomposition [33].

The genus *Entomortierella* (*Mortierellomycotina*, *Mortierellales*) was first established by Vandepol and Bonito in 2020 [27] with *E. lignicola* (G.W. Martin) Vandepol & Bonito as the type species. The members of this genus are usually isolated from soil, roots, rotting plant matter, ant pellets, termite nests, and vermicompost [27, 28, 34]. To date, 11 species of this genus have been identified (www.indexfungorum.org; accessed on October 10, 2024), with no published reports from Korea.

The purpose of this study was to expand the fungal diversity of the orders *Mucorales* and *Mortierellales* in Korea. Herein, a new species and three new records isolated from soil and freshwater samples are described. An updated identification key to the *Backusella* species of Korea is also provided.

2. Materials and methods

2.1. Sampling and isolation of strains

Soil and freshwater samples were collected from different regions of South Korea including, Kunryang-ri, Cheongyang-eup, Cheongyang-gun, Chungnam Province and Geumpyeong-ri, Haeri-myeon, Gochang-gun, Jeonbuk Province, and Jaeun-myeon, Sinan-gun, Jeonnam Province. Samples were collected in polyethylene containers and stored at ambient temperatures during transport to the laboratory. A general dilution-plate method was used to isolate fungi from the samples [35, 36]. Potato dextrose agar (PDA) (PDA; Becton, Dickinson and Co., Sparks, MD) and malt extract agar (MEA; Becton, Dickinson and Co.), supplemented with antibiotics (50 mg/ml streptomycin), were used. The obtained strains were purified and subcultured on PDA. The cultures were maintained in 20% (v/v) glycerol at −80 °C, and PDA slants at 4 °C at the Environmental Microbiology Laboratory Fungarium (Chonnam National University, Gwangju, Korea) under the numbers CNUFC BG21, CNUFC BG22, CNUFC CYS4, CNUFC CY2271, CNUFC GCW-3. Type specimens were deposited at Chonnam National University (CNUFC) Fungarium, Gwangju, South Korea as inactive dried cultures. Ex-type living cultures were deposited at the Environmental Microbiology Laboratory Fungarium, Chonnam National University, Gwangju, South Korea. Strain CNUFC GCW-3 was also deposited at the Culture Collection of the Nakdonggang National Institute of Biological Resources (NNIBR, Sangju, South Korea).

2.2. Morphological and physiological studies

Pure cultures of *Backusella terrestris*, *Mucor nederlandicus*, and *Poitrasia circinans* were grown in triplicate on PDA, MEA, and synthetic mucor agar (SMA) as previously detailed [3, 4]. The plates were incubated at 25 °C in the dark for 7 days. Pure cultures of *Entomortierella sugadairana* was grown in triplicate on PDA, MEA, and miura medium (LCA; 1 g glucose, 1 g KH_2PO_4, 0.2 g $MgSO_4$, 0.2 g KCl, 2 g $NaNO_3$, 0.2 g yeast extract and 15 g agar in 1 L of deionized water). The plates were incubated at 20 °C in the dark for 7 days. The maximum growth temperature (T_{max}) of *Backusella terrestris* was determined by culturing the strains on MEA, PDA, and SMA at temperatures one degree higher than the highest temperature at which growth was observed. For morphological identification, fragments of mycelia were removed from the cultures and placed onto microscopy slides in the presence of lactic acid (60%) and observed under a light microscope (Olympus BX53, Tokyo, Japan).

2.3. DNA extraction, PCR amplification and sequencing

The strains were grown for five days on PDA prior to DNA extraction. DNA was extracted using the Solg™ Genomic DNA Preparation Kit (Solgent Co. Ltd., Daejeon, Republic of Korea) and stored at −20 °C. The ITS, LSU, *RPB1* and *argA* genes were amplified and sequenced using previously described methods and primers [3].

2.4. Phylogenetic analysis

Sequence data of closely related to species of *Backusella*, *Entomortierella*, *Mucor*, and *Poitrasia* were selected from data previously published by Walther et al. [6], Nguyen et al. [3, 15], Urquhart et al. [13], de Lima [14], Nguyen and Lee [20], Telagathoti et al. [28], Takashima [34], and Cordeiro et al. [37], and downloaded from GenBank (https://www.ncbi.nlm.nih.gov/genbank/) for molecular phylogenetic analyses. Sequences of each gene were individually aligned using MAFFT v.7 with default parameters (http://mafft.cbrc.jp/alignment/server) [38] and then trimmed at both ends. Maximum likelihood analysis was performed using RAxML-HPC2 on XSEDE on the online CIPRES Portal (https://www.phylo.org/portal2). The GTR model of nucleotide evolution was used. RAxML rapid bootstrapping of 1000 replicates was performed. The tree

topologies generated in this study were visualized using FigTree version 1.3.1 [39]. The phylogram was edited using Microsoft Office PowerPoint 2016.

3. Results

3.1. Phylogenetic analyses

The phylogenetic tree of *Backusella* was determined by analyzing concatenated sequence datasets of four loci (ITS, LSU, *RPB1*, and *argA*). The aligned dataset contained 3606 characters, including gaps (ITS: 1–1200; LSU: 1201–1837; *RPB1*: 1838–2864; *argA*: 2865–3606). The multigene phylogenetic analysis showed that the newly identified strains CNUFC BG21 and CNUFC BG22 formed distinct clades (Figure 1).

The multigene phylogenetic analyses on ITS and LSU indicated that the new strains CNUFC CYS4, CNUFC CY2271, and CNUFC GCW-3 clustered with the type strains of *Entomortierella sugadairana*, *Mucor nederlandicus*, and *Poitrasia circinans*, respectively (Figures 2–4).

3.2. Taxonomy

Based on the phylogenetic analyses and morphological examination, the isolates collected in this study were established as three newly recorded species – *Entomortierella sugadairana*, *Mucor nederlandicus*, and *Poitrasia circinans* – along with one novel species, *Backusella terrestris*. The descriptions of these species are provided below.

Backusella terrestris Hyang B. Lee **sp. nov.**

Index Fungorum number: IF902349; Figure 5.

Etymology: Refers to soil, the substrate from which the type strain was isolated.

