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Phytophthora: taxonomic and phylogenetic revision of the genus

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Abstract: Many members of the *Oomycota* genus *Phytophthora* cause economic and environmental impact diseases in nurseries, horticulture, forest, and natural ecosystems and many are of regulatory concern around the world. At present, there are 223 described species, including eight unculturable and three lost species. Twenty-eight species need to be redescribed or validated. A lectotype, epitype or neotype was selected for 20 species, and a redescription based on the morphological/molecular characters and phylogenetic placement is provided. In addition, the names of five species are validated: *P. cajani*, *P. honggalleglyana* (Synonym: *P. hydropathica*), *P. megakarya*, *P. pisi* and *P. pseudopolonica* for which morphology and phylogeny are given. Two species, *P. ×multiformis* and *P. uniformis* are presented as new combinations. *Phytophthora palmivora* is treated with a representative strain as both lecto- and epitypification are pending. This manuscript provides the updated multigene phylogeny and molecular toolbox with seven genes (ITS rDNA, *β-tub*, *COI*, *EF1α*, *HSP90*, *L10*, and *YPT1*) generated from the type specimens of 212 validly published, and culturable species (including nine hybrid taxa). The genome information of 23 types published to date is also included. Several aspects of the taxonomic revision and phylogenetic re-evaluation of the genus including species concepts, concept and position of the phylogenetic clades recognized within *Phytophthora* are discussed. Some of the contents of this manuscript, including factsheets for the 212 species, are associated with the "*IDphy*: molecular and morphological identification of *Phytophthora* based on the types" online resource (https://idtools.org/tools/1056/index.cfm). The first version of the *IDphy* online resource released to the public in September 2019 contained 161 species. In conjunction with this publication, we are updating the *IDphy* online resource to version 2 to include the 51 species recently described. The current status of the 223 described species is provided along with information on type specimens with details of the host (substrate), location, year of collection and publications. Additional information is provided regarding the ex-type culture(s) for the 212 valid culturable species and the diagnostic molecular toolbox with seven genes that includes the two metabarcoding genes (ITS and *COI*) that are important for Sanger sequencing and also very valuable Molecular Operational Taxonomic Units (MOTU) for second and third generation metabarcoding High-throughput sequencing (HTS) technologies. The *IDphy* online resource will continue to be updated annually to include new descriptions. This manuscript in conjunction with *IDphy* represents a monographic study and the most updated revision of the taxonomy and phylogeny of *Phytophthora,* widely considered one of the most important genera of plant pathogens.

Key words: *IDphy*, identification, molecular toolbox, multilocus phylogeny, new taxa, online resource, *Phytophthora*, redescription, revision, taxonomy, typification, validation.

Taxonomic novelties: New species: *Phytophthora cajani* K.S. Amin, Baldev & F.J. Williams *ex* Abad, *Phytophthora honggalleglyana* Abad, *Phytophthora megakarya* Brasier & M.J. Griffin *ex* Abad, *Phytophthora pisi* Heyman *ex* Abad, *Phytophthora pseudopolonica* W.W. Li, W.X. Huai & W.X. Zhao *ex* Abad & Kasiborski; **New combinations:** *Phytophthora ×multiformis* (Brasier & S.A. Kirk) Abad, *Phytophthora uniformis* (Brasier & S.A. Kirk) Abad; **Epitypifications (basionyms):** *Peronospora cactorum* Lebert & Cohn, *Pythiacystis citrophthora* R.E. Sm. & E.H. Sm., *Phytophthora colocasiae* Racib., *Phytophthora drechsleri* Tucker, *Phytophthora erythroseptica* Pethybr., *Phytophthora fragariae* Hickman, *Phytophthora hibernalis* Carne, *Phytophthora ilicis* Buddenh. & Roy A. Young, *Phytophthora inundata* Brasier *et al.*, *Phytophthora megasperma* Drechsler, *Phytophthora mexicana* Hotson & Hartge, *Phytophthora nicotianae* Breda de Haan, *Phytophthora phaseoli* Thaxt., *Phytophthora porri* Foister, *Phytophthora primulae* J.A. Toml., *Phytophthora sojae* Kaufm. & Gerd., *Phytophthora vignae* Purss, *Pythiomorpha gonapodyides* H.E. Petersen; **Lectotypifications (basionym):** *Peronospora cactorum* Lebert & Cohn, *Pythiacystis citrophthora* R.E. Sm. & E.H. Sm., *Phytophthora colocasiae* Racib., *Phytophthora drechsleri* Tucker, *Phytophthora erythroseptica* Pethybr., *Phytophthora fragariae* Hickman, *Phytophthora hibernalis* Carne, *Phytophthora ilicis* Buddenh. & Roy A. Young, *Phytophthora megasperma* Drechsler, *Phytophthora mexicana* Hotson & Hartge, *Phytophthora nicotianae* Breda de Haan, *Phytophthora phaseoli* Thaxt., *Phytophthora porri* Foister, *Phytophthora primulae* J.A. Toml., *Phytophthora sojae* Kaufm. & Gerd., *Phytophthora vignae* Purss, *Pythiomorpha gonapodyides* H.E. Petersen; **Neotypifications (basionym):** *Phloeophthora syringae* Kleb., *Phytophthora meadii* McRae

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INTRODUCTION

The *Oomycota* genus *Phytophthora* is one of the most important and studied groups of plant pathogens causing devastating diseases globally with ecological, economic, social, and scientific impacts (Erwin & Ribeiro 1996, Hansen *et al.* 2012a, Brasier *et al.* 2022). The genus encompasses a range of morphologically diverse species that can be either aggressive pathogens on different

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herbaceous and woody plants, saprophytes, or opportunistic necrotrophic pathogens (Jung *et al.* 2015, Brasier *et al.* 2022, Abad *et al.* 2023). The frequent association of *Phytophthora* species with plant diseases, from crops to ornamental and forest hosts, and their increased detection in natural and forest ecosystems in different geographical and climatic areas of the world over the last decades, have stimulated substantial interest in this group (Jung *et al.* 2022a, Chen *et al.* 2022, Abad *et al.* 2023).

The genus *Phytophthora* (Ancient Greek for 'plant destroyer') was introduced by the German mycologist Anton De Bary with the description of *P. infestans* (Mont.) de Bary, the causal agent of the potato late blight epidemic responsible for the Irish famine between 1845 and 1849 (De Bary 1876, Abad & Abad 1997, Haas *et al.* 2009). The species was previously named *Botrytis infestans* by Montagne (1845), *Peronospora trifurcata* by Unger (1847) and *Peronospora infestans* by Caspary (1853). After the discovery of *P. infestans* the number of described *Phytophthora* species increased gradually (Erwin & Ribeiro 1996). Several species currently accepted were described between the 19th and beginning of the 20th century, such as, for example, *P. cactorum* (1886), *P. nicotianae* (1896), *P. phaseoli* (1889), *P. syringae* (1905), *P. erythroseptica* (1913), *P. meadii (1918), P. cryptogea (1919), P. palmivora* (1919), *P. capsici* (1922) and *P. cinnamomi* (1922). At that time, the description of new species and the taxonomic position of the genus *Phytophthora* were exclusively based on their morphological characteristics, especially their reproductive structures (Erwin & Ribeiro 1996, Jung *et al.* 2022a, Chen *et al.* 2022). Initial assumptions about host-specificity lead to several early facultative synonyms for species with wide host ranges, including *P. cactorum* and *P. citricola* (Waterhouse 1963).

Concepts relying on morphological features resulted in several attempts to produce tabular keys to distinguish species. Rosenbaum (1917) was the first to propose keys based on morphology, such as the sporangial dimension and shape, size and abundance of oogonia, type of antheridium, and presence or absence and size of chlamydospore to differentiate species. Tucker (1931) recognized twenty species, emphasizing the significance of ontogenetic characters of sporangia and gametangia and temperature-growth relations in classification. Leonian (1934) utilized most of Tucker's criteria but added growth characteristics in different media as a helpful tool for species identification. In her earlier work, Waterhouse (1963) recognized six groups based on a series of morphological and physiological parameters to which around 40 species were assigned. Later, she listed 60 *Phytophthora* species with a Latin description and/or a designated type (Waterhouse 1970). The Waterhouse key was further revised by Newhook *et al.* (1978) and Stamps *et al.* (1990) raising the number of *Phytophthora* species to 67. However, 19 of these were later discarded by Erwin & Ribeiro (1996) who, in their comprehensive monograph, reported 58 species, seven of which were later considered invalidly published or lost.

With the advent and advance of DNA sequencing techniques and phylogenetic methods, understanding the taxonomy and diversity of *Phytophthora* species has, over time, changed profoundly (Burgess *et al.* 2021). Since 1996, several authors using sequence data have studied the phylogenetic relationships of this genus, and currently more than 200 species have been described (Jung *et al.* 2022a, Chen *et al.* 2022, Abad *et al.* 2023). Most of the newly described species were recovered from forest and natural ecosystems (Jung *et al.* 2002, 2011, 2016, 2017b, 2022, Scanu *et al.* 2015, Burgess *et al.* 2018, Bose *et al.* 2021). However, using metabarcoding approaches, new taxa are also being discovered in anthropized ecosystems investigated for decades and historically assumed to be well known (Prigigallo *et al.* 2016, Burgess *et al.* 2017, 2022, Bose *et al.* 2018, Riddell *et al.* 2019, Khdair *et al.* 2020a, Riolo *et al.* 2020, Gyeltshen *et al.* 2021, La Spada *et al.* 2022). Considering the exponential increase of newly described species in the last years, probably another 200–400 species may remain to be discovered (Brasier 2009, Scott *et al.* 2019a).

Phytophthora species morphologically resemble members of the kingdom *Fungi* (*Eumycota*), but are oomycetes (Phylum *Oomycota*), within kingdom *Stramenopila* (Beakes & Sekimoto 2009). Although previously placed in the *Pythiaceae*, the higher-level classification of the genus is within the family *Peronosporaceae*, order *Peronosporales* and class *Peronosporomycetes* (Fig. 1). Besides *Phytophthora*, the *Peronosporaceae* contains four genera of early-diverging, culturable organisms and 20 genera of unculturable pathogenic biotrophs collectively known as downy mildews (DMs) (Figs 1, 2).

The first phylogenetic study of the genus based on ITS rDNA sequences included 50 described *Phytophthora* species and separated the genus into eight phylogenetic clades (Clades 1–8) and two putatively more distantly related clades (Clades 9 and 10) (Cooke *et al.* 2000). This phylogenetic clade structure was supported by Kroon *et al.* (2004) who added four additional genes (*COI*, *β-tub*, *EF1α* and *nadh*1) for the evaluation of 48 species. This infrageneric structure was later confirmed by multigene phylogenetic analysis of 82 *Phytophthora* species using seven loci, including 60S ribosomal protein *L10*, *tub2*, enolase, heat shock protein90 (*HSP90*), large subunit rDNA, *TigA* gene fusion and *tef1* (Blair *et al.* 2008). Despite adding many new species and subsequent multigene phylogenetic studies, including several mitochondrial genes, the clades have remained structurally stable except for the placement of *P. quercina* (Robideau *et al.* 2011, Kroon *et al.* 2012, Martin *et al.* 2014). However, Rahman *et al.* (2015) proposed an eleventh clade for isolates of *P. lilii*, as they formed a separate monophyletic group from the phylogenetic clades defined by Blair *et al.* (2008). In a comprehensive phylogeny with 142 described and 43 provisionally named *Phytophthora* species, Yang *et al.* (2017) stated that *P. lilii* could not be assigned to a distinct clade, due to the relatively low clade-to-clade resolutions and concluded that further analyses were warranted to determine whether this unique species should be assigned to a new clade. Jung *et al.* (2017a) constructed a multigene phylogeny based on nuclear ITS, *β-tub* and *HSP90* and mitochondrial *cox*1 and *nadh*1 gene sequences and accommodated *P. quercina*, and the newly described species *P. castanetorum* and *P. tubulina,* to Clade 12. The species was previously assigned to Clades 3, 4 and 1 (Cooke *et al.* 2014). Another species, *P. stricta* had a phylogenetic position that varied depending on the type of analysis and loci used but appeared to constitute a separate clade as well (Yang *et al.* 2017). Clades 1–12 were validated and additional clades (13–16) were proposed by Bourret *et al.* (2018); these additional clades include the provisional species *Phytophthora* taxon mugwort (Clade 13), the unculturable *P. cyperi* (Clade 14) and the recently-described species *P. podocarpi* (previously *P.* taxon totara) (Clade 15) (Dobbie *et al.* 2022), with the DMs placed into Clades 15 and 16. The classification scheme based on grouping *Phytophthora* into phylogenetic clades has so far proved to be reasonably robust and at the same time flexible enough to accommodate both newly discovered taxa and historically consolidated species.

Several studies have now shown the downy mildews (DMs) reside within *Phytophthora*, with the DMs being either monophyletic or polyphyletic and *Phytophthora* paraphyletic in cladistic terms

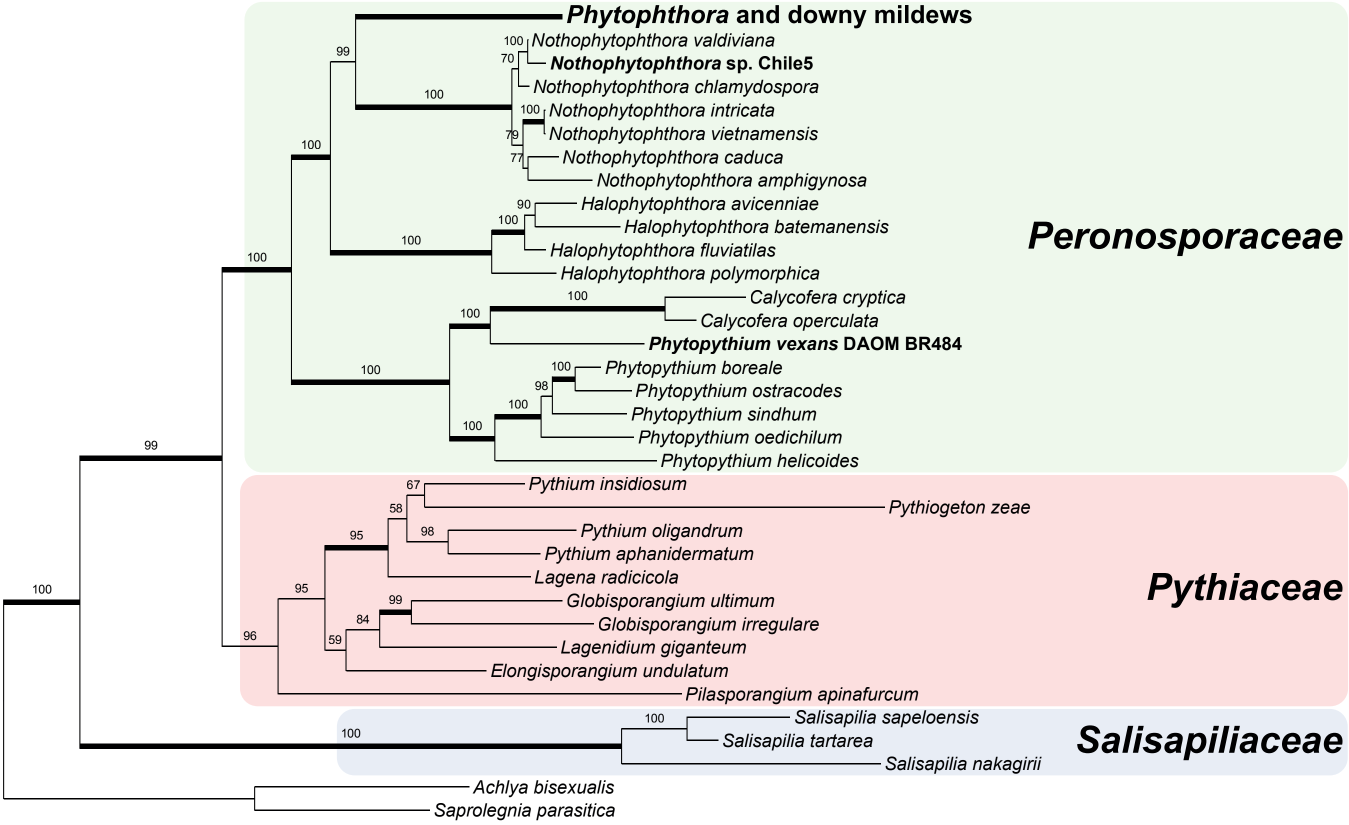

Fig. 1. Order *Peronosporales*. Maximum likelihood tree inferred with IQ-TREE v. 2 from a three-loci (ITS, *COI* and *β-tub*) alignment (Supplementary Table S1). Ultrafast bootstrap support values ≤ 50 % are not shown. The strains employed as outgroups for the remainder of the phylogenetic inference are shown in bold. The uncollapsed version of this tree is available as Supplementary Fig. S1.

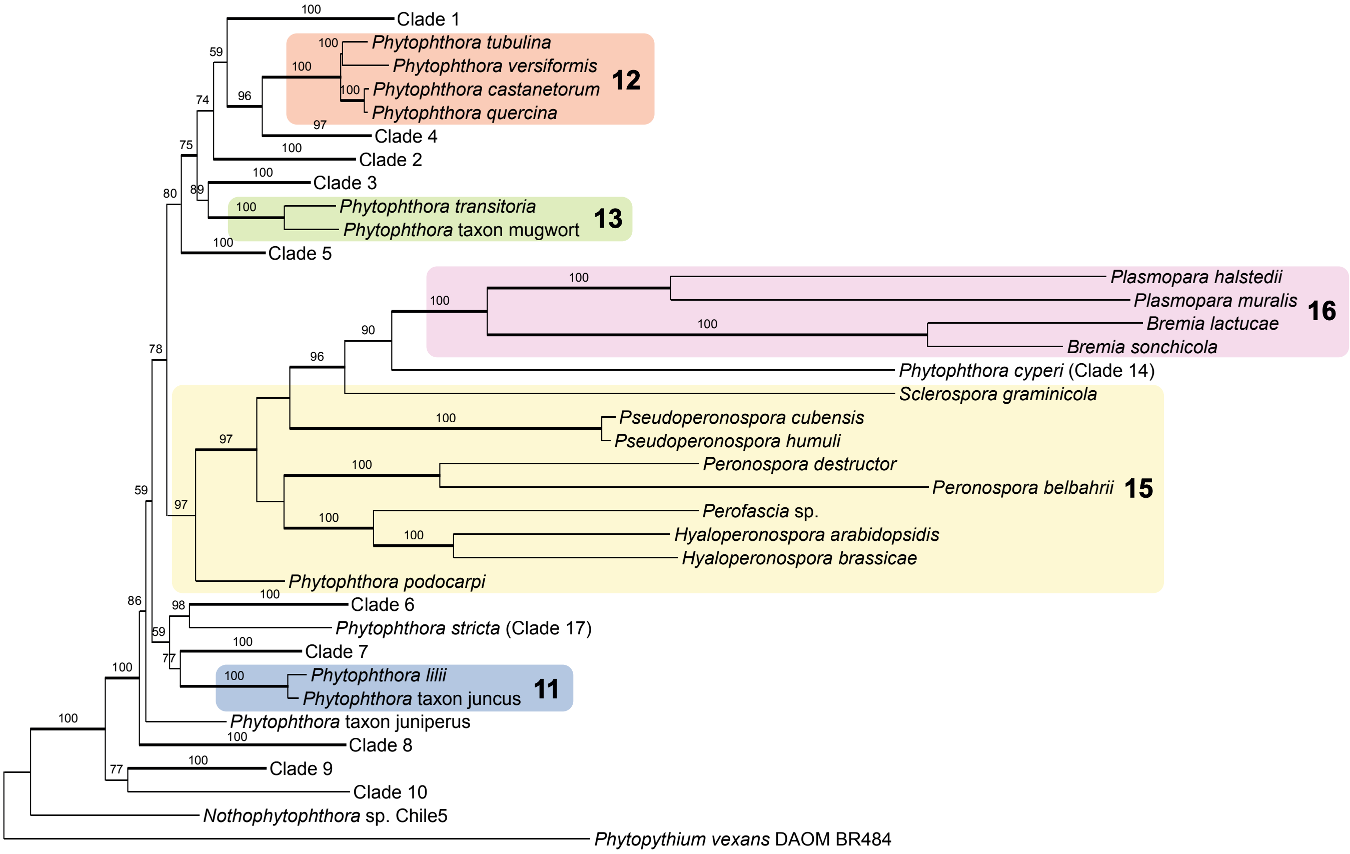

Fig. 2. Numbered clades of *Phytophthora*, and obligate biotrophic taxa including downy mildews. Maximum likelihood tree inferred with IQ-TREE v. 2 from a five-loci (*COI*, *β-tub*, *EF1α*, *L10* and *HSP90*) alignment (Supplementary Table S1). The original ten clades (Clades 1–10) were collapsed for display purposes. The numbering of Bourret *et al.* (2018) was followed for Clades 14–16 despite topological differences. The uncollapsed version of this tree is available as Supplementary Fig. S2.