Typus: Republic of Korea, Jeonnam Province, Sinan-gun, Jaeun-myeon, Yugak-ri, soil sample, February 5, 2023 (holotype CNUFC HT2321, ex-type culture CNUFC BG21, GenBank number: ITS = PQ557609, LSU = PQ555325, *RPB1*=PQ568397, *argA*=PQ568399).

Description: Colonies on SMA white, reaching 85 mm in diameter after four days of incubation at 25 °C; reverse yellowish white. Rhizoids present. Sporangiophores arising from the substrate mycelia curved when young and erect when mature, hyaline, unbranched, or simply branched, 8–13 µm in diameter. Sporangia globose to subglobose, light brown, 44.5–77.5(–81.5) µm in diameter. Columellae of sporangia hyaline, globose, subglobose, oval, or oblong, (20–)25–35(–41) × (18–)22–34(–37) µm. Collar present. Multi-spored sporangiola, hyaline, globose to subglobose, (15–)20–36(–40.5) × (12.5–)19–35(–38) µm, containing 2 to 12 spores. Columellae of sporangiola applanate to conical, 8.5–14.5 × 7–10 µm. Sporangiospores hyaline, globose, subglobose some irregular, 11–15.5(–17) × 10–14(–16.5) µm, smooth walled. Unispored sporangiola rare, globose, wall spinulose, and persistent, 21–28(–33) µm in diameter. Chlamydospores present. Giant cells and zygospores not observed. Sporangia on PDA (42–64.5 × 41–62.5 µm) and MEA (46–74 × 45–72 µm) slightly smaller than those on SMA. The shape and size of columellae on MEA and PDA were similar to those on SMA. Sporangiospores on PDA [11–15 × (9.5–)10–14 µm] were slightly smaller than those on SMA.

Culture characteristics: On PDA, the colonies reached 77 mm in diameter after four days of incubation at 25 °C. On MEA, the colonies reached 80 mm in diameter after four days of incubation at 25 °C. T_{max} was 34 °C on MEA, PDA, and SMA.

Additional material examined: Republic of Korea, Jeonnam Province, Sinan-gun, Jaeun-myeon, Yugak-ri, soil sample, February 5, 2023 (culture CNUFC BG22, GenBank number: ITS = PQ557610, LSU = PQ555326, *RPB1*=PQ568398, *argA*=PQ568400).

Entomortierella sugadairana (Y Takash, Degawa & K Narisawa) Telagathoti, M. Probst & Peintner, Studies in Mycology 103: 30 (2022) (Figure 6).

Description: Colony on PDA at 20 °C, fast-growing, white initially, becomes grayish yellow, reaches 69 mm in diameter after seven days of incubation. Sporangiophores erect, unbranched, 50–175.5 µm in length. Sporangia globose to subglobose, multi-spored, (14–)16.5–31 × (13.5–)16–30 µm. Sporangiospores globose to subglobose, some broadly oval, smooth-walled, 3.5–7(–9) × 3.5–6.5(–8) µm. Zygospores not observed.

Culture characteristics: On MEA, the colonies reached 67 mm in diameter after seven days of incubation at 20 °C. On LCA, the colonies reached 63 mm in diameter after seven days of incubation at 20 °C.

Material examined: Republic of Korea, Chungnam Province, Cheongyang, Cheongyang-eup, Kunryang-ri, soil sample, January 8, 2023, H.B. Lee & J.S. Kim (culture CNUFC CYS4, GenBank number: ITS = PQ557611, LSU = PQ555327).

Mucor nederlandicus Vánová, Ceska Mykol.: 128 (1991) (Figure 7).

Description: Colony on MEA at 25 °C, fast-growing, reaches 68 mm in diameter after four days of incubation; reverse pale yellow. Sporangiophores hyaline, arising directly from the substrate, simple, unbranched, and constricted next to young sporangia, 4.5–9.5 µm in diameter. Sporangia globose to

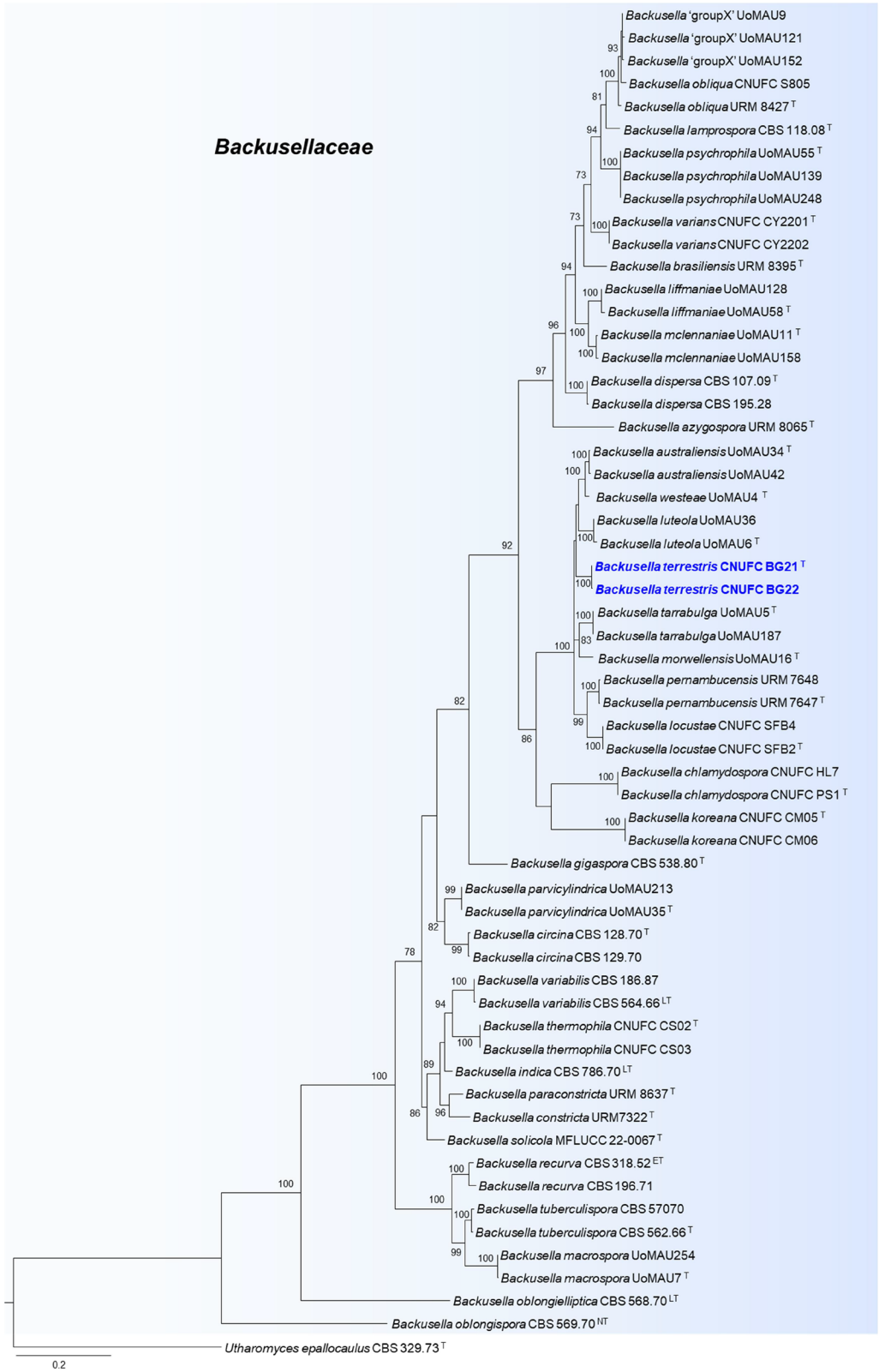

Figure 1. Phylogenetic relationship of *Backusella* species based on the combined ITS, LSU, *RPB1*, and *argA* sequences. The numbers above or below branches represent maximum likelihood bootstrap percentages. Bootstrap values > 70 are shown. *Utharomyces epallocaulus* CBS 329.73^{T} was used as outgroup. Ex-type, ex-epitype, ex-lectotype, and ex-neotype strains are marked with superscript T, ET, LT, and NT, respectively. Newly generated sequences are in bold blue.

subglobose, smooth-walled, yellow, (23.5–)32–53(–56) µm in diameter, walls slightly echinulate. Columellae hyaline, globose, subglobose, some obovoid, (14–)17–25(–29.5) × (13–)16–23.5(–26) µm, with or without short collar. Sporangiospores hyaline, mostly ellipsoidal, sometimes slightly flattened at one side, 4.5–6.5 × 2.5–3 µm, smooth-walled. Chlamydospores abundant, intercalary, terminal, variable in shape (globose to subglobose, ellipsoidal, or cylindrical), 12–32 × 10.5–18.5 µm. Zygospores not observed.