(Cooke *et al.* 2000, Runge *et al.* 2011, Thines & Choi 2016, Bourret *et al.* 2018, Scanu *et al.* 2021) (Fig. 2). It has been suggested to split *Phytophthora* into several genera based on its paraphyletic nature (Runge *et al.* 2011, Crous *et al.* 2021c). However, this would entail substantial taxonomic and nomenclatural changes with a strong impact on both the scientific communication and the management of diseases caused by these pathogens (Brasier *et al.* 2022). While different taxonomic criteria are being discussed, it would be prudent to consolidate the current taxonomy based on clades, which has proven to be phylogenetically informative and has been almost universally adopted by the scientific community. To make this goal a reality, knowledge must be systematized and made available to a broad audience.

Abad *et al.* (2023) highlighted that despite the increase in new *Phytophthora*-related studies worldwide, there is still a lack of standard databases gathering both morphology and molecular information based on type material and well-authenticated specimens that are consistently curated and maintained over time. According to the International Code of Nomenclature for algae, fungi and plants (https://www.iapt-taxon.org/nomen/main.php), a type designation serves to link the name for a given species to a physical entity (a dry specimen, or a 'metabolically inactive culture', or in special cases, an illustration), which is selected to represent that name (Turland *et al.* 2018). A type specimen or an ex-type culture (a living strain obtained from the type) then serves as the standard for future comparative analyses.

In the genus *Phytophthora,* the use and the importance of the types has not always been considered, even when describing related species, often generating confusion and misidentification of species (Abad *et al.* 2023). Additionally, due to incorrectly named specimens (and sequence data) at NCBI, misidentification of species is continuing; most notably for *P. alticola, P. boehmeriae, P. citricola, P. erythroseptica, P. parsiana*, and *P. richardiae* (Abad *et al.* 2023). For the description of *P. heterospora*, Scanu *et al.* (2021) considered *P. palmivora* var. *heterocystica* might be a synonym. However, no specimens or DNA sequence data linked to the original description of the variety are available to confirm this hypothesis. *Phytophthora infestans*, the type species of the genus, has only recently been epitypified, despite its official description in 1876 (Chen *et al.* 2022). The type species concept has been questioned as it does not reflect the broad variability within populations (Brasier 1991). However, types are an attempt to materialize a concept based on representative metabolically inactive organisms (types) or living organisms (ex-types). Many ex-types are often old and have undoubtedly changed their morphological, physiological, and even genetic properties. Although the exclusive focus on type strains has undeniable limits because it tends to ignore intraspecific variability and is not informative of the species boundaries, the definition of type specimens for all the described species of *Phytophthora* according to the ICNafp has some advantages, not least that of being a reference for a stable taxonomic system. To partly circumvent the limits of a taxonomic system relying on type specimens, novel species descriptions should include more than a single strain, naming genetically distinct paratypes (a specimen cited in the protologue other than the holotype or isotype) to provide access to intraspecific phenotypic and genotypic diversity (for example Vettraino *et al.* 2011, Scanu *et al*. 2021, Jung *et al*. 2022).

Approximately 27 *Phytophthora* species need to be redescribed or revalidated as the type or ex-type has been lost at international herbaria or culture collections or the species have been incorrectly described. In addition, type, ex-types or authentic material for three species (*P. japonica*, *P. inflata*, and *P. italica*) have been lost (no specimens exist in any collection or laboratory worldwide) and eight species are unculturable and have therefore not been evaluated in previous and our phylogenetic analysis with the ex-types (*P. cyperi*, *P. cyperi-bulbosi*, *P. eriugena*, *P. lepironiae*, *P. leersiae*, *P. oryzo-bladis*, *P. polygoni* and *P. verrucosa*). In the group of 27 species there are five species that are invalid (*P. cajani*, *P. hydropathica, P. megakarya, P. pisi* and *P. pseudopolonica*) as the respective descriptions do not follow the rules of the ICNafp. This review examines all the currently known 212 *Phytophthora* species, based on their morphological characters and phylogenetic relationships, in a comprehensive scheme founded on clades. The findings are supported by *IDphy* v. 2 (https://idtools.org/tools/1056/index.cfm) online resource including the factsheets for 212 species and the morphological and molecular identification tools for culturable species (Abad *et al.* 2023). In this version of *IDphy* we have updated the tabular key, lucid key, and molecular information for the 212 species, presented new factsheets for 51 species described after September 2019, and listed genomes for 23 culture types (Tables 1–3). The authors intend to provide a baseline tool to researchers who want to identify isolates or describe new species of *Phytophthora* and also for those who are approaching the study of this *Oomycota* genus for the first time.

MORPHOLOGICAL PROTOCOLS AND IDENTIFICATION

Protocols for isolation, maintenance, storage of isolates, methods for sporulation, and other tasks related to morphological identification are presented as SOP-PID-06.01 and SOP-PID-07.01 of the Morphology Section of *IDphy* (https://idtools.org/tools/1056/index.cfm?pageID=1878). This section also contains aspects of the morphological characters of the asexual and sexual morphs useful for correct identification of species including colony morphology. In order to facilitate the work for researchers that need access to the protocols we are including it with this manuscript as Supplementary file S1 - Methods for isolation, maintenance, sporulation, and storage of *Phytophthora* species.

Isolates

In this study we have evaluated approximately 182 culture type specimens including ex-types (ET), ex-epitypes (EEpT) and ex-neotypes (ENT) that were acquired by Gloria Abad (USDA-APHIS-PPQ-S&T-PPCDL) from the World *Phytophthora* Collection at University of California in Riverside or provided by Gerard Verkleij from the Westerdijk Fungal Biodiversity Institute, the Netherlands (https://wi.knaw.nl/page/fungal_table) and from other co-authors including Treena Burgess, Bruno Scanu, and Koji Kageyama, and other collaborators (https://idtools.org/tools/1056/index.cfm?pageID=1542) for the implementation of *IDphy* online resource and this manuscript. These specimens were examined by morphological and molecular characterization. Additional information for these and other species was obtained from the original publications of the 212 species and is presented at the factsheets of each of the species (https://idtools.org/tools/1056/index.cfm?packageID=1131) and in Tables 1–5.

Table 1. List of 223 described *Phytophthora* species until December 2022 including the 212 valid culturable species and three and eight unculturable species (non-validated).

***Phytophthora* species**	**MycoBank**	**Host, country, year of collection**	**Type[1]**	**Reference(s)**
P. abietivora D.W. Li, N.P. Schultes, J.A. LaMondia & R.S. Cowles (2019)	MB 830083	infected roots of *Abies fraseri*, USA, 2017	UAMH 12075 (T)	Li *et al.* (2019)
P. acaciae A.F. dos Santos, T.C.A. Alves, D.J. Tessmann, K.L. Ivors & J.B. Ristaino (2019)	MB 823684	*Acacia mearnsii* trunk, BRAZIL, 1999	MBM 415188 (T)	Alves *et al.* (2019)
P. acaciivora T.Q. Pham, T.I. Burgess & Q.N. Dang (2020)	MB 834471	dying seedlings of *Acacia mangium*, VIETNAM, 2012	MURU 480 (T)	Burgess *et al.* (2020)
P. acerina B. Ginetti, T. Jung, D.E.L. Cooke & S. Moricca (2014)	MB 804019	bleeding canker of *Acer pseudoplatanus*, ITALY, 2010	FI AGR 057 (T)	Ginetti *et al.* (2014)
P. afrocarpa T. Bose & J.M. Hulbert (2021)	MB 838532	rhizosphere soil of *Afrocarpus falcatus*, SOUTH AFRICA, 2017	PREM 63082 (T)	Bose *et al.* (2021)
P. agathidicida B.S. Weir, Beever, Pennycook & Bellgard (2015)	MB 550518	bleeding trunk *Agathis australis*, NEW ZEALAND, 2006	PDD 91595 (T)	Weir *et al.* (2015)
P. aleatoria P.M. Scott, R. McDougal & P.M. Taylor (2019)	MB 830076	*Pinus radiata* seedling, NEW ZEALAND, 2014	NZFS 4037 (T) dried culture	Scott *et al.* (2019b)
P. alpina Bregant, Montecchio & Linald. (2020)	MB 836109	rhizosphere of declining *Alnus viridis* tree, ITALY, 2019	CBS H-24392 (T)	Bregant *et al.* (2020)
P. alticola Maseko, Cout. & M.J. Wingf. (2007) emend. Bose *et al.* (2017)	MB 511177	collar and root rot of *Eucalyptus grandis*, SOUTH AFRICA, 2014	PREM 61767 (NT)	Bose *et al.* (2017)
P. amaranthi J.P. Ann & W.H. Ko (2016)	MB 809424	leaf, stem and root rot of *Amaranthus tricolor*, TAIWAN, 2007	F0027621 (T)	Ann *et al.* (2016)
P. amnicola T.I. Burgess & T. Jung (2012)	MB 563849	Baited stream water, AUSTRALIA, 2009	MURU 471 (T)	Burgess *et al.* (2012), Crous *et al.* (2012)
P. andina Adler & Flier (2010)	MB 514427	leaf and fruit blight of *Solanum brevifolium*, ECUADOR, 2001	**P13365 WPC (T)**	Oliva *et al.* (2010)
P. aquae-cooljarloo Mostowf. & T.I. Burgess (2020)	MB 835165	pond water, AUSTRALIA, 2017	MURU484 (T)	Mostowfizadeh-Ghalamfarsa & Burgess (2020), Crous *et al.* (2020b)
P. aquimorbida C.X. Hong (2012)	MB 513049	from agricultural irrigation water reservoirs, USA, 2006	VPI [as 'VTMH'] 11739 (T)	Hong *et al.* (2012)
P. arenaria A. Rea, Stukely & T. Jung (2011)	MB 518792	soil of *Eucalyptus drummondii*, AUSTRALIA, 2009	MURU 455 (T)	Rea *et al.* (2011)
P. asiatica M.Z. Rahman, H. Mukobata & Kageyama (2014)	MB 804495	leaf and stem blight of *Pueraria lobata*, JAPAN, 2005	NBRC H-13112 (T)	Rahman *et al.* (2014a)
P. asparagi Saude & Hausbeck (2012)	MB 569000	shoots, crown and root rot of *Asparagus officinalis*, Michigan, USA, 2006	CUP SP326 (T)	Granke *et al.* (2012), Crous *et al.* (2012)
P. attenuata T. Jung, M. Horta Jung, Scanu & Bakonyi (2017)	MB 816566	rhizosphere soil of *Castanopsis carlesii*, TAIWAN, 2013	CBS H-22552 (T)	Jung *et al.* (2017b)
P. austrocedri Gresl. & E.M. Hansen (2007)	MB 530225	stem and root rot of *Austrocedrus chilensis*, ARGENTINA, 2005	CIEFAP 203 (T)	Greslebin *et al.* (2007)
P. aysenensis M. Zapata, M.C. Asenjo & M. Gut. (2020)	MB 833553	collar and stem rot of *Aristotelia chilensis*, CHILE, 2016	RGM 2753 (T)	Zapata *et al.* (2020), Crous *et al.* (2020a)
P. balyanboodja T.I. Burgess (2018)	MB 822009	rhizosphere soil of mixed native vegetation, AUSTRALIA, 2015	MURU 475 (T)	Burgess *et al.* (2018)
P. betacei Mideros, L.E. Lagos & S. Restrepo (2018)	MB 815748	leaf blight of *Solanum betaceum*, COLOMBIA, 2008	Andes-F 1172 (T)	Mideros *et al.* (2018)
P. bilorbang Aghighi, G.E. Hardy, J.K. Scott & T.I. Burgess (2012)	MB 563863	rhizosphere soil of dying *Rubus anglocandicans*, AUSTRALIA, 2010	MURU 470 (T)	Aghighi *et al.* (2012)

Table 1. (Continued).

***Phytophthora* species**	**MycoBank**	**Host, country, year of collection**	**Type[1]**	**Reference(s)**
P. bishii Abad, J.A. Abad & Louws (2008)	MB 532906	root rot of *Fragaria ×ananassa*, USA, 1999	BPI 878369 (T)	Abad *et al.* (2008)
P. boehmeriae Sawada (1927)	MB 258590	leaves of *Boehmeriae nivea*, TAIWAN, 1927	IMI180614 (T)	Sawada (1927)
P. boodjera Simamora & T.I. Burgess (2015)	MB 809223	nursery soil dump, AUSTRALIA, 2012	MURU 470 (T)	Simamora *et al.* (2015)
P. borealis E.M. Hansen, W. Sutton & Reeser (2012)	MB 564286	stream water, Alaska, USA, 2008	OSC 144115 (T)	Hansen *et al.* (2012b)
P. botryosa Chee (1969)	MB 336993	leaf and petiols of *Hevea brasiliensis*, MALAYSIA, 1966	IMI 136915 (T)	Chee (1969)
P. brassicae De Cock & Man in 't Veld (2002)	MB 378137	*Brassica oleracea*, NETHERLANDS, 1986	**CBS 179.87** (T)	Man in 't Veld *et al.* (2002)
P. cactorum (Lebert & Cohn) J. Schröt. (1886)	MB 199322	*Syringa vulgaris*, NETHERLANDS, 1930	CBS H-25066 (EpT)	Schröter (1886). **Epitypification in the present publication**.
P. cacuminis I. Khaliq & T.I. Burgess (2019)	MB 825231	root rot of *Eucalyptus coccifera*, AUSTRALIA, 2016	MURU 482 (T)	Khaliq *et al.* (2019)
P. cajani K.S. Amin, Baldev & F.J. Williams ex Abad *sp. nov.* (2023)	MB 846822	stem blight of *Cajanus cajan,* INDIA	**ATCC 44388 (T)**	Amin *et al.* (1978). **Validation in the present publication**.
P. capensis Bezuid., Denman, A. McLeod & S.A. Kirk (2010)	MB 518805	roots of *Curtisia dentata*, SOUTH AFRICA, 2004	P1819 -H WPC (T)	Bezuidenhout *et al.* (2010)
P. capsici Leonian (1922)	MB 259718	stem and fruit blight of *Capsicum annuum*, USA, 1920	MICH 4874 (T)	Leonian (1922)
P. captiosa M.A. Dick & K. Dobbie (2006)	MB 356996	leaves of *Eucalyptus saligna*, NEW ZEALAND, 1992	NZFRI-M 5215 (T)	Dick *et al.* (2006)
P. caryae N.J. Brazee, X. Yang & C.X. Hong (2016)	MB 817838	baited *Rhododendron* leave from river water, USA, 2013	ATCC TSD-54 (T)	Brazee *et al.* (2016)
P. castaneae Katsura & K. Uchida (1976)	MB 283626	trunk rot of chesnut *Castanea crenata*, JAPAN 1971	Plant Pathology Herbarium, Kyoto Prefectural University, Japan no. 1971-031 (T)	Katsura (1976), Weir *et al.* (2015)
P. castanetorum T. Jung, M. Horta Jung, Bakonyi & Scanu (2017)	MB 819699	rhizosphere soil of *Castanea sativa*, PORTUGAL, 2015	CBS H-22983 (T)	Jung *et al.* (2017a)
P. cathayensis C. Morales-Rodríguez, Y. Wang & A. Vannini (2020)	MB 834619	*Carya cathayensis* tree with collar canker, CHINA, 2017	**CGMCC 19655 (T)**	Morales-Rodriguez *et al.* (2020)
P. celebensis Jung, M. Junaid, N. Nasri & I. Milenković (2022)	MB 843002	naturally fallen leaf in stream in tropical rainforest, INDONESIA, 2019	HNHM-MYC-021540 (T)	Jung *et al.* (2022b)
P. chesapeakensis Man in 't Veld & K. Rosend. (2019)	MB 817847	rotten seeds of *Zostera marina*, USA, 2014	**CBS 140655 (T)**	Man in 't Veld *et al.* (2019)
P. chilensis T. Jung, M. Horta Jung, A. Durán & I. Milenković (2022)	MB 842946	baited from stream in *Rhododendron* leaf, CHILE, 2014	HNHM-MYC-009700 (T)	Jung *et al.* (2022b)
P. chlamydospora Brasier & E.M. Hansen (2015)	MB 809175	ornamental *Prunus*, UK, 1971	OSC 153153 (T)	Hansen *et al.* (2015)
P. chrysanthemi M. Naher, H. Watan., Chikuo & K. Kageyama (2011)	MB 560577	root rot of *Chrysanthemum ×morifolium*, JAPAN, 2000	NBRC 104917 (T)	Naher *et al.* (2011)
P. cichorii Bertier, H. Brouwer, de Cock & D.E.L. Cooke (2013)	MB 803102	root of *Cichorium intybus* var. *foliosum*, NETHERLANDS, 2004	CBS H-21127 (T)	Bertier *et al.* (2013a)
P. cinnamomi Rands (1922)	MB 260884	cortex of *Cinnamomum burmannii*, INDONESIA, 1922	CBS H-7638 (IT)	Rands (1922)
P. citricola Sawada (1927)	MB 260970	fruit of *Citrus sinensis*, TAIWAN, 1927	IMI 21173 (T)	Sawada (1927)
P. citrophthora (R.E. Sm. & E.H. Sm.) Leonian (1925)	MB 251464	gummosis of *Citrus* tree, USA	**CBS 950.87 (EpT)**	Leonian (1925). **Epitypification in the present publication**.

Table 1. (Continued).