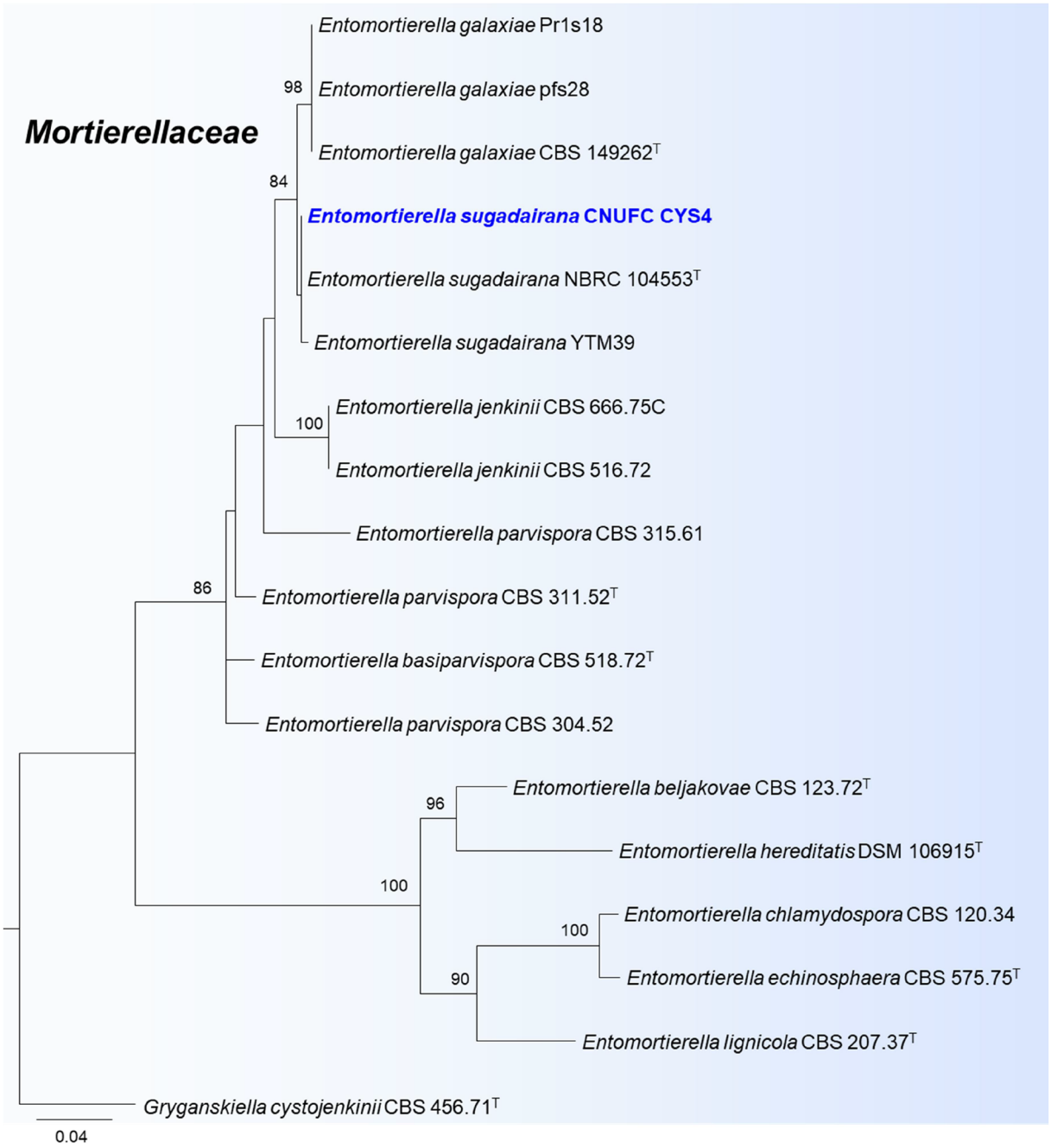

Figure 2. Phylogenetic relationship of *Entomortierella* species based on the combined ITS and LSU sequences. The numbers above branches represent maximum likelihood bootstrap percentages. Bootstrap values > 70 are shown. *Gryganskiella cystojenkinii* CBS 456.71T was used as outgroup. Ex-type strains are marked with superscript T. Newly generated sequences are in bold blue.

Culture characteristics: On PDA, the colonies reached 65 mm in diameter after four days of incubation at 25 °C. On SMA, the colonies reached 72 mm in diameter after four days of incubation at 25 °C.

Material examined: Republic of Korea, Chungnam Province, Cheongyang, Cheongyang-eup, Kunryang-ri, soil sample, May 14, 2022, H.B. Lee & J.S. Kim (culture CNUFC CY2271, GenBank number: ITS = PQ557612, LSU = PQ555328).

Poitrasia circinans (H. Nagan. & N. Kawak.) P.M. Kirk, Mycological Papers 152: 52 (1984) (Figure 8).

Description: Colony on SMA at 25 °C, fast-growing, reaches 80 mm in diameter after four days of incubation, pale olive-buff, reverse pale yellow. Sporangiophores arise from substrate and aerial mycelium, non-septate. Sporangiophores bearing sporangiola absent. Sporangia globose to subglobose, multi-spored, pale brown to dark brown. Columellae smooth-walled, brown, with collar distinct, globose to subglobose, oval to pyriform, 22.5–49.5 µm in diameter. Sporangiospores brown to reddish-brown, ellipsoid to broadly ellipsoid, with striations visible, smooth-walled, with 6–8 appendages, 9.5–14.5×5–7 µm. Chlamydospores and zygospores not observed.

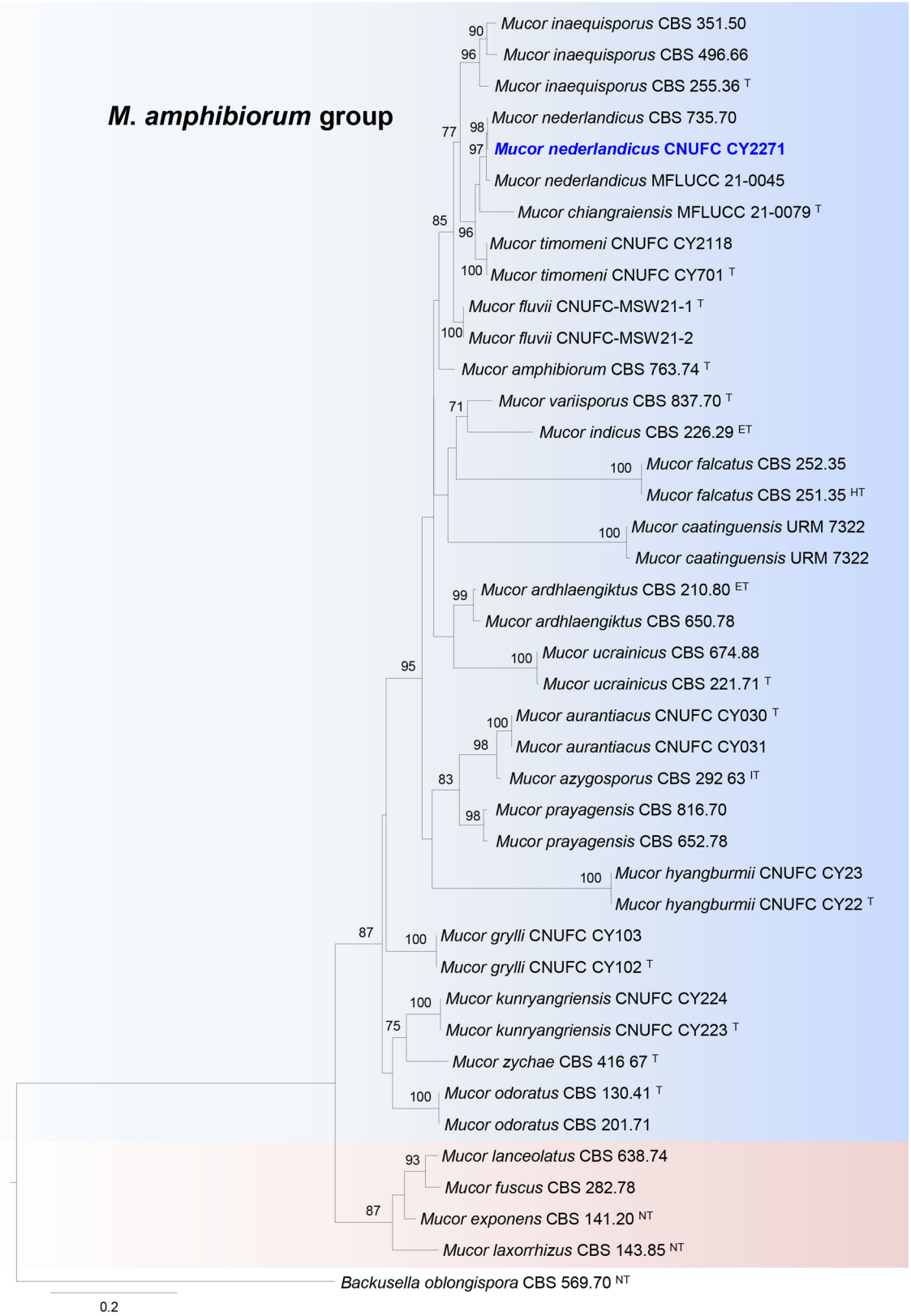

Figure 3. Phylogenetic relationship of *Mucor* species in *Mucor amphibiorum* group and related taxa based on the combined ITS and LSU sequences. The numbers above or below branches represent maximum likelihood bootstrap percentages. Bootstrap values > 70 are shown. *Backusella oblongispora* CBS 569.70^{NT} was used as outgroup. Ex-type, ex-epitype, ex-holotype, ex-isotype, and ex-neotype strains are marked with superscript T, ET, HT, IT, and NT, respectively. Newly generated sequences are in bold blue.

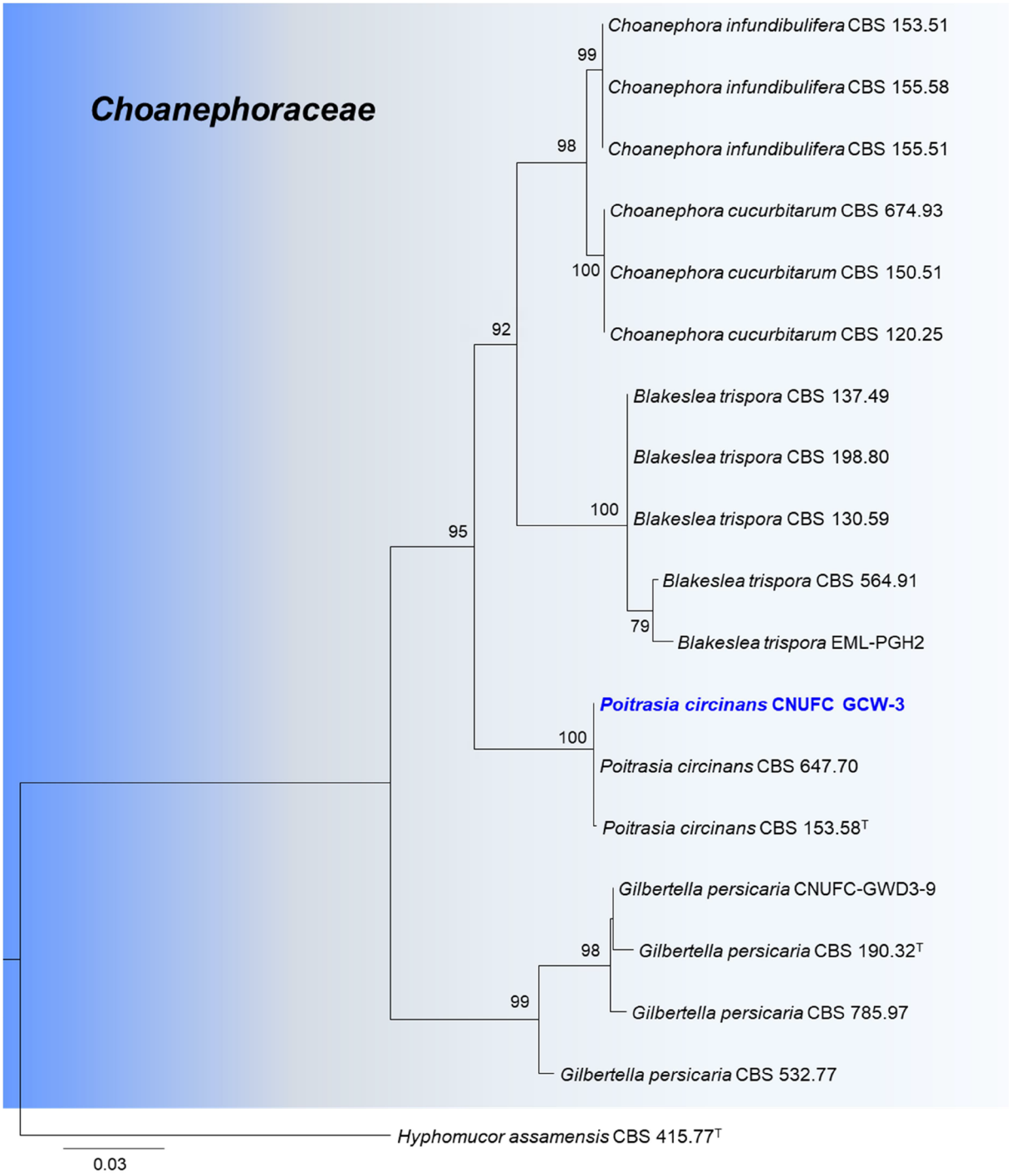

Figure 4. Phylogenetic relationship of *Poitrasia* species and related taxa based on the combined ITS and LSU sequences. The numbers above or below branches represent maximum likelihood bootstrap percentages. Bootstrap values > 70 are shown. *Hyphomucor assamensis* CBS 415.77^{T} was used as outgroup. Ex-type strains are marked with superscript T. Newly generated sequences are in bold blue.

Culture characteristics: On PDA, the colonies reached 85 mm in diameter after four days of incubation at 25 °C. On MEA, the colonies reached 80 mm in diameter after four days of incubation at 25 °C.

Material examined: Republic of Korea, Jeonbuk Province, Gochang-gun, Haeri-myeon, Geumpyeong-ri, freshwater sample, August 2, 2023 (culture CNUFC GCW-3= NNIBRFG54748, GenBank number: ITS = PQ 557613, LSU = PQ555329).