***Phytophthora* species**	**MycoBank**	**Host, country, year of collection**	**Type^1**	**Reference(s)**
P. clandestina P.A. Taylor, Pascoe & F.C. Greenh. (1985)	MB 105695	root rot of *Trifolium subterraneum* subsp. *yanninium* cv. Yarloop, AUSTRALIA, 1985	VPRI 12234 (T)	Taylor *et al.* (1985)
P. cocois B.S. Weir, Beever, Pennycook, Bellgard & J.Y. Uchida (2015)	MB 550519	diseased fruit of *Cocos nucifera*, Hawaii, USA, 1990	PDD 103199 (T)	Weir *et al.* (2015)
P. colocasiae Racib. (1900)	MB 232219	leaves of *Colocasia esculenta*, INDONESIA	CBS H-25067 (EpT)	Raciborski (1900). **Epitypification in the present publication.**
P. condilina T.I. Burgess (2018)	MB 822010	rhizosphere soil of dying *Casuarina obesa*, AUSTRALIA, 2011	MURU 476 (T)	Burgess *et al.* (2018)
P. constricta A. Rea, Stukely & T. Jung (2011)	MB 518793	soil dying of Kwongan vegetation, AUSTRALIA, 2006	MURU 454 (T)	Rea *et al.* (2011)
P. cooljarloo T.I. Burgess (2018)	MB 822011	rhizosphere soil of dying *Hibbertia* sp., AUSTRALIA, 2008	MURU 479 (T)	Burgess *et al.* (2018)
P. crassamura Scanu, A. Deidda & T. Jung (2015)	MB 814006	rhizosphere soil of a dying *Juniperus phoenicea*, ITALY, 2012	CBS H-22392 (T)	Scanu *et al.* (2015)
P. cryptogea Pethybr. & Laff. (1919)	MB 231743	roots/stem rot of *Solanum lycopersicum*, IRELAND, 1916	CBS H-7640 (IT)	Pethybridge & Lafferty (1919)
P. dauci Bertier, H. Brouwer & De Cock (2013)	MB 803103	roots of *Daucus carota*, FRANCE, 2009	CBS H-21128 (T)	Bertier *et al.* (2013a)
P. docyniae Q.N. Dang, T.H. Nguyen & T.I. Burgess (2021)	MB840241	soil and root of *Docynia indica*, VIETNAM, 2019	CBS H-24780 (T)	Dang *et al.* (2021), Crous *et al.* (2021b)
P. drechsleri Tucker (1931)	MB 251892	from *Beta vulgaris* var. *altissima*, California USA. Tucker authentic isolate	CBS H-25068 (EpT)	Tucker (1931). **Epitypification in the present publication.**
P. elongata A. Rea, M. Stukely & T. Jung (2010)	MB 515142	rhizosphere of *Eucalyptus marginata*, AUSTRALIA, 2004	MURU 453 (T)	Rea *et al.* (2010)
P. emzansi T. Bose, T. Paap & J.M. Hulbert (2021)	MB 838530	rhizosphere soil of *Afrocarpus falcatus*, SOUTH AFRICA, 2017	PREM 63081 (T)	Bose *et al.* (2021)
P. erythroseptica Pethybr. (1913)	MB 231826	tuber rot of *Solanum tuberosum*, IRELAND, 1989	CBS H-25069 (EpT)	Pethybridge (1913). **Epitypification in the present publication.**
P. estuarina Marano, A.L. Jesus & Pires-Zottar. (2016)	MB 551608	leaves of *Laguncularia racemosa*, BRAZIL, 2013	SP 466380 (T)	Li *et al.* (2016)
P. europaea E.M. Hansen & T. Jung (2002)	MB 484596	rhizosphere of *Quercus robur*, FRANCE, 1998	OSC 86347 (T)	Jung *et al.* (2002)
P. fallax K. Dobbie & M.A. Dick (2006)	MB 357172	leaves of *Eucalyptus delegatensis*, NEW ZEALAND, 1997	NZFRI-M 5216 (T)	Dick *et al.* (2006)
P. flexuosa T. Jung, M. Horta Jung, Scanu & Bakonyi (2017)	MB 816571	rhizosphere soil of *Fagus hayatae*, TAIWAN, 2013	CBS H-22550 (T)	Jung *et al.* (2017b)
P. fluvialis T. Jung & T.I. Burgess (2011)	MB 561042	baited from water in native bushland AUSTRALIA, 2009	MURU 468 (T)	Jung *et al.* (2011a), Crous *et al.* (2011)
P. foliorum Donahoo & Lamour (2006)	MB 504752	Azalea ‘Pink Ruffles’, USA, 2004	**ATCC MYA-3638 (T)**	Donahoo *et al.* (2006)
P. formosa T. Jung, M. Horta Jung, Scanu & Bakonyi (2017)	MB 816568	rhizosphere of *Araucaria cunninghamii*, TAIWAN, 2013	CBS H-22551 (T)	Jung *et al.* (2017b)
P. fragariae Hickman 1940	MB 289688	roots of *Fragaria xananassa* England, UK, 1946	CBS H-25070 (EpT)	Hickman (1940). **Epitypification in the present publication.**
P. fragariaefolia M.Z. Rahman, S. Uematsu, Toru Takeuchi, K. Shirai & Kageyama (2014)	MB 804990	crown of *Fragaria ×ananassa*, JAPAN, 2005	NBRC H-13133 (T)	Rahman *et al.* (2014)
P. frigida Maseko, Cout. & M.J. Wingf. (2007)	MB 511178	collar and root rot of *Eucalyptus smithii*, SOUTH AFRICA, 2001	PREM 59222 (T)	Maseko *et al.* (2007)
P. gallica T. Jung & Nechw. (2008)	MB 497405	rhizosphere of *Quercus robur*, FRANCE, 1998	PRC-III 5/1 (T)	Jung & Nechwatal (2008)

Table 1. (Continued).

***Phytophthora* species**	**MycoBank**	**Host, country, year of collection**	**Type[1]**	**Reference(s)**
P. gemini Man in 't Veld, K. Rosend., Brouwer & De Cock (2011)	MB 519967	decaying leaves and seeds of *Zostera marina*, NETHERLANDS	**CBS 123381 (T)**	Man in 't Veld *et al.* (2011)
P. gibbosa T. Jung, M.J.C. Stukely & T.I. Burgess (2011)	MB 518763	rhizosphere soil of dying *Acacia pycnantha*, AUSTRALIA, 2009	MURU 461 (T)	Jung *et al.* (2011b)
P. gloveri Abad & Shew (2011)	MB 568754	root rot of *Nicotiana tabacum*, BRAZIL, 1995	BPI 878720 (T)	Abad *et al.* (2011)
P. gonapodyides (H. E. Petersen) Buisman (1927)	MB 252402	from lake water, England, UK	CBS H-25071 (EpT)	Buisman (1927). **Epitypification in the present publication.**
P. gondwanensis L.A. Shuttlew., K. Scarlett, R. Daniel & D.I. Guest (2015)	MB 812576	soil, AUSTRALIA, 2011	CBS H-22283 (T)	Shuttleworth *et al.* (2016), Crous *et al.* (2015)
P. gregata T. Jung, M.J.C. Stukely & T.I. Burgess (2011)	MB 518764	soil of dying *Patersonia* sp., AUSTRALIA, 2009	MURU 462 (T)	Jung *et al.* (2011b)
P. hedraiandra De Cock & Man in 't Veld (2004)	MB 500126	leaves of *Viburnum* sp., NETHERLANDS	CBS H-12856 (T)	De Cock & Lévesque (2004)
P. heterospora Scanu, Cacciola, Linal. & T. Jung (2021)	MB 841284	bark of *Olea europaea*, Sardinia, ITALY, 2010	CBS H-24777 (T)	Scanu *et al.* (2021)
P. heveae A.W. Thomps. (1929)	MB 252580	pod rot of *Hevea brasiliensis*, MALAYSIA, 1927	**CBS 296.29 (EpT)**	Thompson (1929), Weir *et al.* (2015)
P. hibernalis Carne (1926)	MB 267110	*Citrus sinensis*, AUSTRALIA	**IMI134760 (EpT)**	Carne (1926). **Epitypification in the present publication.**
P. himalsilva Vettraino, Brasier & A. Vannini (2011)	MB 517974	rhizosphere of *Quercus leucotricophora*, NEPAL, 2005	**CBS 128767 (T)**	Vettraino *et al.* (2011)
P. honggalleglyana Abad *sp. nov.* (2023)	MB 844805	irrigation water of ornamentals, USA, 2000	**VPI 11736 (T)**	Hong *et al.* (2010). **Present publication.**
P. humicola W.H. Ko & Ann (1985)	MB 105696	soil of citrus grove, TAIWAN	TAI 9017 (T)	Ko & Ann (1985)
P. hydrogena X. Yang & C.X. Hong (2014)	MB 803274	irrigation water of a nursery reservoir, USA, 2007	VTMH 14882 (T)	Yang *et al.* (2014b)
P. idaei D.M. Kenn. (1995)	MB 363440	roots of *Rubus idaeus*, UK, 1987	IMI 313728 (T)	Kennedy & Duncan (1995)
P. ilicis Buddenh. & Roy A. Young (1957)	MB 303620	*Ilex* sp., CANADA	CBS H-25072 (EpT)	Buddenhagen & Young (1957). **Epitypification in the present publication.**
P. infestans (Mont.) de Bary (1876)	MB 232148	leaf blight of *Solanum tuberosum,* NETHERLANDS, 1993	CBS H-24657 (EpT)	Jung *et al.* (2022a), Chen *et al.* (2022)
P. insolita Ann & W.H. Ko (1981)	MB 112569	soil in citrus orchard, TAIWAN, 1979	TAI 5131 (T)	Ann & Ko (1980)
P. insulinativitatica Q.N. Dang, G. Hardy & T.I. Burgess (2021)	MB 836442	rhizosphere soil from disturbed rainforest, AUSTRALIA, 2016	MURU 468 (T)	Dang *et al.* (2021)
P. intercalaris Xiao Yang, Balci, Brazee, Loyd & C.X. Hong (2016)	MB 812881	stream and irrigation water, USA, 2007	ATCC TSD-7 (T)	Yang *et al.* (2016)
P. intricata T. Jung, M. Horta Jung, Scanu & Bakonyi (2017)	MB 816569	rhizosphere soil of *Quercus tarokoensis*, TAIWAN, 2013	CBS H-22553 (T)	Jung *et al.* (2017b)
P. inundata Brasier, Sánch. Hern. & S.A. Kirk (2003)	MB 373599	from roots of *Salix matsudana*, UK, 1976	**IMI 389751 (EpT) (A2)**	Brasier *et al.* (2003). **Epitypification in the present publication.**
P. ipomoeae Flier & Grünwald (2013)	MB 805536	leaf blight of *Ipomoea longipedunculata*, MEXICO, 1999	CBS H-21401 (T)	Grünwald (2013), Crous *et al.* (2013)
P. iranica Ershad (1971)	MB 320479	roots of *Solanum melongena*, IRAN, 1999	CBS H-7642 (T)	Ershad (1971)
P. irrigata C.X. Hong & Gallegly (2008)	MB 538246	ATCC MYA-4457 substrate? USA, 2000	ATCC MYA-4457 (T)	Hong *et al.* (2008)

Table 1. (Continued).

Phytophthora species	MycoBank	Host, country, year of collection	Type[1]	Reference(s)
P. javanensis T. Jung, M. Junaid, N. Nasri & M. Horta Jung (2022)	MB 842954	naturally fallen leaf in a stream in tropical rainforest, INDONESIA, 2019	HNHM-MYC-009702 (T)	Jung *et al.* (2022b)
P. kelmanii Abad, J.A. Abad, T.I. Burgess & Mostowf. (2021)	MB 838760	baited rhizosphere soil of *Ptilotus pyramidatus,* AUSTRALIA, 2016	MURU 485 (T)	Mostowfizadeh-Ghalamfarsa *et al.* (2021), Crous *et al.* (2021a)
P. kernoviae Brasier, Beales & S.A. Kirk (2005)	MB 305803	bark necrosis of *Fagus sylvatica,* UK, 2004	IMI 393170 (T)	Brasier *et al.* (2005)
P. kwongonina T.I. Burgess (2018)	MB 822012	rhizosphere soil of dying *Banksia grandis*, AUSTRALIA, 2010	MURU 477 (T)	Burgess *et al.* (2018)
P. lactucae Bertier, H. Brouwer & De Cock (2013)	MB 803104	stem of *Lactuca sativa*, GREECE, 2001	CBS H-21129 (T)	Bertier *et al.* (2013a)
P. lacustris Brasier, Cacciola, Nechw., T. Jung & Bakonyi (2013)	MB 564262	diseased root of *Salix matsudana*, UK, 1972	PPIHAS-P566 (T)	Nechwatal *et al.* (2013)
P. lateralis Tucker & Milbrath (1942)	MB 289691	root rot of *Chamaecyparis lawsoniana*, USA	CBS H-7643 (IT)	Tucker & Milbrath (1942)
P. lilii M.Z. Rahman, S. Uematsu, Kimish. & Kageyama (2015)	MB 807071	stems of *Lilium longiflorum*, JAPAN, 1987	NBRC H-13200 (T)	Rahman *et al.* (2015)
P. litchii (C.C. Chen ex W.H. Ko, H.S. Chang, H.J. Su, C.C. Chen & L.S. Leu) Voglmayr, Göker, Riethm. & Oberw. (2007)	MB 532416	fruits of diseased *Litchi chinensis*, TAIWAN, 1978	TAI 4800 (NT)	Göker *et al.* (2007)
P. litoralis T. Jung, M.J.C. Stukely & T.I. Burgess (2011)	MB 518765	rhizosphere soil of dying *Banksia* sp., AUSTRALIA, 2008	MURU 463 (T)	Jung *et al.* (2011a)
P. ludoviciana T. Jung, T. Májek, M. Ferreira & I. Milenković (2022)	MB 842943	naturally fallen leaf in a swamp forest, USA, 2020	HNHM-MYC-009703 (T)	Jung *et al.* (2022b)
P. macilentosa Xiao Yang, Copes & C.X. Hong (2014)	MB 804934	water of nursery reservoir, USA, 2012	ATCC MYA-4945 (T)	Yang *et al.* (2014a)
P. macrochlamydospora J.A.G. Irwin (1991)	MB 355271	root and stem rot of *Glycine max*, AUSTRALIA, 1974	BRIP 17047 (T)	Irwin (1991)
P. marrasii Bregant, Rossetto & Linald. (2021)	MB 840582	crown and root of *Cynara cardunculus* var. *scolymus*, Sardinia, ITALY, 2021	CBS H-24776 (T)	Bregant *et al.* (2021b)
P. meadii McRae (1918)	MB 120866	*Hevea brasiliensis*, Kerala, INDIA, 2001	**CBS H-25073 (NT)**	McRae (1918b). **Neotypification in the present publication.**
P. medicaginis E.M. Hansen & D.P. Maxwell (1991)	MB 127932	*Medicago sativa*, USA, 1978	Hamm AL1 Sq - OSC (T)	Hansen & Maxwell (1991)
P. mediterranea C. Bregant, Mulas & Linald. (2021)	MB 839612	root rot of *Myrtus communis*, ITALY, 2019	CBS H-24768 (T)	Bregant *et al.* (2021a)
P. megakarya Brasier & M.J. Griffin ex Abad *sp. nov.* (2023)	MB 844806	pod rot of *Theobroma cacao,* CAMEROON, 1975	**IMI 202077 (T)**	Brasier & Griffin (1979). **Present publication.**
P. megasperma Drechsler (1931)	MB 270758	crown rot of *Althaea rosea,* USA, 1949	**IMI 32035 (EpT)**	Drechsler (1931). **Epitypification in the present publication.**
P. mekongensis Cacciola & Hoa (2018)	MB 554524	fruits of *Citrus grandis*, VIETNAM, 2012	**CBS 135136 (T)**	Cacciola *et al.* (2018), Crous *et al.* (2017)
P. melonis Katsura (1976)	MB 320484	damping-off of *Cucumis sativus*, JAPAN	No 1967-008 (T)	Katsura (1976)
P. mengei G.T. Browne, Gallegly & C.X. Hong (2009)	MB 513047	canker of *Persea americana*, USA	**ATCC MYA-4554 (T)**	Hong *et al.* (2009)
P. mexicana Hotson & Hartge (1923)	MB 253321	root rot of *Capsicum annuum* var. 'latigo', Texas, USA, 2007	CBS H-25074 (EpT)	Hotson & Hartge (1923) **Epitypification in the present publication.**

Table 1. (Continued).

***Phytophthora* species**	**MycoBank**	**Host, country, year of collection**	**Type[1]**	**Reference(s)**
P. mirabilis Galindo & H.R. Hohl (1986)	MB 128307	leaf blight of *Mirabilis jalapa*, MEXICO, 1985	**CBS 678.85 (T)**	Galindo, Hohl (1986)
P. mississippiae X. Yang, W.E. Copes & C.X. Hong (2013)	MB 804659	irrigation water of a nursery reservoir, USA, 2012	**ATCC MYA-4946 (T)**	Yang *et al.* (2013)
P. morindae Abad & S.C. Nelson (2010)	MB 513008	leaf black flag of *Morinda citrifolia*, Hawaii, USA, 2005	BPI 878721 (T)	Nelson & Abad (2010)
P. moyootj T.I. Burgess (2014)	MB 809152	mud from vehicle, AUSTRALIA, 2012	MURU 469 (T)	Burgess & Stukely (2014), Crous *et al.* (2014)
P. multibullata Q.N. Dang & T.I. Burgess (2021)	MB 836441	rhizosphere soil of *Cinnamomum cassia* plantations, VIETNAM, 2018	MURU 489 (T)	Dang *et al.* (2021)
P. multiglobulosa Jung, M. Junaid, M. Horta Jung & I. Milenković (2022)	MB 843003	naturally fallen leaf in a stream in tropical hill rainforest, INDONESIA, 2019	HNHM-MYC-021539 (T)	Jung *et al.* (2022b)
P. multivesiculata Ilieva, Man in 't Veld, W. Veenb.-Rijks & R. Pieters (1998)	MB 445238	leaf rot of *Cymbidium* sp., NETHERLANDS, 1995	**CBS 545.96 (T)**	Ilieva *et al.* (1998)
P. multivora P.M. Scott & T. Jung (2009)	MB 512497	rhizosphere soil of declining *Eucalyptus marginata*, AUSTRALIA, 2007	MURU 434 (T)	Scott *et al.* (2009)
P. nagaii M.Z. Rahman, S. Uematsu, Toru Takeuchi, K. Shirai & Kageyama (2014)	MB 804991	leaf and stem blight of *Rosa* sp., JAPAN, 1968	NBRC H-13102 (T)	Rahman *et al.* (2014b)
P. nemorosa E.M. Hansen & Reeser (2003)	MB 489132	canker and blight of *Lithocarpus densiflorus*, USA	OSC 104381 (T)	Hansen *et al.* (2003)
P. nicotianae Breda de Haan (1896)	MB 194443	*Gramatophyllum* sp., INDONESIA, 1989	CBS H-25075 (EpT)	Breda de Haan (1896). **Epitypification in the present publication.**
P. niederhauseri Abad & J.A. Abad (2014)	MB 509104	collar and root rot of *Hedera helix*, USA, 2001	**WPC P10616 (T)**	Abad *et al.* (2014)
P. obscura Grünwald & Werres (2012)	MB 519834	soil of *Aesculus hippocastanum*, GERMANY, 1994	BBA 2/ 94-IIB (T)	Grünwald *et al.* (2012)
P. occultans Man in 't Veld & K. Rosend. (2015)	MB 803534	rotten roots of *Buxus sempervirens*, NETHERLANDS, 1998	**CBS 101557 (T)**	Man in 't Veld *et al.* (2015)
P. oleae Schena, Ruano-Rosa, Agosteo & Cacciola (2018)	MB 824218	rotten drupes of *Olea europaea,* ITALY, 2015	REGGIO PH3 (T)	Ruano-Rosa *et al.* (2018)
P. oreophila I. Khaliq & T.I. Burgess (2019)	MB 825232	soil and associated roots in disturbed alpine herbfield, AUSTRALIA, 2016	MURU 483 (T)	Khaliq *et al.* (2019)
P. ornamentata Scanu, Linald. & T. Jung (2015)	MB 814009	rhizosphere soil of diseased *Pistacia lentiscus*, ITALY, 2012	CBS H-22393 (T)	Scanu *et al.* (2015)
P. pachypleura Henricot, Pérez Sierra & T. Jung (2014)	MB 570084	root rot of *Acuba japonica*, UK, 2008	IMI 502404 (T)	Henricot *et al.* (2014)
P. palmivora (E.J. Butler) E.J. Butler (1919)	MB 194605	fruit of *Areca catechu*, INDIA	**IMI 348384 (RS)**	Butler (1918–1919). **Present publication.**
P. panamensis T. Jung, Balci, Broders & I. Milenković (2022)	MB 840175	necrotic lession leaf of unidentified tree species, PANAMA, 2019	CBS H-24773 (T)	Jung *et al.* (2022a), Chen *et al.* (2022)
P. parsiana Mostowf., D.E.L. Cooke & Banihash. (2008)	MB 511268	crown of *Ficus carica*, IRAN, 1991	IMI 395329 (T)	Mostowfizadeh-Ghalamfarsa *et al.* (2008)
P. parvispora Scanu & Denman (2014)	MB 803239	collar rot of *Arbutus unedo*, ITALY, 2011	CBS H-21132 (T)	Scanu *et al.* (2014a)
P. personensis Abad, W. Gut. & T.I. Burgess (2020)	MB 834875	Baited soil associated with dying *Grevillea mccutcheonii*, AUSTRALIA, 2005	MURU 481 (T)	Burgess & Abad (2020), Crous *et al.* (2020a)
P. phaseoli Thaxt. (1889)	MB 194478	beans of *Phaseolus lunatus*, Delaware, USA	**CBS 114105 (EpT)**	Thaxter (1889). **Epitypification in the present publication.**

Table 1. (Continued).