4. Discussion

The number of species in the orders *Mucorales* and *Mortierellales* has significantly increased over the past decade [3, 7, 27, 28, 40]. However, the total number of fungal species in South Korea remains low [3, 31, 41–47]. In this study, one novel species and three newly recorded species in the orders *Mucorales* and *Mortierellales* were isolated from soil and freshwater samples collected in different regions

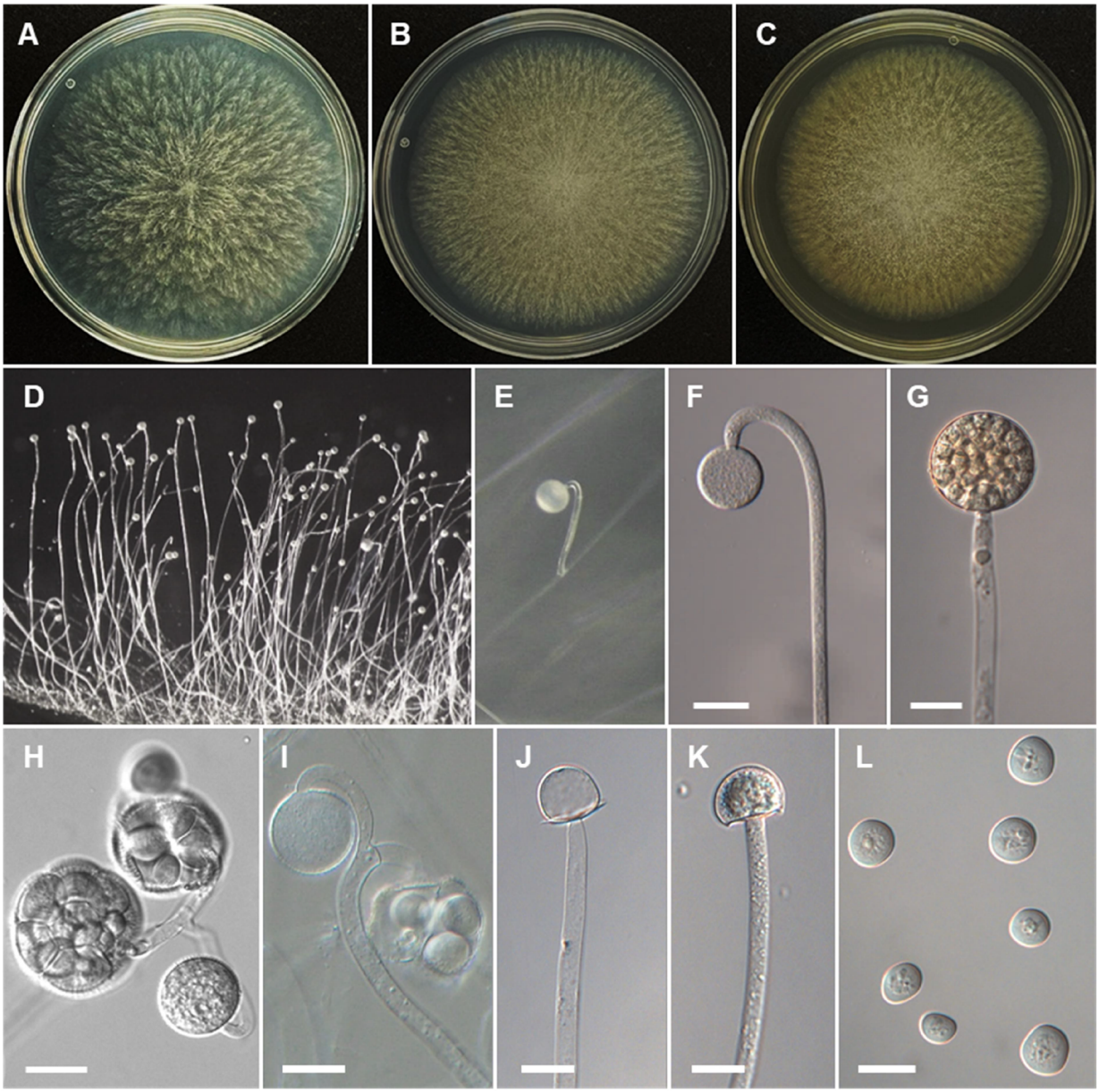

Figure 5. *Backusella terrestris* (CNUFC BG21). A, Colony on SMA. B, Colony on PDA. C, Colony on MEA. D, Sporangiophores with sporangia. E, Sporangiophore branch with sporangium. F, G, Young and mature sporangia. H, I, Short-branched sporangiophore bearing uni and multispored sporangiola. J, K, Columellae. L, Sporangiospores. Scale bars = 20 μm.

of South Korea. These species are described and compared to their closely related species.

Multigene phylogenetic analysis of ITS, LSU, *RPB1*, and *argA* sequences indicated that *Backusella terrestris* formed a clade distant from other *Backusella* species but close to *B. luteola, B. tarrabulga,* and *B. morwellensis* species (Figure 1). *Backusella terrestris* differs from these species in its production of chlamydospores, variable columellae, and bigger sporangia. *Backusella terrestris* produces bigger sporangia (42–64.5 × 41–62.5 μm) than *B. luteola* (25.8–59.2 × 22.9–55 μm), *B. morwellensis* (23.5–71.6 × 23.2–57.2 μm), and *B. tarrabulga* (29.7–48 × 24.2–41.8 μm) on PDA [13]. Columellae of *B. luteola* (16.9–26.4 × 14.7–23.4 μm), and *B. morwellensis* (18.6–29.8 × 16.1–28 μm are slightly smaller than *Backusella terrestris* [(20–)25–35(–41) × (18–)22–34(–37) μm] on PDA [13]. Sporangiospores of *B. luteola* (12.9–20.1 × 12.3–16.7 μm) and *B. tarrabulga* (12.2–23.4 × 11.9–20.1 μm) are bigger than those of *B. terrestris* [11–15 × (9.5–)10–14 μm] on PDA [13]. The T_{max} was found to be 30 °C for both *B. luteola* and *B. morwellensis* [37]; while T_{max} of *B. terrestris* is 34 °C. Collectively, based on morphological and phylogenetic evidence, we establish a new species, *B. terrestris*, from a soil habitat in South Korea.

Backusella species have mainly been reported as saprobes in various hosts. Most species of this genus have been recorded in Australia, Brazil, China, and South Korea [3, 7, 13, 15, 37]. To date, 40 *Backusella* species have been identified (www.indexfungorum.org; accessed on October 12, 2024). However, only

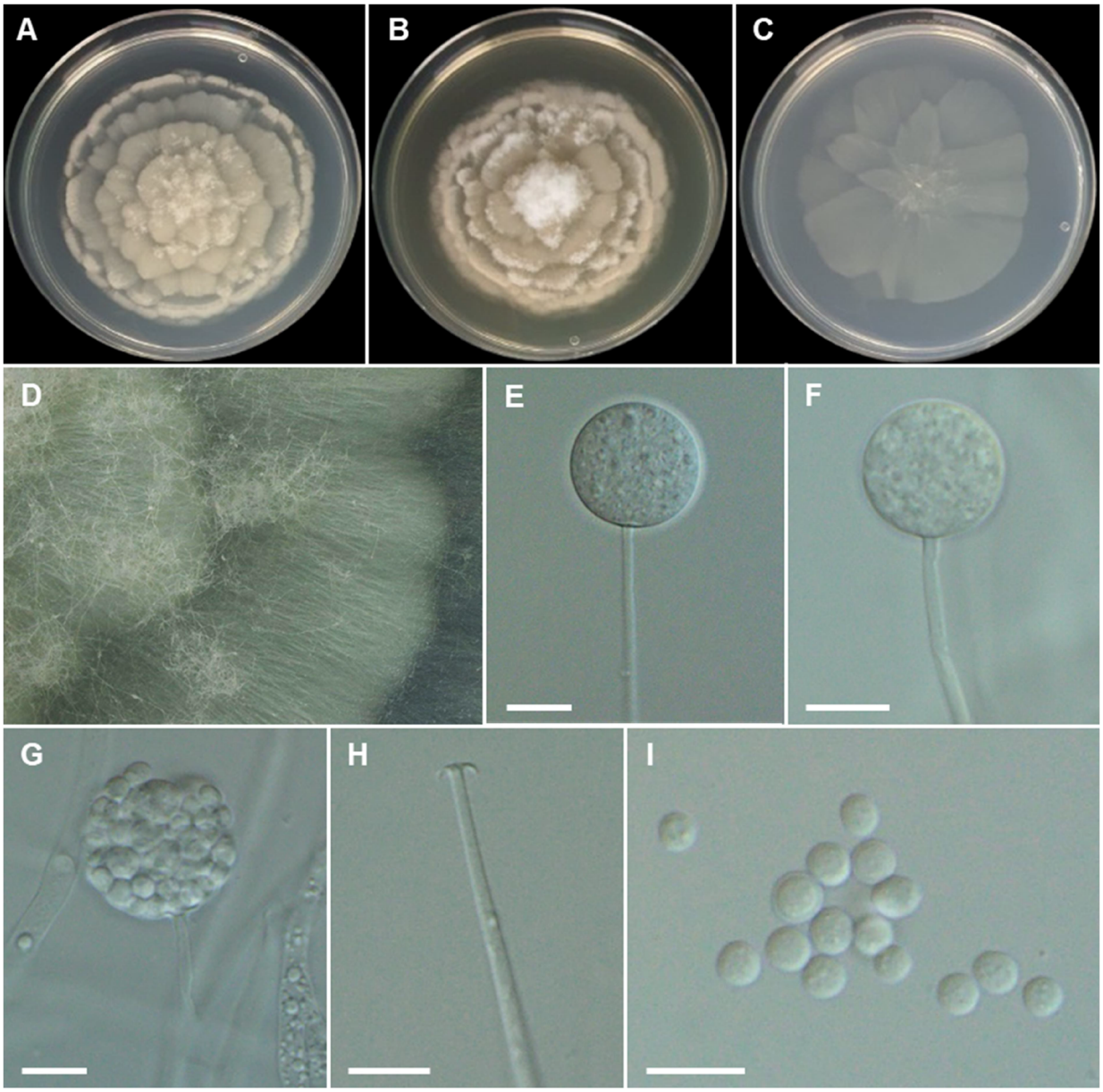

Figure 6. *Entomortierella sugadairana* (CNUFC CYS4). A, Colony on PDA. B, Colony on MEA. C, Colony on LCA. D, Colony texture on PDA after 7 days incubation. E-G, Young and mature sporangia. H, Sporangiophore tip showing collarette. I, Sporangiospores. Scale bars = 10 µm.

B. circina, *B. dispersa*, *B. oblongielliptica*, *B. oblongispora*, *B. lamprospora*, *B. obliqua*, and *B. recurva*, have been reported in more than one country [3, 13, 15, 37, 48] suggesting geographic endemism.

The strain CNUFC CYS4, newly identified and described in this study, clustered together with *Entomortierella sugadairana* strains NBRC 104553 and YTM39 (Figure 2). Our strain showed a close similarity with the descriptions of Takashima et al. [34]. However, Takashima et al. reported sporangiospores with 2–6 µm diam., which were smaller than the ones observed by us [3.5–7(–9) × 3.5–6.5(–8) µm]. *Entomortierella sugadairana* has been isolated from a decayed twig of *Fagus crenata*, the root of *Solanum lycopersicum*, and soil under *Abies veitchii* Lindl. in Japan [34]. This study describes the first isolation of *E. sugadairana* from South Korean soil, which is the second report of *E. sugadairana* globally. This contributes to our understanding of the geographic distribution of these fungi.

Mucor species are commonly isolated from soil, dung, insects, and plant debris [4, 6, 20]. This genus is distributed worldwide. The strain CNUFC CY2271 was found to be within the clade of *M. nederlandicus*, belonging to the *M. amphibiorum* group [6]. The members of the *M. amphibiorum* group are characterized by unbranched tall sporangiophores or sporangia with a maximum diameter of between 70–175 µm [6]. Morphologically, *M. nederlandicus* CNUFC CY2271 forms unbranched and sympodially branched sporangiophores, with globose and subglobose columellae, as well as ellipsoid sporangiospores.