***Phytophthora* species**	**MycoBank**	**Host, country, year of collection**	**Type¹**	**Reference(s)**
P. pini Leonian (1925)	MB 194320	roots of *Pinus resinosa*, Minnesota, USA, 1925	VTMH: 11737 (T)	Leonian (1925)
P. pinifolia Alv. Durán, Gryzenh. & M.J. Wingf. (2008)	MB 511870	needle disease of *Pinus radiata*, CHILE, 2007	PREM 59887 (T)	Durán *et al.* (2008)
P. pisi Heyman ex Abad *sp. nov.* (2023)	MB 845099	root rot of *Pisum sativum*, SWEDEN, 1997	**CBS 130350 (T)**	Heyman *et al.* (2013). **Validation in the present publication.**
P. pistaciae Mirab. (2001)	MB 474133	crown gummosis of *Pistacia vera*, IRAN, 1986	IMI 386658 (T)	Mirabolfathy *et al.* (2001)
P. plurivora T. Jung & T.I. Burgess (2009)	MB 512914	roots of *Fagus sylvatica*, GERMANY, 2004	MURU 433 (T)	Jung & Burgess (2009)
P. pluvialis Reeser, W. Sutton & E.M. Hansen (2013)	MB 803172	baited rainwater, USA, 2008	OSC 147940 (T)	Reeser *et al.* (2013)
P. podocarpi K. Dobbie, R.L. McDougal & P.M. Scott (2022)	MB 841407	from needles and shoots of *Podocarpus totara*, NEW ZEALAND, 2011	NZFRIM 5991 (T)	Dobbie *et al.* (2022)
P. polonica Belbahri, E. Moralejo & Lefort (2006)	MB 501096	rhizosphere of declining *Alnus glutinosa*, POLAND, 2004	UASWS0198 (T)	Belbahri *et al.* (2006)
P. porri Foister (1931)	MB 275104	whitening leaves and stems of *Allium porrum*, UK, 1994	CBS H-25076 **(EpT)**	Foister (1931). **Epitypification in the present publication.**
P. primulae J.A. Toml. (1952)	MB 303623	root rot of *Primula acaulis*, GERMANY, 1997	CBS H-25077 **(EpT)**	Tomlinson (1952). **Epitypification in the present publication.**
P. procera T. Jung, T. Corcobado, S. Raghuwinder & I. Milenković (2022)	MB 842944	fallen leaf in a flooded swamp forest, USA, 2020	HNHM-MYC-009704 (T)	Jung *et al.* (2022b)
P. prodigiosa Cacciola & Tri (2018)	MB 554541	fruit of *Citrus grandis*, VIETNAM, 2012	**CBS 135138** (T)	Cacciola *et al.* (2018), Crous *et. al.* (2017)
P. pseudochilensis T. Jung, M. Horta Jung, E. Sanfuentes & I. Milenković (2022)	MB 842947	baited from stream in *Rhododendron* leaf, CHILE, 2014	HNHM-MYC-009705 (T)	Jung *et al.* (2022b)
P. pseudocryptogea Safaief., Mostowf., G.E. Hardy & T.I. Burgess (2015)	MB 811590	roots of dying *Isopogon buxifolius*, AUSTRALIA, 2006	MURU 471 (T)	Safaiefarahani *et al.* (2015)
P. pseudogallica T. Jung, N.M. Chi, Brasier & I. Milenković (2022)	MB 842950	fallen leaf in stream in evergreen cloud forest, VIETNAM, 2017	HNHM-MYC-009706 (T)	Jung *et al.* (2022b)
P. pseudokernoviae T. Jung, M. Horta Jung, A. Durán & E. Sanfuentes (2022)	MB 842949	naturally fallen necrotic leaf of *Drimys winteri* in rain forest, CHILE, 2014	HNHM-MYC-009707 (T)	Jung *et al.* (2022b)
P. pseudolactucae M.Z. Rahman, S. Uematsu, Kanto, M. Kusunoki & Kageyama (2015)	MB 807138	crown rot of *Lactuca sativa*, JAPAN, 2013	NBRC H-13221 (T)	Rahman *et al.* (2015)
P. pseudopolonica W.W. Li, W.X. Huai & W.X. Zhao ex Abad & B. Kasiborski *sp. nov.* (2023)	MB 844808	stream water, Sichuan, CHINA	CBS H-25078 **(T)**	Li *et al.* (2017). **Validation in the present publication.**
P. pseudorosacearum T.I. Burgess (2018)	MB 822013	rhizosphere soil of dying *Persoonia longifolia*, AUSTRALIA, 2013	MURU 478 (T)	Burgess *et al.* (2018)
P. pseudosyringae T. Jung & Delatour (2003)	MB 489464	root and collar rot of *Quercus robur*, GERMANY, 1997	IFB-GeroR7 (T)	Jung *et al.* (2003)
P. pseudotsugae Hamm & E.M. Hansen (1983)	MB 107141	root rot of *Pseudotsuga menziesii*, USA, 1975	ATCC Hamm 268 (T)	Hamm & Hansen (1983)
P. psychrophila T. Jung & E.M. Hansen (2002)	MB 484598	rhizosphere of decaying *Quercus robur*, GERMANY, 1995	IFB-Mühl1/2 (T)	Jung *et al.* (2002)
P. quercetorum Y. Balci & S. Balci (2008)	MB 510683	rhizosphere soil of *Quercus rubra*, USA, 2004	BPI 878357 (T)	Balci *et al.* (2008)

Table 1. (Continued).

***Phytophthora* species**	**MycoBank**	**Host, country, year of collection**	**Type[1]**	**Reference(s)**
P. quercina T. Jung (1999)	MB 460046	rhizosphere soil with necrotic roots of declining *Quercus robur*, GERMANY, 1995	**CBS 784.95** (T)	Jung *et al.* (1999)
P. quininea Crand. (1947)	MB 289693	root and collar rot of *Cinchona officinalis*, PERU, 1947	No: C-67 (EETM) (T)	Crandall (1947)
P. ramorum Werres, De Cock & Man in 't Veld (2001)	MB 474485	twig blight of *Rhododendron catawbiense* 'Grandiorum', GERMANY, 1995	CBS H-7707 (T)	Werres *et al.* (2001)
P. rhizophorae Pires-Zottar., A.L. Jesus & Marano (2016)	MB 551607	leaves of *Rhizophora mangle*, BRAZIL, 2012	SP 466375 (T)	Li *et al.* (2016)
P. richardiae Buisman (1927)	MB 276520	roots of decayed *Zantedeschia aethiopica*, NETHERLANDS	IMI 340618 (T)	Buisman (1927)
P. riparia Reeser, W. Sutton & E.M. Hansen (2012)	MB 564287	oak creek stream water, USA, 2006	OSC 144116 (T)	Hansen *et al.* (2012b)
P. rosacearum E.M. Hansen & W.F. Wilcox (2009)	MB 499442	*Malus domestica*, USA, 1979	OSC 134507 (T)	Hansen *et al.* (2009)
P. rubi (W.F. Wilcox & J.M. Duncan) Man in 't Veld (2007)	MB 505721	cane of *Rubus idaeus* cv. "Glen Clova", UK, 1985	CUP 62528 (T)	Man in 't Veld (2007)
P. sansomeana E.M. Hansen & Reeser (2009)	MB 499443	*Glycine max*, USA	OSC 134508 (T)	Hansen *et al.* (2009)
P. scandinavica T. Jung, I. Milenković, M.A. Redondo & T. Corcobado (2022)	MB 842951	riverbank soil, SWEDEN, 2017	HNHM-MYC-009708 (T)	Jung *et al.* (2022b)
P. siskiyouensis Reeser & E.M. Hansen (2008)	MB 505953	seasonal tributary river, USA, 2003	ATCC MYA-4187 (T)	Reeser *et al.* (2008)
P. sojae Kaufm. & Gerd. (1958)	MB 303624	*Glycine max*, USA	CBS H-25079 (EpT)	Kaufmann & Gerdemann (1958). **Epitypification in the present publication.**
P. stricta Xiao Yang, W.E. Copes & C.X. Hong (2014)	MB 804933	water in a nursery reservoir, USA, 2012	ATCC MYA-4944 (T)	Yang *et al.* (2014a)
P. subarctica T. Jung, T. Corcobado, J. Oliva & I. Milenković (2022)	MB 843134	forest stream using a *Fagus sylvatica* leaf as bait, SWEDEN, 2017	HNHM-MYC-020632 (T)	Jung *et al.* (2022b)
P. syringae (Kleb.) Kleb. (1905)	MB 194524	*Syringa vulgaris*, GERMANY, 1995	CBS H-25080 (NT)	Klebahn (1909). **Neotypification in the present publication.**
P. tentaculata Kröber & Marwitz (1993)	MB 360186	*Chrysanthemum frutescens*, GERMANY, 1990	BBA 65425 (T)	Kröber, Marwitz (1993)
P. tenuimura T. Jung, T. Corcobado, T. Májek & M. Ferreira (2022)	MB 842945	fallen leaf in a flooded swamp forest, USA, 2020	HNHM-MYC-009709 (T)	Jung *et al.* (2022b)
P. terminalis Man in 't Veld & K. Rosend. (2015)	MB 803536	root and stem rot of *Pachysandra terminalis*, NETHERLANDS, 2010	**CBS 133865** (T)	Man in 't Veld *et al.* (2015)
P. theobromicola Pinho, Ramos-Sobrinho & Marelli (2021)	MB 833783	black pod disease of *Theobroma cacao,* BRAZIL, 2017	UB23904 (T)	Decloquement *et al.* (2021)
P. thermophila T. Jung, M.J.C. Stukely & T.I. Burgess (2011)	MB 518766	rhizosphere soil of declining *Eucalyptus marginata*, AUSTRALIA, 2004	MURU 464 (T)	Jung *et al.* (2011b)
P. tonkinensis T. Jung, N.M. Chi, Scanu & I. Milenković (2022)	MB 843135	fallen leaf in a stream in evergreen cloud forest, VIETNAM, 2017	HNHM-MYC-009701 (T)	Jung *et al.* (2022b)
P. transitoria I. Milenković, Májek & T. Jung (2022)	MB 839452	rhizosphere soil of a *Quercus robur* seedling, CZECH REPUBLIC, 2018	CBS H-24578 (T)	Jung *et al.* (2022a), Chen *et al.* (2022)
P. trifolii E.M. Hansen & D.P. Maxwell (1991)	MB 127933	clover *Trifolium vesiculosum*, USA	Pratt No. 105 (OSC) (T)	Hansen & Maxwell (1991)

Table 1. (Continued).

***Phytophthora* species**	**MycoBank**	**Host, country, year of collection**	**Type**[1]	**Reference(s)**
P. tropicalis Aragaki & J.Y. Uchida (2001)	MB 467732	inflorescense of *Macadamia integrifolia*, Hawaii, USA, 1975	**CBS 434.91** (T)	Aragaki & Uchida (2001)
P. tubulina T. Jung, T. Cech, Scanu, M. Horta Jung & Bakonyi (2017)	MB 819701	rhizosphere soil of *Fagus sylvatica*, AUSTRIA, 2010	CBS H-22557 (T)	Jung *et al.* (2017a)
P. tyrrhenica Scanu, Cacciola, Seddaiu, Bakonyi & T. Jung (2017)	MB 819700	rhizosphere soil of *Quercus ilex*, ITALY, 2012	CBS H-22984 (T)	Jung *et al.* (2017a)
P. ukrainensis I. Milenković, T. Jung, T. Corcobado & I. Matsiakh (2022)	MB 843136	naturally fallen Quercus leaf in the Vereshchytsia River, UKRAINE, 2019	HNHM-MYC-009710 (T)	Jung *et al.* (2022b)
P. uliginosa T. Jung & E.M. Hansen (2002)	MB 484597	rhizosphere of *Quercus robur*, POLAND, 1998	IFB-Niep 8 (T)	Jung *et al.* (2002)
P. uniformis (Brasier & S.A. Kirk) Abad, comb. nov. (2023)	MB 846427	bark of *Alnus*, SWEDEN, 1996	IMI 392315 (T)	Husson *et al.* (2015). **Validation of the combination in the present publication.**
P. urerae G.A. Forbes & Grünwald (2019)	MB 828472	*Urera laciniata*, PERU	BPI 893220 (T)	Grünwald *et al.* (2019)
P. variabilis T. Jung, M. Horta Jung & I. Milenković (2022)	MB 840174	commercial tree planting substrate, SLOVAKIA, 2013	CBS H-24772 (T)	Jung *et al.* (2022a), Chen *et al.* (2022)
P. versiformis T. Paap & T.I. Burgess (2017)	MB 820727	rhizosphere soil of *Corymbia calophylla*, AUSTRALIA, 2013	MURU 474 (T)	Paap *et al.* (2017)
P. vignae Purss (1957)	MB 303625	stem of *Vigna unguiculata*, AUSTRALIA	**P3019 WPC (EpT)**	Purss (1957). **Epitypification in the present publication.**
P. virginiana X. Yang & C.X. Hong (2013)	MB 804533	baited leaf irrigation water, USA, 2007	ATCC MYA-4927 (T)	Yang & Hong (2013)
P. vulcanica T. Jung, M. Horta Jung, Scanu, Bakonyi & Cacciola (2017)	MB 819702	rhizosphere soil of *Fagus sylvatica*, ITALY, 2013	CBS H-22556 (T)	Jung *et al.* (2017a)
P. ×alni Brasier & S.A. Kirk (2004)	MB 631644	*Alnus glutinosa*, UK, 1994	IMI 392314 (T)	Husson *et al.* (2015)
P. ×cambivora (Petri) Buisman (1927)	MB 817284	declining mature *Quercus pubescens* tree, ITALY, 2013	CBS H-22558 (NT)	Jung *et al.* (2017b)
P. ×*heterohybrida* T. Jung, M. Horta Jung, Scanu & Bakonyi (2017)	MB 816572	a tributary of Hapen River, TAIWAN, 2013	CBS H-22549 (T)	Jung *et al.* (2017b)
P. ×*incrassata* T. Jung, M. Horta Jung, Scanu & Bakonyi (2017)	MB 816573	a tributary of Hapen River, TAIWAN, 2013	CBS H-22554 (T)	Jung *et al.* (2017b)
P. ×multiformis (Brasier & S.A. Kirk) Abad, comb. nov. (2023)	MB 846426	*Alnus* sp., NETHERLANDS, 1994	IMI 392316 (T)	Husson *et al.* (2015). **Validation of the combination in the present publication.**
P. ×*pelgrandis* W.F. Gerlach, Nirenberg & Gräfenhan (2009)	MB 507949	stems of *Pelargonium grandiflorum,* GERMANY, 2001	BBA 71729 in B (T)	Nirenberg *et al.* (2009)
P. ×*serendipita* Man in 't Veld & K. Rosend. (2012)	MB 560686	stem-base rot of *Idesia polycarpa,* NETHERLANDS, 1995	CBS 100427(T)	Man in 't Veld *et al.* (2012)
P. ×*stagnum* Xiao Yang & C.X. Hong (2014)	MB 807978	from irrigation runoff reservoir, USA, 2007	ATCC MYA-4926 (T)	Yang *et al.* (2014c)
P. ×vanyenensis Q.N. Dang & T.I. Burgess (2020)	MB 836443	soil and stream in *Cinnamomum cassia* plantations, VIETNAM, 2018	MURU 488(T)	Dang *et al.* (2021)
P. inflata Caros. & Tucker (1949) **LOST**	MB 289690	*Ulmus americana*, USA	Not indicated	Caroselli & Tucker (1949)
P. italica Cacciola, Magnano & Belisario (1996) **LOST**	MB 415901	*Myrtus communis*, Sardegna, ITALY	IMI 371760 LOST?	Cacciola *et al.* (1996)
P. japonica G.M. Waterh. (1974) **LOST**	MB 320480	*Oryza sativa*, JAPAN	NA?	Waterhouse (1974)
P. cyperi (Ideta) S. Ito (1935) **UNCULTURABLE**	MB 262686	*Cyperus tegetiformis*, 1925 TAIWAN and *Cyperus malaccenis*, 1932 TAIWAN	NA?	Ito & Tokunaga (1935), Ho & Chang (1992)
P. cyperi-bulbosi Seethal. & K. Ramakr. (1953) **UNCULTURABLE**	MB 303619	leaves of *Cyperus bulbosus,* INDIA	NA?	Seethalakshmi & Ramakrishnan (1953)
P. eriugena Clancy & Kavanagh (1979), *nom. inval.* **UNCULTURABLE**	MB 320476	stems and leaves of *Chaemaecyparis lawsoniana,* IRELAND	NA?	Clancy & Kavanagh (1977)

Table 1. (Continued).

***Phytophthora* species**	**MycoBank**	**Host, country, year of collection**	**Type[1]**	**Reference(s)**
P. leersiae Sawada ex H.H. Ho & H.S. Chang (1992) **UNCULTURABLE**	MB 355507	leaves of *Leersia hexandra*, TAIWAN, 1927	Sawada, 4 Jul. 1927 - National Taiwan University, Taipei (T)	Ho & Chang (1992)
P. lepironiae Sawada (1919) **UNCULTURABLE**	MB 477292	*Lepironia mucromata*, TAIWAN	NA?	Sawada (1919)
P. oryzo-bladis J.S. Wang & J.Y. Lu ex H.H. Ho (2001) **UNCULTURABLE**	MB 467821	leaves of *Oryza sativa*, Jiangsu, CHINA, 1976	Wang 10037 - Nanjing Agricultural University	Ho (2001)
P. polygoni Sawada (1922) **UNCULTURABLE**	MB 274928	leaves of *Polygonum lapathifolium*, TAIWAN	NA?	Sawada (1922)
P. verrucosa Alcock & Foister (1940) **UNCULTURABLE**	MB 289694	roots of *Lycopersicum esculentum* and *Meconopsis* sp., UK	NA?	Foister (1940)

[1] In bold a metabolically inactive culture. Andes-F: Universidad de Los Andes, Bogotá, Colombia; BPI: Herbarium, USDA-ARS, Maryland, USA; BRIP: Queensland Plant Pathology Herbarium, Department of Agriculture and Fisheries; Australia; CBS: Westerdijk Fungal Biodiversity Institute, KNAW The Netherlands (CBS-H); IMI: HerbIMI Kew Royal Botanical Gardens; CGMCC: China General Microbiological Culture Collection Center, Institute of Microbiology, Chinese Academy of Science; CIEFAP: Protección Forestal, Centro de Investigación y Extensión Forestal Andino Patagónico; CUP: Cornell Plant Pathology Herbarium; EETM: Department of Plant Pathology and Entomology of the "Estacion Experimental Agricola de Tingo Maria", Peru; FI: Natural History Myseum, Florence, Italy; HNHM-MYC: Herbarium Hungarian Natural History Museum; IFB: Institute of Forest Botany, Section Forest Pathology, Technische Universität München, Germany; MBM: Museu Botânico Municipal; Curitiba, Paraná, Brazil; MICH: University of Michigan Herbarium; MURU: Murdoch University Herbarium School of Biological Sciences and Biotechnology, Australia; NBRC: National Institute of Technology and Evaluation – National Biological Resource Center, Japan (NBRC-H); NZFRI: National Forestry Herbarium, New Zealand Forest Research Institute Limited (Scion), Rotorua, New Zealand; OSC: Oregon State University Mycological Herbarium, USA; PDD: New Zealand Fungal and Plant Disease Fungarium, New Zealand; PPIHAS: Herbarium of the Plant Protection Institute, Hungarian Academy of Sciences, Budapest, Hungary; PRC: Charles University - Herbarium collections & Department of Botany, Praha, Czech Republic; PREM: Plant Protection Research Institute, Gauteng Province, Pretoria, South Africa; TAI: National Taiwan University Herbarium; UAMH: Center for Global Microfungal Biodiversity, University of Toronto, Canada; UASWS: Universitatis Helvaticae Occidentalis, Poland; UB: Herbário Departamento de Botânica Universidade de Brasília, Brazil; VPRI: Victorian Plant Pathology Herbarium, Australia; VTMH: Virginia Tech Massey Herbarium, USA; WPC: World Phytophthora Genetic Resource Collection (WPC), University of California, Riverside, USA; WVS: West Virginia Univeristy, USA. FUSION94490: In Muséum d´e histoire naturelle de Paris. T = type; IT = isotype; NT = neotype; EpT = epitype; RS = representative strain.

Table 2. Molecular Toolbox for *Phytophthora* with seven genes from the 212 valid culturable species and with hyperlinks to the Factsheets available online from "*IDphy*: molecular and morphological identification of *Phytophthora* based on the types".

Phytophthora species with factsheets in *Idphy*	**Clade**	**Type cultures[1]**	**Molecular Toolbox and Multigenic Phylogeny Genes[2]**							**Reference(s) / *** Genome Biosample**
			ITS[3]	***COI*[3]**	***YPT***	***β-tub***	***EF1α***	***L10***	***HSP90***	
P. abietivora (2019)	**7a**	**(ET) NRRL 66892**, RC2017-1, UAMH 12075	MK163944	MK164270	—	MK164274	—	—	MK164275	Li *et al.* (2019)
P. acaciae (2019)	**2e**	**(ET) AN02**	KX396303	—	KX396313	KX396338	KX396326	—	—	Alves *et al.* (2019)
P. acaciivora (2020)	**2e**	**(ET) CBS 138638**, AMTQ1	KX011263	**OK185359**	—	MN991983	**OK267376**	**OK533439**	KX011238	**Present publication**, Burgess *et al.* (2020)
P. acerina (2014)	**2c**	**(ET) CBS 133931**, NRRL 64028, B057, WPC P19934, S&T BL 114, 61H1, TJ 0469	**MG518642**	**MH136845**	**MH209241**	**MH493901**	**MH358950**	**MH380049**	**MK020268**	**Present publication**
P. afrocarpa (2021)	**10b**	**(ET) CBS 147467**, NRRL 64331, PPRI28450, CMW54630, S&T BL 204	MT762306	—	—	MT762324	—	—	MT762333	Bose *et al.* (2021)
P. agathidicida (2015)	**5**	**(ET) CBS 149819**, NRRL 64473, ICMP 17027, WPC P15175, NZFS 3770, S&T BL 154, 67D5	**MG602692**	**MK493471**	**MH209242**	**MH493902**	**MH358951**	**MH380050**	**MK020269**	**Present publication**

Table 2. (Continued).

Phytophthora species with factsheets in *Idphy*	Clade	Type cultures[1]	Molecular Toolbox and Multigenic Phylogeny Genes[2]							Reference(s) / *** Genome Biosample
			ITS[3]	*COI*[3]	*YPT*	*β-tub*	*EF1α*	*L10*	*HSP90*	
P. aleatoria (2019)	**1a**	**(ET) NZFS 4037**	MK282209	*	*	MK294172	*	*	*	Scott *et al.* (2019b). * Genome SAMN17151088
P. alpina (2020)	**1a**	**(ET) CBS 146801**, NRRL 64334, OV3, S&T BL 205	MT707332	—	—	MT729673	—	—	—	Bregant *et al.* (2020)
P. alticola (2017)	**4**	**(ENT) CBS 141718**, CMW48711, TB-F0060A10	KX247599	KX247585	—	KX247592	—	—	KX247578	Bose *et al.* (2017)
P. amaranthi (2016)	**2b**	**(ET) CH30042**, TARI28041, WPC P20892, S&T BL 174	**MG783373**	**MH477739**	**OP104617**	**OL466899**	**MK864032**	**OK533424**	**OL466909**	**Present publication**
P. amnicola (2012)	**6b**	**(ET) CBS 131652**, DH228, WPC P19862, S&T BL 100, 61G6	JQ029956	**MH477740**	**OP104618**	**MN207266**	**MK864033**	**OL342754**	**MK020273**	**Present publication**, Burgess *et al.* (2012), Crous *et al.* (2012)
P. andina (2010)	**1c**	**(ET) CBS 115547**, CIP EC3189, WPC P13365, S&T BL 32	**MK496515**	**MH136846**	**OP104619**	EU080183	**MH358954**	**MH380054**	EU080186	**Present publication**, Blair *et al.* (2008)
P. aquae-cooljarloo (2020)	**6a**	**(ET) CBS 146550**, VHS36940, AUS6D	MT210484	—	—	MT210475	—	—	MT210480	Mostowfizadeh-Ghalamfarsa & Burgess (2020), Crous *et al.* (2020b)
P. aquimorbida (2012)	**9a**	**(ET) CBS 149820,** NRRL 64365, ATCC MYA-4578, 40A6, CCH-2009b, WPC P19964, S&T BL 128, 40A6	**MG783376**	**MH136847**	**OP104620**	GQ294534	**MH358955**	**MH380055**	KX252242	**Present publication**, Hong *et al.* (2012), Yang *et al.* (2017)
P. arenaria (2011)	**4**	**(ET) CBS 127950**, WPC P19599, S&T BL 78, 55C2, ENA3	HQ013219	**MH136848**	**OP104621**	**MH493906**	**MH358956**	**MH380056**	KX251017	**Present publication**, Rea *et al.* (2011), Yang *et al.* (2017)
P. asiatica (2014)	**7b**	**(ET) CBS 133347,** NRRL 64336, NBRC 109140, Toku-1, WPC P19977, S&T BL 124, 61H3	**MG783378**	**OK185357**	**OP104622**	AB539560	AB539557	**OL342763**	**OL466913**	**Present publication**, Rahman *et al.* (2014a)
P. asparagi (2012)	**6e**	**(ET) CBS 132095,** NRRL 64320, ATCC MYA-4826, SP326, S&T BL 206	LC595781	LC595898	**OP104623**	**OL466906**	**OK267373**	**OK533437**	**OL466914**	**Present publication**, Hieno *et al.* (2020) NCBI
P. attenuata (2017)	**7a**	**(ET) CBS 141199**, NRRL 64145, TW129, S&T BL 207. 67C5	KU517154	—	**OP081640**	KU899277	KX251611	KX251609	KU899434	**Present publication**, Jung *et al.* (2017b), Yang *et al.* (2017)
P. austrocedri (2007)	**8d**	**(ET) CBS 122911**, ATCC MYA-4074, AG203, WPC P16040, S&T BL 5, 41B6	**MG783380**	**MH136850**	**OP104624**	**MH493907**	**MH358958**	**MH380057**	**MK020274**	**Present publication**
P. aysenensis (2020)	**2b**	**(ET) CBS 146737**, NRRL 64319, CCCT 19.159, RGM 2753, S&T BL 208, SAG-72203b-16	MN557838	—	—	MN557840	—	—	—	Zapata *et al.* (2020) NCBI
P. balyanboodja (2018)	**6a**	**(ET) CBS 143058**, VHS25675, R1C, S&T BL 186	KJ372258	**MH477741**	**OP104625**	**MN207267**	**MK864034**	**OL342755**	**OL466910**	**Present publication**, Belhaj *et al.* (2018)
P. betacei (2018)	**1c**	**(ET) MFM-P8084**	***	***	***	***	***	***	***	Mideros *et al.* (2018) *** Genome SAMN14214885
P. bilorbang (2012)	**6c**	**(ET) CBS 131653**, NRRL 64189, SA262, WPC P19863, S&T BL 101, 61G8	JQ256377	**MH477742**	**OP104626**	**MN207268**	**MK864035**	**OK533425**	**MK020275**	**Present publication**, Aghighi *et al.* (2012)
P. bishii (2008)	**2e**	**(ET) CBS 122081**, WPC P10117, Cg 2.3.3 (G. Abad), S&T BL 6, 31E6	**MG783381**	**MH136851**	**MH974992**	**MH493908**	**MH358959**	EU080741	EU080745	**Present publication**, Blair *et al.* (2008)

Table 2. (Continued).

Phytophthora species with factsheets in Idphy	Clade	Type cultures[1]	Molecular Toolbox and Multigenic Phylogeny Genes[2]							Reference(s) / *** Genome Biosample
			ITS[3]	*COI*[3]	*YPT*	*β-tub*	*EF1α*	*L10*	*HSP90*	
P. boehmeriae (1927)	**10a**	**(ET) CBS 291.29**, WPC P6950, CABI IMI180614 (PL), S&T BL 32G, 45F9	**MG783382**	**MH136852**	**MH974993**	**MH493909**	**MH358960**	**MH380058**	**MK020276**	**Present publication**
P. boodjera (2015)	**4**	**(ET) CBS 138637**, VHS 26806, S&T BL 181	KJ372244	**MH477743**	**MH974995**	KJ372283	**MK864036**	**OL342756**	**MK020277**	**Present publication**, Simamora *et al.* (2015)
P. borealis (2012)	**6b**	**(ET) CBS 132023**, ATCC MYA-4881, WPC P19794, AKWA58.1-0708, S&T BL 93, 60B2	HM004232	**MH136854**	**MH974996**	JQ626615	KX251189	KX251187	KX251191	**Present publication**, Reeser *et al.* (2011), Hansen *et al.* (2012b), Yang *et al.* (2017)
P. botryosa (1969)	**2a**	**(ET) CBS 581.69** (A2), NRRL 64115, WPC P3425, ATCC 58105 MCI, CABI IMI136915 (PL), S&T BL 132, 62C6	**MK496516**	**MH136855**	**MH974997**	**MH493910**	**MH358961**	**MH380059**	KX250541	**Present publication,** Yang *et al.* (2017)
P. brassicae (2002)	**8b**	**(ET) CBS 179.87**, WPC P7517, S&T BL 8, 61J8	**MG783384**	**MH136857**	**MH974999**	AY564083	AY564139	KX252000	KX252004	**Present publication,** Kroon *et al.* (2004), Yang *et al.* (2017)
P. cactorum (1886)	**1a**	**(EEpT) CBS 231.30**, NRRL 64109, MUCL 9638, WPC P0714, ATCC 10091, 200785 MCI, S&T BL 9	**MG783385**	**MH136858**	**MH975000**	**MH493911**	**MK864038**	**MH380060**	**MK020279**	**Present publication**
P. cacuminis (2019)	**9d**	**(ET) CBS 144709**, U40	MG542997	MG543010	**OP104627**	MG543045	**OK267377**	**OK533440**	MG543032	**Present publication**, Khaliq *et al.* (2019)
P. cajani (2023)	**7b**	**(ET) ATCC 44388** (MCI), N516, WPC P3105, S&T BL 116, D.C. Erwin P2 from J. Kannaiyan 5, p349 (Gallegly), 45F7	**MG783386**	**MH136859**	**MH975001**	**MH493912**	**MH358962**	**MH380061**	KX251690	**Present publication**, Yang *et al.* (2017)
P. capensis (2010)	**2c**	**(ET) CBS 128319**, WPC P1819, S&T BL 10, 62C1	**MG865466**	**MH136862**	**MH975002**	**MH493914**	**MH358965**	**MH380064**	**MK020282**	**Present publication**
P. capsici (1922)	**2b**	**(ET) CBS 128.23** (A2), NRRL 64133, ATCC 52771, CABI IMI40502 (AVA), WPC P1091 P3605, S&T BL 33G	**MG865467**	**MH136863**	**MH975003**	**MH493915**	**MH358966**	**MH380065**	**MK020283**	**Present publication**
P. captiosa (2006)	**9d**	**(ET) CBS 119107**, NZFS 310C, ICMP 15576, WPC P10719, S&T BL 11, 46H7	**MG865469**	**MH136865**	**MH975005**	**MH493917**	**MH358968**	EU079658	EU079662	**Present publication**, Blair *et al.* (2008)
P. caryae (2016)	**2c**	**(ET) NJB2013-AF-08**, 67F4	KJ631538	—	—	KJ631572	KU695515	—	—	Brazee *et al.* (2017)
P. castaneae (1976)	**5**	**(ET) CBS 149821,** NRRL 64367, NBRC 9753, ICMP 19434, WPC P10187, S&T BL 47G, 22H6	**MG865470**	**MH136866**	**MH975006**	**MH493918**	**MH358969**	EU080802	EU080806	**Present publication**, Blair *et al.* (2008)
P. castanetorum (2017)	**12**	**(ET) CBS 142299**, BD 292, S&T BL 201	MF036182	**OK185355**	**OP104628**	MF036214	**OK267370**	***	MF036240	**Present publication**, Jung *et al.* (2017). *** Genome SAMN15299697 GCA_014706115.1 Ex-type
P. cathayensis (2020)	**4**	**(ET) CGMCC 19655**, CP30	MN385741	—	—	MT063102	—	—	MN692211	Morales-Rodriguez *et al.* (2020)
P. celebensis (2022)	**10a**	**(ET) CBS 148800**, SL092	ON000720	ON013786	ON024938	OM975899	OM984880	OM974453	OM976416	Jung *et al.* (2022b)
P. chesapeakensis (2019)	**6a**	**(ET) CBS 140655**, NRRL 64322, S&T BL 209, PD 015/04632347	KX172092	KX172096	—	—	—	—	—	Man in 't Veld *et al.* (2019)
P. chilensis (2022)	**10a**	**(ET) CBS 148797**, NRRL 64353, CL165	ON000726	ON013792	ON024944	OM975905	OM984886	OM974459	OM976422	Jung *et al.* (2022b)

Table 2. (Continued).

Phytophthora species with factsheets in *Idphy*	Clade	Type cultures[1]	Molecular Toolbox and Multigenic Phylogeny Genes[2]							Reference(s) / *** Genome Biosample
			ITS[3]	*COI*[3]	*YPT*	*β-tub*	*EF1α*	*L10*	*HSP90*	
P. chlamydospora (2015)	**6b**	**(ET) CBS 149403,** NRRL 64368, WPC P6133, P236, S&T BL 156	**MG865471**	**MH136867**	**MH975007**	**MH493919**	**MH358970**	**MH380067**	**MK020285**	**Present publication**
P. chrysanthemi (2011)	**9a**	**(ET) CBS 123163,** S&T BL 94, GF749, 61F1	**MG865472**	**MH136868**	**MH975008**	AB511995	**MH358971**	**MH380068**	AB511987	**Present publication**, Naher *et al.* (2011)
P. cichorii (2013)	**8b**	**(ET) CBS 115029**, WPC P19844, S&T BL 95, 62A8	KC478773	KC478743	—	KX252008	KX252009	KX252007	KX252011	Bertier *et al.* (2013a), Yang *et al.* (2017)
P. cinnamomi (1922)	**7c**	**(ET) CBS 144.22** (A2) Ex-isotype, NRRL 64213, ATCC 46671 MCI, CABI IMI22938 (PA), WPC P2110, S&T BL 12, 61J1	**MG865473**	**MH136870**	**MH975009**	**MH493921**	**MH358973**	**MH380070**	**MK020287**	**Present publication**
P. citricola (1927)	**2c**	**(ET) CBS 221.88**, NRRL 64191, ATCC 60440 MCI, CABI IMI21173 (PA), WPC P0716 P1689, S&T BL 34, 33H8, NCTC3057	**MG865475**	**MH136871**	**MH975010**	**MH493922**	**MH358974**	**MH380071**	**MK020288**	**Present publication**
P. citrophthora (1925)	**2a**	**(EEpT) CBS 950.87**, NRRL 64128, ATCC 52231, WPC P0479, UCR P749, S&T BL 60, Fawcett 1309A, P.O. 479 (P. Oudemans)	**MG865476**	**MH136872**	**MH988434**	**MH493923**	**MH358975**	**MH380072**	**MK020289**	**Present publication**
P. clandestina (1985)	**1b**	**(ET) CBS 347.86**, ATCC 58713 (MCI), CABI IMI278933 (PA), WPC P3943 P3652, S&T BL 15, 32G1	**MG865477**	**MH136873**	—	**MH493924**	**MH358976**	EU079866	EU079870	**Present publication**, Blair *et al.* (2008)
P. cocois (2015)	**5**	**(ET) CBS 149822, NRRL 64369, ICMP 16948, WPC P19948, S&T BL 157, 67D6**	**MG865478**	**MH136874**	**MH988435**	**MH493925**	**MH358977**	**MH380073**	**MK020290**	**Present publication**
P. colocasiae (1900)	**2a**	**(EEpT) CBS 149404,** NRRL 64370, WPC P6317, S&T BL 173	**MG865479**	**MH136875**	**MH988436**	**MH493926**	**MH358978**	**MH380074**	**MK020291**	**Present publication**
P. condilina (2018)	**6a**	**(ET) CBS 143059**, VHS24244, S&T BL 184	KJ372262	**MH477744**	—	**MN207271**	**MK864040**	**OL342757**	**MK020292**	**Present publication**, Burgess *et al.* (2018)
P. constricta (2011)	**9d**	**(ET) CBS 125801**, VHS 16130, WPC P19614, S&T BL 61, 55C3	**MG865480**	**MH136876**	**OP104629**	**MH493927**	**MH358979**	**MH380075**	**MK020293**	**Present publication**
P. cooljarloo (2018)	**6a**	**(ET) CBS 143062**, CLJ0100, S&T BL 185	HQ012957	**MH477745**	**OP104630**	**MF326816**	**MK864041**	**OL342758**	**MK020294**	**Present publication**, Burgess *et al.* (2018)
P. crassamura (2015)	**6b**	**(ET) CBS 140357**, PH138, WPC P20138, S&T BL 150A, 66D1	**MG865481**	**MK493474**	**OP104631**	KX251202	**MK864042**	**OK533426**	**MK020295**	**Present publication**, Yang *et al.* (2017)
P. cryptogea (1919)	**8a**	**(ET) CBS 113.19**, NRRL 64127, CABI IMI180615 (PA), WPC P1738, P3448, S&T BL 16, 61H9	**MG865483**	**MH136878**	**MH988437**	**MH493928**	**MH358980**	**MH380076**	**MK020297**	**Present publication**
P. dauci (2013)	**8b**	**(ET) CBS 127102**, WPC P19845 P19879, S&T BL 96, 61E5	KC478761	KC478731	**OP104632**	KX252015	KX252016	KX252014	KX252018	**Present publication**, Bertier *et al.* (2013a), Yang *et al.* (2017)
P. docyniae (2021)	**9c**	**(ET) CBS 148031**, FP77	MZ420209	—	—	MZ435255	—	—	—	Dang *et al.* (2021), Crous *et al.* (2021b)

Table 2. (Continued).