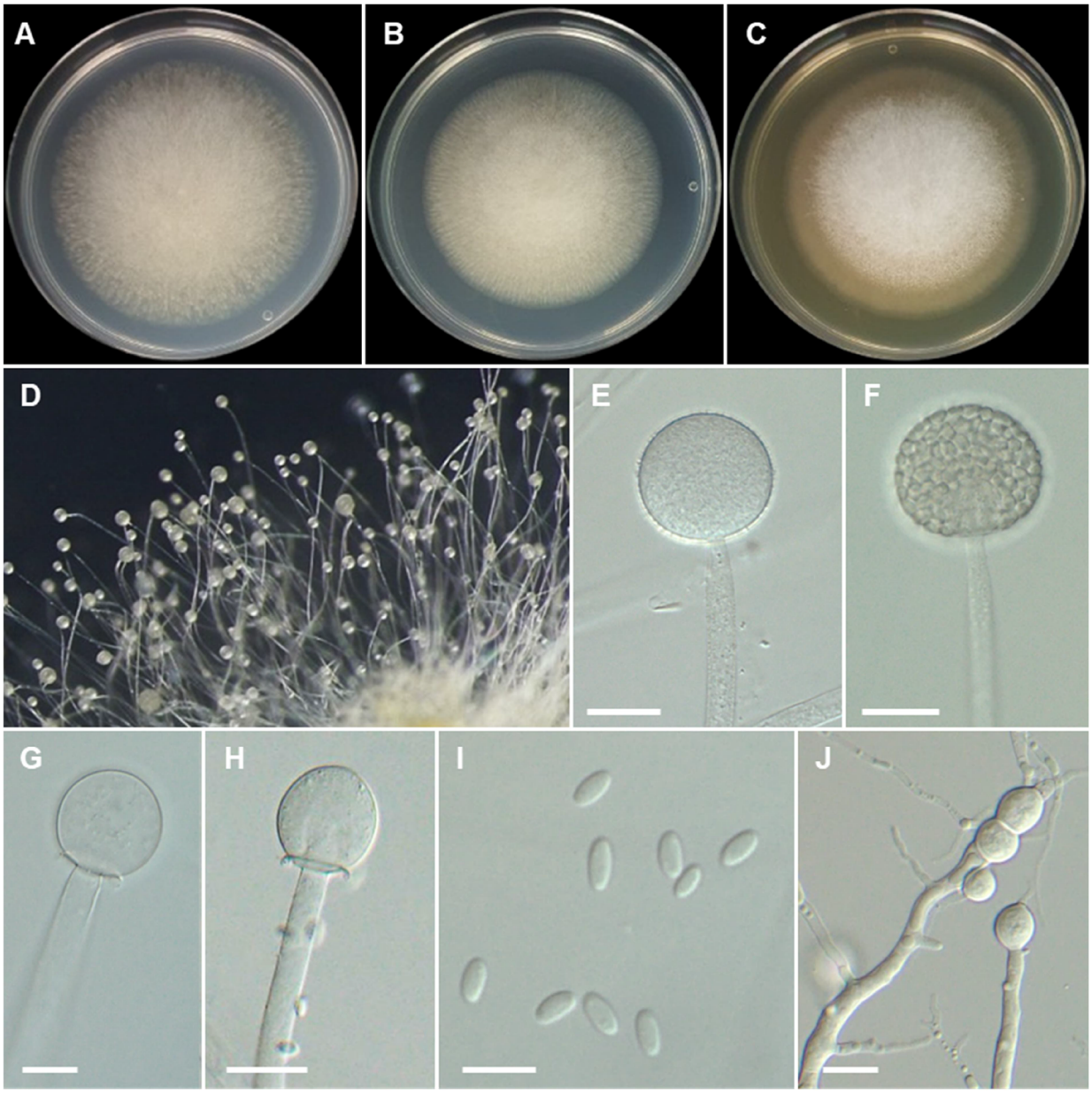

Figure 7. *Mucor nederlandicus* (CNUFC CY2271). A, Colony on SMA. B, Colony on PDA. C, Colony on MEA. D, Sporangiophores with sporangia. E, F, Young and mature sporangia. G, H, Columellae with collars. I, Sporangiospores. J, Chlamydospores. Scale bars = 20 µm.

This closely resembles the species of *M. nederlandicus* described by Schipper [49] and Hurdeal et al. [50]. To the best of our knowledge, this species has only been reported from the soil in the USA [49] and from the soil and fruiting body of *Russula* sp. in Thailand [50, 51]. For the first time, we report the isolation of *M. nederlandicus* from soil sample in South Korea, marking the third global report of this species.

As shown in Figure 4, our newly identified strain CNUFC GCW-3 is monophyletic with *Poitrasia circinans* (CBS 153.58, CBS 647.70). CNUFC GCW-3 is morphologically most similar to *P. circinans* described by Kirk [26] as follows: simple, non-septate, unbranched sporangiophores, and ellipsoid to broadly ellipsoid sporangiospores. However, their sporangiospores were smaller than those observed in our isolate. *Poitrasia circinans* has been isolated from soil in Florida, USA, Sri Lanka, and Trinidad and Tobago [6, 26]. In this regard, our isolation of *P. circinans* from freshwater in South Korea suggests that this species has a broad ecological niche and geographic distribution.

The species within the orders *Mucorales* and *Mortierellales* in Korea are not yet fully elucidated. New inventories in the Korean ecosystems may reveal a high richness of species in these basal fungal orders.

Figure 8. *Poitrasia circinans* (CNUFC GCW-3). A, Colony on SMA. B, Colony on PDA. C, Colony on MEA. D, Sporangiophores with sporangia. E, Sporangium surface breaks to release sporangiospores. F-H, Typical columellae. I, Sporangiospores with appendages. Scale bars: E–H = 20 µm, I = 10 µm.

Key to *Backusella* species of Korea

1. Chlamydospores not present 2
1. Chlamydospores present 4
2. Sporangiola formed 3
2. Sporangiola not formed..... *B. oblongispora*
3. Unispored sporangiola abundant ..... *B. circina*
3. Unispored sporangiola 5
4. Multispores sporangiola globose to subglobose, up to 26 sporangiospores..... *B. chlamydospora*
4. Multispores sporangiola globose to subglobose, containing 2–12 sporangiospores.....*B. terrestris*
5. Columellae of sporangia with varied shapes, maximum growth temperature 32 °C..... *B. obliqua*
5. Columellae of sporangia with varied shapes, maximum growth temperature 39 °C.....*B. thermophila*
6. Sporangiospores with varied shapes .....*B. varians*
6. Sporangiospores globose to subglobose..... *B. locustae*
7. Colonies white to light gray; yeast-like cells abundant ..... *B. koreana*

7. Colonies white; yeast-like cells absent…… ……. *B. oblongielliptica*

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