Phytophthora species with factsheets in *Idphy*	Clade	Type cultures[1]	Molecular Toolbox and Multigenic Phylogeny Genes[2]							Reference(s) / *** Genome Biosample
			ITS[3]	*COI*[3]	*YPT*	*β-tub*	*EF1α*	*L10*	*HSP90*	
P. drechsleri (1931)	8a	**(EEpT) CBS 292.35** (A2), NRRL 64328, ATCC 46724 (MCI), WPC P1087 P11638 (Tucker authentic), S&T BL 17, 23J5	**MG865484**	**MH136879**	**OP104633**	**MH493930**	**MH358981**	**MH380078**	**MK020299**	**Present publication**
P. elongata (2010)	2e	**(ET) CBS 125799**, NRRL 64165, VHS 13482, WPC P19596, S&T BL 62, 55C4	**MG865485**	**MH136881**	**MH988439**	**MH493932**	**MH358983**	**MH380080**	**MK020301**	**Present publication**
P. emzansi (2021)	2c	**(ET) CBS 147464**, NRRL 64318, PPRI28451, CMW54354, S&T BL 210	MT762301	—	—	MT762318	—	—	MT762327	Bose *et al.* (2021)
P. erythroseptica (1913)	8a	**(EEpT) CBS 148925**, NRRL 64171, WPC P6180, S&T BL 80	**MG865486**	**MH136882**	**MH988440**	**MH493933**	**MH358984**	**MH380081**	**MK020302**	**Present publication**
P. estuarina (2016)	9a	**(ET) CCIBt 4157**, MMBF 14/15	KT886034	KT886051	—	—	—	—	—	Marano *et al.* (2016) NCBI
P. europaea (2002)	7a	**(ET) CBS 109049**, NRRL 64166, IFB-EUR 2, WPC P10324, S&T BL 37G, 62A2	**MG865488**	**MH136884**	**MH988442**	**MH493935**	**MH358986**	**MH380083**	KX251526	**Present publication**, Yang *et al.* (2017)
P. fallax (2006)	9d	**(ET) CBS 119109**, NZFS 310L, ICMP 15575, WPC P10722, S&T BL 63	**MG865489**	**MH136885**	**MH443229**	**MH493936**	**MH358987**	**MH380084**	**MK020304**	**Present publication**
P. flexuosa (2017)	7a	**(ET) CBS 141201**, NRRL 64130, TW78, S&T BL 211, 67C3	KU517152	—	**OP081641**	KX251617	KX251618	KX251616	KX251620	**Present publication**, Jung *et al.* (2017b), Yang *et al.* (2017),
P. fluvialis (2011)	6b	**(ET) CBS 129424**, NRRL 64160, MUCC 771, DH086, WPC P19584, S&T BL 64	**MG865491**	**MH136887**	**OP104634**	JN547595	**MH358988**	**MH380085**	JF701439	**Present publication**, Aghighi *et al.* (2012)
P. foliorum (2006)	8c	**(ET) CBS 121655**, ATCC MYA-3638, CMW 31064, WPC P10969, S&T BL 168, 49J8	**MG865492**	**MH136888**	**MH443231**	**MH493937**	**MH358989**	**MH380086**	**MK020305**	**Present publication**
P. formosa (2017)	7a	**(ET) CBS 141203**, NRRL 64141, TW107, S&T BL 212, 67C4	KU517153	—	**OP081642**	KX251624	KX251625	KX251623	KX251627	**Present publication**, Jung *et al.* (2017b), Yang *et al.* (2017)
P. fragariae (1940)	7a	**(EEpT) CBS 309.62**, NRRL 64315, ATCC 11107, Hickman R-4, S&T BL 213	HQ643231	HQ708295	***	***	***	***	***	Robideau *et al.* (2011). *** Genome SAMN02712365
P. fragariaefolia (2014)	7d	**(ET) CBS 135747**, NBRC 109709, CH05N-SU11, MAFF 244058, WPC P19990, S&T BL 141	**MG865495**	**MH136891**	**MH443234**	**MH493939**	**MH358991**	**MH380088**	**MK020307**	**Present publication**
P. frigida (2007)	2e	**(ET) CBS 121941**, NRRL 64110, CMW20311, PREM 59221, WPC P16947, S&T BL 39G, 47G8	**MG865496**	**MH136892**	**MH443235**	**MH493940**	**MH358992**	**MH380089**	KX250919	**Present publication**, Yang *et al.* (2017)
P. gallica (2008)	10b	**(ET) CBS 117474**, NRRL 64377, PRC-GAL 1, MM497405, WPC P16826, S&T BL 35	**MG865497**	**MH136893**	**MH443236**	**MH493941**	**MH358993**	**MH380090**	**MK020308**	**Present publication**
P. gemini (2011)	6a	**(ET) CBS 123381**, WPC P15880, S&T BL 97	HQ261693	HQ261440	**OP104635**	MF326818	**OK267374**	—	**OL466915**	**Present publication**, Robideau *et al.* (2011), Burgess *et al.* (2018)
P. gibbosa (2011)	6b	**(ET) CBS 127951**, NRRL 64012, VHS21998, WPC P19586, S&T BL 65, TJ345	**MG865499**	**MH136894**	**OP104636**	**MH493942**	**MH380091**	**MH380091**	**MK020309**	**Present publication**
P. gloveri (2011)	2b	**(ET) CBS 121969**, WPC P11685, S&T BL 36	**MG865500**	**MH136895**	**MH443237**	**MH493943**	**MH358995**	**MH380092**	**MK020310**	**Present publication**

Table 2. (Continued).

Phytophthora species with factsheets in Idphy	Clade	Type cultures[1]	Molecular Toolbox and Multigenic Phylogeny Genes[2]							Reference(s) / *** Genome Biosample
			ITS[3]	COI[3]	*YPT*	*β-tub*	*EF1α*	*L10*	*HSP90*	
P. gonapodyides (1927)	**6b**	**(EEpT) CBS 554.67**, NRRL 64034, ATCC 60351 (MCI), S&T BL 214, No 451a, 34A8	HQ643233	HQ708297	—	KX251237	KX251238	KX251236	KX251240	Robideau *et al.* (2011), Yang *et al.* (2017)
P. gondwanensis (2015)	**10a**	**(ET) CBS 139336**, CMW 42633, W1858	KP070695	**OK185360**	**OP104637**	KP070605	**OK267378**	**OK533441**	**OL466916**	**Present publication**, Scarlett *et al.* (2015)
P. gregata (2011)	**6b**	**(ET) CBS 127952**, VHS21962, NRRL 64017, WPC P19588, S&T BL 37	**MG865503**	**MH477746**	**MH443240**	**MH493945**	**MH358997**	**MH380094**	**MK020312**	**Present publication**
P. hedraiandra (2004)	**1a**	**(ET) CBS 111725**, NRRL 66991, WPC P19523, S&T BL 4, PD 20017520, TJ0069	**MG865504**	**MH136898**	**MH443241**	**MH493946**	**MH358998**	**MH380095**	**MK020313**	**Present publication**
P. heterospora (2021)	**4**	**(ET) CBS 148034**, PH054, S&T BL 119	MT232393	—	—	MZ782807	—	—	—	Scanu *et al.* (2021)
P. heveae (1929)	**5**	**(ET) CBS 296.29**, ATCC 58815, CABI IMI180616 (AVA), WPC P3428, S&T BL 67	**MG865505**	**MH136899**	**MH443242**	**MH493947**	**MH358999**	**MH380096**	**MK020314**	**Present publication**
P. hibernalis (1926)	**8c**	**(EEpT) CBS 114104**, NRRL 64317, S&T BL 41G, WPC P3822, ATCC 56353, CABI IMI134760 (PA), CMI13460, 32F7	**MG865506**	**MH136900**	**MH443243**	**MH493948**	**MH359000**	**MH380097**	**MK020315**	**Present publication**
P. himalsilva (2011)	**2a**	**(ET) CBS 128767**, WPC P19820, S&T BL 102, 61G2	**MG865507**	**MH136901**	**MH443244**	HM752790	KX250574	KX250572	KX250576	**Present publication,** Vettraino *et al.* (2011), Yang *et al.* (2017)
P. honggalleglyana (2023)	**9a**	**(ET) ATCC MYA-4460**, WPC P19616, S&T BL 68, 5D1	EU583793	—	—	GQ260069	GQ260061	KX252294	KX252298	Hong *et al.* (2010), Yang *et al.* (2017)
P. humicola (1985)	**6a**	**(ET) CBS 200.81**, NRRL 64256, ATCC 52179 (MCI), CABI IMI302303 (PA), WPC P3826, S&T BL 42G	**MK496519**	**MK493476**	—	**MH493949**	**MH359001**	**MH380098**	**MK020316**	**Present publication**
P. hydrogena (2014)	**9a**	**(ET) NRRL 64262**, ATCC MYA-4919, WPC P19968, S&T BL 129, 46A3	**MG865508**	**MH136902**	**MH443245**	**MH493950**	**MH359002**	**MH380099**	**MK020317**	**Present publication**
P. idaei (1995)	**1a**	**(ET) CBS 971.95**, MYA-4065, SCRI R77, WPC P6767, S&T BL 38	**MG865509**	**MH136903**	—	**MH493951**	**MH359003**	**MH380100**	**MK020318**	**Present publication**
P. ilicis (1957)	**3**	**(EEpT) CBS 149896**, NRRL 64374, MYA-3897, WPC P3939, S&T BL 39	**MG865511**	**MH136905**	**MH443247**	**MH493953**	**MH359005**	**MH380102**	**MK020320**	**Present publication**
P. infestans (1876)	**1c**	**(EEpT) CBS 147289**, T30-4	MZ753914	***	***	MZ736454	***	***	***	Scanu *et al.* (2021). *** Genome T30-4. SAMN02953670
P. insolita (1981)	**9b**	**(ET) CBS 691.79**, ATCC 38789 (MCI), CABI IMI288805 (PA), WPC P6195, S&T BL 144	**MG865515**	**MH136909**	**MH443251**	**MH493957**	**MH359009**	**MH380106**	**MK020323**	**Present publication**
P. insulinativitatica (2021)	**2a**	**(ET) CBS 146553**, CI-10A	KY212028	**OK185361**	**OP104638**	MT583631	**OK267379**	**OL342764**	MT583676	**Present publication**, Dang *et al.* (2021)
P. intercalaris (2016)	**10c**	**(ET) CBS 140632**, 45B7	KT163268	**OK185358**	**OP104674**	KT163336	KX252612	KX252610	KX252614	**Present publication**, Yang *et al.* (2016), Yang *et al.* (2017)
P. intricata (2017)	**7a**	**(ET) CBS 141211**, NRRL 64321, TW259, 67B9	KU517155	—	**OP081644**	**OP081605**	**OP081633**	**OP081620**	**OP081612**	**Present publication**, Jung *et al.* (2017b), Yang *et al.* (2017)
P. inundata (2003)	**6a**	**(EEpT) CBS 216.85**, NRRL 64162, CABI IMI389751 (AVA) (UK) (A2), P246b, WPC P8479, S&T BL 20	**MG865516**	**MH136910**	**OP104639**	**MH493958**	**MH359010**	**MH380107**	**MK020324**	**Present publication**

Table 2. (Continued).

Phytophthora species with factsheets in *Idphy*	Clade	Type cultures[1]	Molecular Toolbox and Multigenic Phylogeny Genes[2]							Reference(s) / *** Genome Biosample
			ITS[3]	*COI*[3]	*YPT*	*β-tub*	*EF1α*	*L10*	*HSP90*	
P. ipomoeae (2013)	**1c**	**(ET) CBS 109229**, PIC 99169, MUCL 30219, WPC P10225, S&T BL 21	**MG865518**	**MH136912**	**MH443252**	**MH493960**	**MH359012**	**MH380109**	EU080834	**Present publication**, Blair *et al.* (2008)
P. iranica (1971)	**1b**	**(ET) CBS 374.72**, ATCC 60237, CABI IMI158964 (PA), WPC P3882, S&T BL 40	**MG865519**	**MH136913**	**MH443253**	**MH493961**	**MH359013**	**MH380110**	**MK020326**	**Present publication**
P. irrigata (2008)	**9a**	**(ET) NRRL 64264**, MYA-4457, P108 (WVU), WPC P16861, S&T BL 41	**MG865520**	**MH136914**	**OP104640**	**MH493962**	**MH359014**	**MH380111**	**MK020327**	**Present publication**
P. javanensis (2022)	**10a**	**(ET) CBS 149203**, NRRL 64129, JV025a	ON000750	ON013816	ON024966	OM975929	OM984909	OM974483	OM976446	Jung *et al.* (2022b)
P. kelmanii (2021)	**8a**	**(ET) CBS 146551**, Phyt7	MT210487	**OK185362**	**OP104641**	MT210491	**OK267380**	**OK533442**	MT210495	**Present publication**, Mostowfizadeh-Ghalamfarsa *et al.* (2021), Crous *et al.* (2021a)
P. kernoviae (2005)	**10a**	**(ET) NRRL 64375**, CABI IMI393170 (AVA), WPC P19827, S&T BL 91	**MG865521**	**MH136915**	**MH443254**	**MH493963**	**MH359015**	**MH380112**	**MK020328**	**Present publication**
P. kwongonina (2018)	**6a**	**(ET) CBS 143060**, VHS23298, S&T BL 187	JN547636	**MH477747**	**OP104642**	MF326824	**MK864044**	**OL342759**	**MK020329**	**Present publication**, Burgess *et al.* (2018)
P. lactucae (2013)	**8b**	**(ET) BPIC 1985**, WPC P19872 P19875, S&T BL113, 61F4	KC478768	KC478738	**MH443255**	KX252043	**MH359016**	**MH380113**	KX252046	**Present publication**, Bertier *et al.* (2013a), Yang *et al.* (2017)
P. lacustris (2013)	**6d**	**(ET) CABI IMI389725** (PA), WPC P10337, S&T BL 69, P245	AF266793	**MH136916**	**OP104643**	EU080531	EU080532	**MH380114**	EU080534	**Present publication**, Cooke *et al.* (2000), Blair *et al.* 2008
P. lateralis (1942)	**8c**	**(ET) CBS 168.42**, ATCC 58816 (MCI), CABI IMI40503 (PA), WPC P3361 P3917, S&T BL 42	**MG865522**	**MH136917**	**MH443256**	**MH493964**	**MH359017**	**MH380115**	**MK020330**	**Present publication**
P. lilii (2015)	**11**	**(ET) CBS 135746**, NBRC 32174, MAFF 237500, WPC P19991, S&T BL 123	**MG865523**	**MH136918**	**MH443257**	**MH493965**	**MH359018**	**MH380116**	**MK020331**	**Present publication**
P. litchii (2007)	**4**	**(ENT) CBS 100.81**, ATCC34595, WPC P15218, S&T BL 48G	**MG865525**	**MH136920**	**MH443259**	**MH493966**	**MH359019**	**MH380117**	**MK020332**	**Present publication**
P. litoralis (2011)	**6b**	**(ET) CBS 127953**, VHS20763, WPC P19591, S&T BL 70	**MG865526**	**MH136921**	**MH443260**	**MH493967**	**MH359021**	**MH380119**	**MK020334**	**Present publication**
P. ludoviciana (2022)	**10d**	**(ET) CBS 149205**, NRRL 64143, LU057	ON000760	ON013826	ON024976	OM975939	OM984919	OM974493	OM976456	Jung *et al.* (2022b)
P. macilentosa (2014)	**9a**	**(ET) ATCC MYA-4945 (MCI)**, WPC P19993, S&T BL 125, 58A7	**MG865527**	**MH136922**	**MH443261**	KX252344	KX252345	KX252343	KX252347	**Present publication**, Yang *et al.* (2017)
P. macrochlamydospora (1991)	**9c**	**(ET) WPC P10263**, S&T BL 71, Irwin 20502	**MG865528**	**MH136923**	**MH443262**	**MH493968**	**MH359022**	**MH380120**	**MK020335**	**Present publication**
P. marrasii (2021)	**8e**	**(ET) CBS 148033**, NRRL 64314, CB150, S&T BL 216	MZ569854	—	—	MZ603724	—	—	—	Bregant *et al.* (2021b)
P. meadii (1918)	**2a**	**(ENT) CBS 148927**, NRRL 64146, WPC P19007, S&T BL 81	**MG865529**	**MH136924**	**MH443263**	**MH493969**	**MH359023**	**MH380121**	**MK020336**	**Present publication**
P. medicaginis (1991)	**8a**	**(ET) CBS 119902**, NRRL 64260, WPC P19830, S&T BL 83	**MG865532**	**MH136927**	**MH443266**	**MH493972**	**MH359026**	**MH380124**	**MK020338**	**Present publication**
P. mediterranea (2021)	**7c**	**(ET) CBS 147720**, NRRL 64337, S&T BL 217, CB84	MW892398	—	—	MW900443	—	—	—	Bregant *et al.* (2021a)

Table 2. (Continued).

Phytophthora species with factsheets in *Idphy*	Clade	Type cultures[1]	Molecular Toolbox and Multigenic Phylogeny Genes[2]							Reference(s) / *** Genome Biosample
			ITS[3]	*COI*[3]	*YPT*	*β-tub*	*EF1α*	*L10*	*HSP90*	
P. megakarya (2023)	4	**(ET) CBS 238.83** (A2), NRRL 64259, ATCC 42100 (MCI), CABI IMI202077 (AVA), P184, WPC P1672, S&T BL 73, 61J5	**MG865534**	**MH136929**	**OP104644**	**OL466903**	**MH359028**	**OK533435**	—	**Present publication**
P. megasperma (1931)	6b	**(EEpT) CBS 402.72**, ATCC 58817 (MCI), CABI IMI32035 (PA), WPC P6957, S&T BL 43	**MG865535**	**MH136930**	**OP104645**	**MH493973**	**MH359029**	**MH380126**	**MK020340**	**Present publication**
P. mekongensis (2018)	2a	**(ET) CBS 135136**, NRRL 64108, PF6a2, TJ120, S&T BL 218	KC875838	KT366920	**OP081638**	**OP081603**	**OP081630**	**OP081617**	**OP081610**	**Present publication**, Cacciola *et al.* (2017), Crous *et al.* (2017)
P. melonis (1976)	7b	**(ET) CBS 582.69**, NRRL 64013, ATCC 52854, WPC P6870, S&T BL 23, No. P 10-4-1, Ho 513, H27.2, 45F3	**MG865536**	**MH136931**	**MH443268**	**MH493974**	**MH359030**	**MH380127**	**MK020341**	**Present publication**
P. mengei (2009)	2b	**(ET) NRRL 64116**, ATCC MYA-4554, WPC P16862, S&T BL 31, TJ1109	**MG865539**	**MH136932**	**MH988443**	**MH493977**	**MH359033**	**MH380130**	**MK020344**	**Present publication**
P. mexicana (1923)	2b	**(EEpT) CBS 149405**, S&T BL 199, French Ph213, S972	**OP020178**	**OP728146**	**OP728145**	**OP728147**	**OP728148**	—	—	**Present publication**
P. mirabilis (1986)	1c	**(ET) CBS 678.85**, ATCC 64071, ATCC 64130, WPC P3008, S&T BL 25, M10	**MG865541**	**MH136934**	**OP104646**	**MH493979**	**MH359035**	**MH380132**	**MK020346**	**Present publication**
P. mississippiae (2013)	6b	**(ET) NRRL 64167**, ATCC MYA-4946, WPC P19994, S&T BL 126, 57J3	**MG865542**	**MH136935**	**MH988445**	**MH493980**	**MH359036**	**MH380133**	**MK020347**	**Present publication**
P. morindae (2010)	10a	**(ET) CBS 121982**, WPC P19748, S&T BL 49G	**MG865543**	**MH136936**	**MH988446**	**MH493981**	**MH359037**	**MH380134**	**MK020348**	**Present publication**
P. moyootj (2014)	6b	**(ET) CBS 138759**, VHS27218, S&T BL 182	KJ372256	**MH477750**	**OP104647**	KJ372303	**MK864046**	**OL342760**	MK020349	**Present publication**, Burgess, Stukely (2014), Crous *et al.* (2014)
P. multibullata (2021)	2a	**(ET) CBS 146552, QD27, VTN2A**	MT568655	OK185363	**OP104648**	MT583643	OK267381	OK533443	MT583684	**Present publication**, Dang *et al.* (2021)
P. multiglobulosa (2022)	10a	**(ET) CBS 148799**, SL005	ON000763	ON013829	ON024979	OM975942	OM984922	OM974496	OM976459	Jung *et al.* (2022b)
P. multivesiculata (1998)	2e	**(ET) CBS 545.96**, WPC P10410, S&T BL 50G	**MG865544**	**MH136937**	**MH988447**	**MH493982**	**MH359038**	EU080065	EU080069	**Present publication**, Blair *et al.* (2008)
P. multivora (2009)	2c	**(ET) CBS 124094**, NRRL 66992, WAC13201, WPC P19594, S&T BL 104	**MG865546**	**MH136939**	**MH988449**	**MN207273**	**MK864047**	**OK533427**	**OL466911**	**Present publication**
P. nagaii (2014)	7d	**(ET) CBS 133348**, NBRC 109131, WPC P19989, S&T BL 121	**MG865547**	**MH136940**	**MH988450**	**MN207274**	**MK864048**	**OK533428**	**MK020351**	**Present publication**
P. nemorosa (2003)	3	**(ET) CBS 114870**, ATCC MYA-2948, WPC P19600, S&T BL 27, P-13, 41C4	**MG865548**	**MH136941**	**MH988451**	**MH493984**	**MH359040**	KX250964	**MK020352**	**Present publication**, Yang *et al.* (2017)
P. nicotianae (1896)	1d	**(EEpT) CBS 149823,** NRRL 64371, WPC P6303, S&T BL 162	**OP020179**	**MH477752**	**MH988453**	**MH493986**	**MH359042**	**MH380137**	**MK020354**	**Present publication**
P. niederhauseri (2014)	7b	**(ET) CBS 149824**, NRRL 64258, WPC P10616, S&T BL 45 Ph289, PPIL 01.6056	**MG865552**	**MH136944**	**MK058409**	**MH493988**	**MH359044**	**MH380139**	**MK020356**	**Present publication**
P. obscura (2012)	8d	**(ET) CBS 129273**, S&T BL 84, WPC P19796	**MG865554**	**MH136946**	**OP104649**	**MH493989**	**MK864049**	**MH380140**	**MK020357**	**Present publication**

Table 2. (Continued).

Phytophthora species with factsheets in *Idphy*	Clade	Type cultures[1]	Molecular Toolbox and Multigenic Phylogeny Genes[2]							Reference(s) / *** Genome Biosample
			ITS[3]	*COI*[3]	*YPT*	*β-tub*	*EF1α*	*L10*	*HSP90*	
P. occultans (2015)	**2a**	**(ET) CBS 101557**, S&T BL 163, WPC P19955	**MG865555**	**MH477753**	**OP104650**	**MH493990**	**MH359045**	**MH380141**	**MK020359**	**Present publication**
P. oleae (2018)	**2d**	**(ET) CBS 141871**, NRRL 64313, Po1a, S&T BL 219	KY982930	MF083569	**OP081647**	**OP081608**	**OP081636**	**OP081623**	**OP081615**	**Present publication**, Ruano-Rosa *et al.* (2018)
P. oreophila (2019)	**6a**	**(ET) CBS 144708**, U11	MG542976	MG543002	**OP104651**	MG543037	**OK267382**	**OL342765**	MG543025	**Present publication**, Khaliq *et al.* (2019)
P. ornamentata (2015)	**6b**	**(ET) CBS 140647**, PH152, S&T BL 152, WPC P19906, 66D2	**MG865556**	**MH136947**	**OP104652**	**MN207275**	**MK864050**	KX251319	**MK020360**	**Present publication**, Yang *et al.* (2017)
P. pachypleura (2014)	**2c**	**(ET) CABI IMI502404 (AVA)**, WPC P19987, S&T BL 146, TJ 0472	**MG865558**	**MH136948**	**MK058411**	**MH493991**	**MH359046**	**MH380142**	**MK020362**	**Present publication**
P. palmivora (1919)	**4**	**(RS) CBS 305.62** (A2), NRRL 64372, ATCC 46716 (MCI), CABI IMI348384 (AVA), WPC P0633, S&T BL 105	**MG865559**	**MH136949**	**MK058412**	**MH493992**	**MH359047**	**MH380143**	**MK020363**	**Present publication**
P. panamensis (2022)	**4**	**(ET) CBS 147925**, NRRL 64033, PA328	MZ753919	—	—	MZ736459	—	—	—	Jung *et al.* (2022a), Chen *et al.* (2022)
P. parsiana (2008)	**9a**	**(ET) SUC25**, SCRP791, WPC P15164, S&T BL 47	**MG865562**	**MH136952**	—	**MH493995**	**MH359050**	**MH380146**	**MK020366**	**Present publication**
P. parvispora (2014)	**7c**	**(ET) CBS 132772**, WPC P19847, S&T BL 98, PH072, TJ 1542, 66C8	KC478667	**MH136953**	—	KC609402	**MH359051**	**MH380147**	KX251843	**Present publication,** Scanu *et al.* (2014), Yang *et al.* (2017)
P. personensis (2020)	**6a**	**(ET) CBS 146549**, VHS14081	EU301169	**OK185364**	**OP104653**	MF326805	**OK267383**	**OL342766**	MF326890	**Present publication**, Burgess *et al.* (2020)
P. phaseoli (1889)	**1c**	**(EEpT) CBS 114105**, NRRL 64338, WPC P10150, S&T BL 28	**MG865564**	**MH136956**	**MK058415**	**MH493997**	**MH359054**	**MH380150**	**MK020368**	**Present publication**
P. pini (1925)	**2c**	**(ET) CBS 181.25**, NRRL 64190, ATCC 64532, CABI IMI77970 (PA), WPC P3274, S&T BL 48	**MG865565**	**MH136957**	**MK058416**	**MH493998**	**MH359055**	**MH380151**	**MK020369**	**Present publication**
P. pinifolia (2008)	**6b**	**(ET) CBS 122924**, CMW 26668, WPC P16100, S&T BL 49, TJ 0074	**MG865566**	**MH136958**	**MK058417**	**MH493999**	**MH359056**	**MH380152**	**MK020370**	**Present publication**
P. pisi (2023)	**7b**	**(ET) CBS 130350**, WPC P19612, S&T BL 133	**MG865567**	**MH477754**	**MK058418**	**MH494000**	**MH359057**	**MH380153**	**MK020371**	**Present publication**
P. pistaciae (2001)	**7b**	**(ET) CBS 137185**, ATCC MYA-4082, CABI IMI386658 (PA), WPC P19883, PIS16, S&T BL 99, SCRP 533, 33D6	FJ746648	LC595934	**OP104675**	KX251749	KX251750	KX251748	KX251752	**Present publication**, Yang *et al.* (2017), Igo *et al.* (2009), Hieno *et al.* (2020) NCBI
P. plurivora (2009)	**2c**	**(ET) CBS 124093**, NRRL 64168, WPC P16840, S&T BL 74, PLU-A5	**MG865568**	**MH136959**	**MK058419**	**MH494001**	**MH359058**	**MH380154**	**MK020372**	**Present publication**
P. pluvialis (2013)	**3**	**(ET) ATCC MYA-4930**, LC-9.2-020508, 33D6	KC529657	LC595935	**OP104654**	KX250972	KX250973	KX250971	KX250975	Present publication, Reeser et al. (2013), Hieno et at. (2020) NCBI, Yang et al. (2017),
P. podocarpi (2022)	**15**	**(ET) ICMP 24118**, NZFS 3642	***	***	***	***	***	***	***	Dobie *et al.* (2022). *** Genome SAMN03897384
P. polonica (2006)	**9b**	**(ET) CBS 119650,** UASWS0198, WPC P19522 P19846, S&T BL 109	DQ396410	**MH136960**	**MK058420**	DQ399844	**MK864052**	**OK533429**	**MK020373**	**Present publication**, Belbahri *et al.* (2006)

Table 2. (Continued).

Phytophthora species with factsheets in *Idphy*	Clade	Type cultures[1]	Molecular Toolbox and Multigenic Phylogeny Genes[2]							Reference(s) / *** Genome Biosample
			ITS[3]	*COI*[3]	*YPT*	*β-tub*	*EF1α*	*L10*	*HSP90*	
P. porri (1931)	8b	**(EEpT) CBS 116662**, NRRL 64316, WPC P9186, S&T BL 147, AdC 00.21b, Smilde GG	**MG865569**	**MH136961**	**MK058421**	**OL466904**	**MH359059**	**MH380155**	**MK020374**	**Present publication**
P. primulae (1952)	8b	**(EEpT) CBS 620.97**, NRRL 64336, WPC P10333 P10220, S&T BL 50, PD97/875, 29E9, P286	**MG865571**	**MH136963**	**MK058423.**	**MH494002**	**MH359062**	**MH380157**	KX252067	**Present publication**, Yang *et al.* (2017)
P. procera (2022)	10d	**(ET) CBS 149226**, NRRL 64144, LU013	ON000767	ON013833	ON024983	OM975946	OM984926	OM974500	OM976463	Jung *et al.* (2022b)
P. prodigiosa (2018)	9b	**(ET) CBS 135138**, NRRL 64326, PF6e, S&T BL 220	KC875840	KT366918	**OP081639**	**OP081604**	**OP081631**	**OP081618**	**OP081611**	**Present publication**, Cacciola *et al.* (2017)
P. pseudochilensis (2022)	10a	**(ET) CBS 148798**, NRRL 64352, CL168	ON000773	ON013839	ON024989	OM975952	OM984932	OM974506	OM976469	Jung *et al.* (2022b)
P. pseudocryptogea (2015)	8a	**(ET) CBS 139749**, VHS16118, S&T BL 183	KP288376	**MH477756**	**OP104655**	KP288392	**MK864053**	**OK533430**	**MK020376**	**Present publication**, Safaiefarahani *et al.* (2015)
P. pseudogallica (2022)	10b	**(ET) CBS 149206**, NRRL 64136, VN861	ON000774	ON013840	ON024990	OM975953	OM984933	OM974507	OM976470	Jung *et al.* (2022b)
P. pseudokernoviae (2022)	10a	**(ET) CBS 148796**, NRRL 64351, CL012	ON000780	ON013846	ON024996	OM975959	OM984939	OM974513	OM976476	Jung *et al.* (2022b)
P. pseudolactucae (2015)	8b	**(ET) CBS 137103**, NBRC 110060, KPh 2013-2-1, WPC P19992, S&T BL 118	**MG865573**	**MH136965**	**OP104656**	**OL466907**	**MH359065**	**MH380160**	**MK020381**	**Present publication**
P. pseudopolonica (2023)	9b	**(ET) CBS 142610**, NRRL 64333, S&T BL 221, LS06.3.2	KY707115	—	—	KY707104	KY787198	—	—	Li *et al.* (2017)
P. pseudorosacearum (2018)	6a	**(ET) CBS 143061**, VHS29592, S&T BL 188	KJ372267	**MH477757**	**OP104657**	**MN207277**	**MK864055**	**OL342762**	**MK020378**	**Present publication**, Burgess *et al.* (2018)
P. pseudosyringae (2003)	3	**(ET) CBS 111772**, NRRL 64157, IFB-PSEU 6, WPC P10437, TJ1528, S&T BL 51G	**MG865574**	**MH136966**	**OP104658**	**MH494004**	**MH359064**	**MH380159**	**MK020380**	**Present publication**
P. pseudotsugae (1983)	1a	**(ET) NRRL 64376**, ATCC 52938, CABI IMI331662 (AVA), WPC P10339, S&T BL 51	**MG865575**	**MH136967**	**OP104659**	**MH494003**	**MH359063**	**MH380158**	**MK020379**	**Present publication**
P. psychrophila (2002)	3	**(ET) CBS 803.95**, IFB-PSY 1, WPC P10433, S&T BL 52	**MG865576**	**MH136968**	**OP104660**	**MH494005**	**MH359066**	**MH380161**	**MK020382**	**Present publication**
P. quercetorum (2008)	4	**(ET) CBS 121119**, NRRL 64164, ATCC MYA-4186, WPC P15555, S&T BL 52G, MD 9/2	**MG865577**	**MH136969**	**OP104661**	**MH494006**	**MH359067**	**MH380162**	—	**Present publication**
P. quercina (1999)	12	**(ET) CBS 784.95, IFB-QUE3, ATCC MYA-4084 (MCI), WPC P10439, S&T BL 110, No. Hag 4, 30A5, p290**	**MG865578**	**MH136970**	**OP104662**	**MH494007**	**MH359068**	**MH380163**	**MK020383**	**Present publication**
P. quininea (1947)	9c	**(ET) CBS 407.48**, ATCC 46733, CMW 31062, C-67 Crandall, WPC P8488 P1089, S&T BL 54G	**MG865580**	**MH136972**	**OP104663**	**MH494009**	**MH359070**	**OK533436**	—	**Present publication**
P. ramorum (2001)	8c	**(ET) CBS 101553**, WPC P10103, BBA 9/95, S&T BL 55G	**MG865581**	**MH136973**	**OP104664**	**EF117938**	**MH359071**	**MH380165**	**MK020385**	**Present publication**
P. rhizophorae (2016)	9a	**(ET) CCIBt 4152**, MMBF 09/15	KT886031	KT886048	—	—	—	—	—	Marano *et al.* (2016) NCBI

Table 2. (Continued).

Phytophthora species with factsheets in *Idphy*	Clade	Type cultures[1]	Molecular Toolbox and Multigenic Phylogeny Genes[2]							Reference(s) / *** Genome Biosample
			ITS[3]	*COI*[3]	*YPT*	*β-tub*	*EF1α*	*L10*	*HSP90*	
P. richardiae (1927)	**9c**	**(ET) CBS 149410**, NRRL 64472, CABI IMI340618 (AVA), WPC P7789, S&T BL 76	**MK496521**	**MH136974**	**OP104665**	**MH494010**	**MH359072**	**MH380166**	**MK020386**	**Present publication**
P. riparia (2012)	**6d**	**(ET) CBS 132024**, ATCC MYA-4882, WPC P19799, S&T BL 111	**MG865583**	**MH136975**	**OP104666**	JQ626618	**MK864056**	**OK533431**	**MK020387**	**Present publication**, Hansen *et al.* (2012b)
P. rosacearum (2009)	**6a**	**(ET) CBS 124696**, NRRL 66998, ATCC MYA-4456, WPC P3112, S&T BL 53, Isolate 52 (Hansen), Mircetich 20-3-9, P462 Brazier	EU925376	**MH477758**	**OP104667**	**MN207278**	**MK864057**	**OL342761**	**MK020388**	**Present publication**, Hansen *et al.* (2009)
P. rubi (2007)	**7a**	**(ET) CBS 967.95**, ATCC 90442, CABI IMI355974 (PA), WPC P15597 P16899, S&T BL 54, No R49, FVR 11, NY 588	**MG865584**	**MH136976**	**OP104668**	**MH494011**	**MH359073**	**MH380167**	**MK020389**	**Present publication**
P. sansomeana (2009)	**8a**	**(ET) CBS 117693**, ATCC MYA-4455, WPC P8051, S&T BL 55	**MG865585**	**MH136977**	**MK032149**	**MH494012**	**MH359074**	**MH380168**	**MK020390**	**Present publication**
P. scadinavica (2022)	**10c**	**(ET) CBS 149204**, NRRL 66990, SW325	ON000786	ON013852	ON025002	OM975965	OM984945	OM974519	OM976482	Jung *et al.* (2022b)
P. siskiyouensis (2008)	**2b**	**(ET) CBS 122779**, ATCC MYA-4187, WA5-30403, WPC P15122, S&T BL 56, 41B7	**MG865586**	**MH136978**	**MK032150**	**MH494013**	KX250679	**MH380169**	**MK020391**	**Present publication**, Yang *et al.* (2017)
P. sojae (1958)	**7b**	**(EEpT) CBS 149406**, NRRL 64266 (Race 1), WPC P3114, S&T BL 56G	**MG865588.**	**MH136980**	**MK032151**	**MH494014**	**MH359075**	**MH380170**	—	**Present publication**
P. stricta (2014)	**17**	**(ET) NRRL 64261**, MYA-4944 (MCI), WPC P19972, S&T BL 127, 58A1	**MG865589**	**MH136981**	**MK032152**	**MH494015**	**MH359076**	**MH380171**	**MK020392**	**Present publication**
P. subarctica (2022)	**10b**	**(ET) CBS 148850**, NRRL 64339, SW176	ON000790	ON013856	ON025006	OM975969	OM984949	OM974523	OM976486	Jung *et al.* (2022b)
P. syringae (1905)	**8d**	**(ENT) CBS 110161**, NRRL 64329, WPC P10330, S&T BL 57G, BBA 70008	**MG865590**	**MH136982**	**MK032153**	**MH494016**	**MH359077**	**MH380172**	**MK020393**	**Present publication**
P. tentaculata (1993)	**1b**	**(ET) CBS 412.96**, WPC P8496, S&T BL 29, BBA 65425	**MG865591**	**MH136983**	**MK032154**	**MH494017**	**MH359078**	**MH380173**	**MK020394**	**Present publication**
P. tenuimura (2022)	**10d**	**(ET) CBS 149227**, NRRL 64142, LU052	ON000798	ON013864	ON025014	OM975977	OM984957	OM974531	OM976494	Jung *et al.* (2022b)
P. terminalis (2015)	**2a**	**(ET) CBS 133865**, WPC P19956, S&T BL 164, PD 010 04885512-1	**MG865592**	**MH136984**	**MK032155**	**MH494018**	**MH359079**	**MH380174**	**MK020395**	**Present publication**
P. theobromicola (2021)	**2b**	**(ET) CCUB1091**, ATCC 64859, ubadn 950	MT074263	—	—	MT074223	MT074279	—	MT074287	Decloquement *et al.* (2021)
P. thermophila (2011)	**6b**	**(ET) CBS 127954**, NRRL 64163, VHS13530, WPC P19593, S&T BL 77	**MG865593**	**MH136985**	**OP104670**	**MH494019**	**MH359080**	**MH380175**	**MK020396**	**Present publication**
P. tonkinensis (2022)	**10b**	**(ET) CBS 148852**, NRRL 64356, VN859	ON000799	ON013865	ON025015	OM975978	OM984958	OM974532	OM976495	Jung *et al.* (2022b)
P. transitoria (2022)	**13**	**(ET) CBS 147245**, CZ001	MZ753925	—	—	MZ736466	—	—	—	Jung *et al.* (2022a), Chen *et al.* (2022)
P. trifolii (1991)	**8a**	**(ET) CBS 117687**, WPC P6980, S&T BL 57, Pratt. 105, Ham 32	**MG865594**	**MH136986**	**MK032156**	**MH494020**	**MH359081**	**MH380176**	**MK020397**	**Present publication**
P. tropicalis (2001)	**2b**	**(ET) CBS 434.91**, NRRL 64471, ATCC 76651 (MCI), WPC P10329, H245-24 (Aragaki), S&T BL 58	**MG865596**	**MH136987**	**MK032158**	**MH494022**	**MH359082**	**MH380178**	**MK020399**	**Present publication**
P. tubulina (2017)	**12**	**(ET) CBS 141212**, NRRL 64149, S&T BL 200, TJ0271, TUB1, TUB II/1	MF036196	**OK185356**	**OP104671**	MF036225	**OK267372**	***	MF036251	**Present publication**, Jung *et al.* (2017a). *** Genome SAMN15299832

Table 2. (Continued).

Phytophthora species with factsheets in Idphy	Clade	Type cultures[1]	Molecular Toolbox and Multigenic Phylogeny Genes[2]							Reference(s) / *** Genome Biosample
			ITS[3]	*COI*[3]	*YPT*	*β-tub*	*EF1α*	*L10*	*HSP90*	
P. tyrrhenica (2017)	**7a**	**(ET) CBS 142301**, NRRL 64153, S&T BL 222, PH154, TJ1153	KU899188	—	**OP081648**	**OP081609**	**OP081637**	**OP081624**	**OP081616**	**Present publication**, Jung *et al.* (2017a)
P. ukrainensis (2022)	**10b**	**(ET) CBS 148851**, NRRL 64255, UA373	ON000805	ON013871	ON025021	OM975984	OM984964	OM974538	OM976501	Jung *et al.* (2022b)
P. uliginosa (2002)	**7a**	**(ET) CBS 109054**, WPC P10413, S&T BL 59	**MG865597**	**MH136988**	**MK032159**	**MH494023**	**MH359083**	EU080011	**MK020400**	**Present publication**, Blair *et al.* (2008)
P. uniformis (2023)	**7a**	**(ET) CBS 149409**, NRRL 64373, WPC P16206, S&T BL 3, P875 (Brasier - DEFRA)	**MK496514**	**MH136992**	**MH974991**	**MH493905**	**OK267369**	**MH380053**	**MK020272**	**Present publication**
P. urerae (2019)	**1c**	**(ET) CBS 148929,** NRRL 64200, PSR27, S&T BL 203, VJF-2015a	KR632862	—	—	KR632888	—	—	—	Grünwald *et al.* (2019) PSR27
P. variabilis (2022)	**7b**	**(ET) CBS 147923**, NRRL 64113, TJ915	MZ753930	—	—	MZ736472	—	—	—	Jung *et al.* (2022a), Chen *et al.* (2022)
P. versiformis (2017)	**12**	**(ET) CBS 142005**, TP13.46, S&T BL 189	KX011279	**MH477760**	**OP104672**	**MN207280**	**MK864060**	**OK533433**	**MK020401**	**Present publication**, Paap *et al.* (2017)
P. vignae (1957)	**7b**	**(EEpT) WPC P3019**, S&T BL 30, Pegg 20853	**MG865598**	**MH136989**	**MK032160**	**MH494024**	EU079784	**MH359084**	**MK020402**	**Present publication**, Blair *et al.* (2008)
P. virginiana (2013)	**9a**	**(ET) ATCC MYA-4927**, WPC P19829, S&T BL 165, 46A2	**MK496522**	**MH477761**	—	**MH494025**	**MH359085**	**MH380179**	**MK020403**	**Present publication**
P. vulcanica (2017)	**7a**	**(ET) CBS 141216**, NRRL 64330, S&T BL 223, X3a	MF036209	—	**OP081645**	**OP081606**	**OP081634**	**OP081621**	**OP081613**	**Present publication**, Jung *et al.* (2017)
P. ×*alni* (2004)	**7a**	**(ET) CABI IMI403468** (AVA) (OLD IMI392314), P772 (Brasier - DEFRA), S&T BL 1	**MK496513**	**MH136991**	**MH209243**	**MH493903**	**MH358952**	**MH380051**	**MK020270**	**Present publication**
P. ×*cambivora* (1927)	**7a**	**(NT) CBS 141218**, NRRL 64019, TJ0197, P711, V/3+4B, S&T BL 225	KU899179	—	**OP081646**	**OP081607**	**OP081635**	**OP081622**	**OP081614**	**Present publication**, Jung *et al.* (2016)
P. ×*heterohybrida* (2017)	**7a**	**(ET) CBS 141207**, NRRL 64119, TW30, S&T BL 226	KU517151	—	**OP081643**	KU899290	**OP081632**	**OP081619**	KU899447	**Present publication**, Jung *et al.* (2017)
P. ×*incrassata* (2017)	**7a**	**(ET) CBS 141209**, NRRL 64126, TW269, S&T BL 224	KU517156	—	—	KU899286.	—	—	KU899443	Jung *et al.* (2017)
P. ×*multiformis* (2023)	**7a**	**(ET) WPC P16202**, S&T BL 2, P770 (Brasier - DEFRA)	**MG783372**	**MK493472**	**MH209244**	**MH493904**	**MH358953**	**MH380052**	**MK020271**	**Present publication**
P. ×*pelgrandis* (2009)	**1d**	**(ET) CBS 123385**, BBA 71729, S&T BL 122	**MK496523**	**MH136990**	**MK032161**	**MH494026**	**MH359086**	**MH380180**	—	**Present publication**
P. ×*serendipita* (2012)	**1a**	**(ET) CBS 100427**, PD95/5111, WPC P19540, S&T BL 149	**MG865599**	**MH477762**	—	**MH494027**	**MH359087**	**MH380181**	—	**Present publication**
P. ×*stagnum* (2014)	**6b**	**(ET) ATCC MYA-4926** (MCI), 43F3	KJ705084, KJ705085, KJ705086	KX251376	—	KX251376	KX251377	KX251375	KX251379	Yang *et al.* (2014), Yang *et al.* (2017)
P. ×*vanyenensis* (2021)	**2a**	**(ET) CBS 146554,** QD13; VTN2B	MT568651	**OK185365**	**OP104673**	MT583634	**OK267384**	**OL342767**	MT583680	**Present publication**, Dang *et al.* (2020)
P. taxon juncus		(SE) CBS 149407. T. Bourret # SCVWD615, S&T BL 227	MG707853	MG701996	—	—	—	—	—	

Table 2. (Continued).

Phytophthora species with factsheets in *Idphy*	Clade	Type cultures[1]	Molecular Toolbox and Multigenic Phylogeny Genes[2]							Reference(s) / *** Genome Biosample
			ITS[3]	*COI*[3]	*YPT*	*β-tub*	*EF1α*	*L10*	*HSP90*	
P. taxon *juniperis*		(SE) Ph409.03.2633. (Abad)	**OP852375**	—	—	—	**OP753346**	—	—	
P. taxon *mugwort*		(SE) CBS 149408. T. Bourret # SCVWD302, S&T BL 228	MF693893	MF687218	—	—	—	—	—	

[1] ATCC: American Type Culture Collection, Manassas, VA, USA (MCI = Mission Collection Item); BPIC: Benaki Phytopathological Institute Collection, Greece; CABI: Genetic Resource Collection, Commonwealth Agricultural Bureaux (CAB) International (CABI-IMI), U.K.; CBS: Filamentous fungi and Yeast Collection, Westerdijk Fungal Biodiversity Institute, KNAW The Netherlands; CCCT/UFRO: Colección Chilena de Cultivos Tipo- BIOREN-UFRO Scientific and Technological Bioresource Nucleus | Universidad de La Frontera, Chile; CGMCC: China General Microbiological Culture Collection Center, Institute of Microbiology, Chinese Academy of Science; CMW: Culture collection at the FABI, University of Pretoria, South Africa; ICMP: International Collection of Micro-organisms from Plants, Auckland New Zealand; IFB: Institute of Forest Botany, Section Forest Pathology, Technische Universität München, Germany; MUCL: Belgian Coordinated Collections of Microorganisms / MUCL Agro-food & Environmental Fungal Collection, Université Catholique de Louvain, Louvain-la-Neuve, Belgium; NBRC: National Institute of Technology and Evaluation – National Biological Resource Center, Japan; NRRL: Agricultural Research Service Culture Collection, National Center for Agricultural Utilization Research, USDA, Peoria, IL, USA; NZFS: Forest Research Culture Collection, New Zealand; PPRI: National Collections of Fungi: Culture Collection, ARC-Plant Protection Research Institute, South Africa; S&T BL: Collection of Z.G. Abad, Plant Pathogen Confirmatory, Science & Technology, USDA-APHIS-PPQ-S&T-PPCDL; TJ: Thomas Jung collection, Mendel University in Brno, Germany; UAMH: Center for Global Microfungal Biodiversity, University of Toronto, Canada; VHS: Vegetation Health Service of the Department of Environment and Conservation, Perth, Western Australia; WAC: Department of Agriculture and Food Western Australia Plant Pathology Collection, Australia; WPC: World Phytophthora Genetic Resource Collection (WPC), University of California, Riverside, USA. ET = ex-type; ENT = ex-neotype; EEpT = ex-epitype, RS = reperesentative strain.

[2] In bold: Sequences generated for this study. ITS: Internal transcribed spacer 1, partial sequence; 5.8S ribosomal RNA gene and internal transcribed spacer 2, complete sequence; and large subunit ribosomal RNA gene, partial sequence; *COI*: Cytochrome c oxidase subunit 1 (COI) gene, partial cds; mitochondrial. *YPT1*: Ras-related protein ypt1 (ypt) gene, partial cds; *β-tub*: Beta-tubulin gene, partial cds; *EF1α*: Translation elongation factor 1-alpha (EF1A) gene, partial cds; *L10*: 60S ribosomal protein L10 (RPL10) gene, partial cds; *HSP90*: Heat shock protein 90 (HSP90) gene, partial cds; * = Whole genome sequence contig accession numbers at GenBank. "*IDphy*: molecular and morphological identification of *Phytophthora* based on the types" online resource.

[3] ITS and *COI*: Barcoding genes used for Database for SANGER sequencing in SOP-PID-05.05 of *IDphy* online resource. ITS and *COI* are also used in Local Metabarcoding Databases Second and Third Generation High-throughput Sequencing (2G-HTS and 3G-HTS) for *Phytophthora* species identification in environmental DNA (eDNA) samples. 3G-HTS via MinION are using metabarcoding primers designed by Gloria Abad (Mathew et al. 2022 in progress).

Table 3. Whole genomes for the ex-types of 23 species from the 53 *Phytophthora* at the NCBI including 190 assemblies by December 2022.

***Phytophthora* species**	**Isolate and Typ status[1]**	**Assembly**	**GenBank Assembly (GCA)**	**Level**	**Size**	**BioProject**	**WGS Project**	**Institution/Year**	**Publication**
P. agathidicida	NZFS 3770 (ET)	NZFS 3770 v2	GCA 001314445.1	Scaffold	37.23 Mbp	PRJNA290659	LGTS01	University of Exeter (2015)	Studholme *et al.* (2015)
P. aleatoria	NZFS4037 (ET)	NZFS4037v1 reference	GCA 018873745.1	Scaffold	50.59 Mbp	PRJNA687640	JAENGY01	University of Exeter (2021)	—
P. betacei	P8084 (ET)	UAnd PBet P8084 reference	GCA 011320135.1	Contig	270.9 Mbp	PRJNA608953	JAANHX01	Universidad de los Andes (2020)	Mideros *et al.* (2015)
P. castanetorum	ST_20191112 (ET) (= BL 201)	ASM1470611v1 reference	GCA 014706115.1	Contig	69.76 Mbp	PRJNA640137	JACBOV01	USDA-APHIS-PPQ-S&T (2020)	—
P. cinnamomi	CBS 144.22 (ET)	ASM2028349v1	GCA 020283495.1	Scaffold	77.97 Mbp	PRJNA68241	JAIWQA01	University of Liverpool (2021)	—
P. citricola	P0716 (ET)	USDA Pcit BL34 1.0 reference	GCA 007655245.1	Contig	50.32 Mbp	PRJNA555328	VMRO01	USDA-APHIS-PPQ-S&T (2019)	Srivastava *et al.* (2022)
P. constricta	BL 61 (ET)	USDA Pcon 61 1.0 reference	GCA 011947335.1	Contig	84.72 Mbp	PRJNA612532	JAAVTI01	USDA-APHIS-PPQ-S&T (2020)	—
P. fragariae	CBS 309.62 (EEpT)	P.fr2.0	GCA 000686205.4	Scaffold	75.98 Mbp	PRJNA243070	JHVZ04	Shenzhen Entry-Exit Inspection and Quarantine Bureau (2018)	Gao *et al.* (2015)
P. hibernalis	SBL41G (EEpT)	USDA Phib BL41 1.0 reference	GCA 012656075.1	Contig	84.51 Mbp	PRJNA605765	JAAKBF01	USDA-APHIS-PPQ-S&T (2020)	Srivastava *et al.* (2022)
P. infestans	T30-4 (EEpT)	ASM14294v1 reference	GCF 000142945.1	Scaffold	228.54 Mbp	PRJNA17665	AATU01	Broad Institute of MIT and Harvard (2009)	Haas *et al.* (2009)

Table 3. (Continued).

Phytophthora species	Isolate and Typ status[1]	Assembly	GenBank Assembly (GCA)	Level	Size	BioProject	WGS Project	Institution/Year	Publication
P. kernoviae	P19827 (ET)	CPHST-BL-91 reference	GCA_008080845.1	Contig	41.91 Mbp	PRJNA554119	VKKV01	USDA-APHIS-PPQ-S&T (2019)	Srivastava *et al.* (2020)
P. lateralis	CBS 168.42 (ET)	ASM50020v2	GCA_000500205.2	Scaffold	52.45 Mbp	PRJNA190827	AWVV02	Tree Aggressors Identification using Genomic Approaches (2016)	Feau *et al.* (2016)
P. macrochlamydospora	BL 71 (ET)	USDA_Pmac_71_1.0	GCA_011947325.1	Contig	69.85 Mbp	PRJNA612532	JAAVTH01	USDA-APHIS-PPQ-S&T (2020)	—
P. melonis	BL 23 (ET)	USDA_Pmel_BL23_1.0 reference	GCA_008553785.1	Contig	112 Mbp	PRJNA556690	VXDT01	USDA-APHIS-PPQ-S&T (2019)	Srivastava *et al.* (2020)
P. nicotianae	BL162 (EEpT)	USDA_Pnic_BL162_1.0	GCA_012658955.1	Contig	106.7 Mbp	PRJNA605765	JAAKBE01	USDA-APHIS-PPQ-S&T (2020)	Srivastava *et al.* (2022)
P. pinifolia	SCBS 122922 (ET)	ASM50022v2 reference	GCA_000500225.2	Scaffold	94.62 Mbp	PRJNA190828	AWVW02	Tree Aggressors Identification using Genomic Approaches (2016)	Feau *et al.* (2016)
P. podocarpi	NZFS 3642 (ET)	NZFS3642v1 reference	GCA_001314375.1	Scaffold	55.58 Mbp	PRJNA290788	LGSN01	University of Exeter (2015)	Studholme *et al.* (2015)
P. quercina	ST_20190808 (ET) (= BL 110)	ASM1470610v1 reference	GCA_014706105.1	Contig	71.72 Mbp	PRJNA640137	JACBOW01	USDA-APHIS-PPQ-S&T (2020)	—
P. quininea	BL 54 (ET)	USDA_Pqui_54_1.0 reference	GCA_011947345.1	Contig	87.65 Mbp	PRJNA612532	JAAVTG01	USDA-APHIS-PPQ-S&T (2020)	—
P. ramorum	CPHST BL 55G (ET)	CPHST_55G Assem3	GCA_004343245.1	Contig	52.44 Mbp	PRJNA510798	RYEP01	USDA-APHIS-PPQ-S&T (2019)	Srivastava *et al.* (2020)
P. syringae	BL57G (ENT)	USDA_Psyr_BL57G_1.0 reference	GCA_012656105.1	Scaffold	74.93 Mbp	PRJNA605765	JAAKBD01	USDA-APHIS-PPQ-S&T (2020)	Srivastava *et al.* (2022)
P. tubulina	ST_20191127 (ET) (= BL 200)	ASM1470613v1 reference	GCA_014706135.1	Contig	76.8 Mbp	PRJNA640137	JACBOY01	USDA-APHIS-PPQ-S&T (2020)	—
P. versiformis	ST_20190930 (ET) (= BL 189)	ASM1470621v1 reference	GCA_014706215.1	Contig	116.9 Mbp	PRJNA640137	JACBOZ01	USDA-APHIS-PPQ-S&T (2020)	—

[1] ET = ex-type; ENT = ex-neotype; EEpT = ex-epitype.

Table 4. The seven loci employed for phylogenetic inference and Molecular Toolbox for *Phytophthora*.

Locus name(s)	Abbreviation in manuscript	Gene ID	Aligned length (bp)	Taxon coverage
Internal transcribed spacer of ribosomal DNA	ITS	—	1 178 (404 gaps)	217
Mitochondrially-encoded cytochrome c oxidase subunit I, *cox1*	*COI*	854598	744	190
Yeast Protein Two, RAS (Rat sarcoma virus)-related protein	*YPT1*	20184076	850 (322 gaps)	180
Beta-tubulin, *β-tub*	*β-tub*	9476750	1 053	213
Translation-elongation factor 1-alpha	*EF1α*	20191507	879	192
60S ribosomal protein *L10*, *RPL10*	*L10*	6134	465	186
Heat shock protein 90	*HSP90*	2543539	933	190

Table 5. *Phytophthora* Tabular Key organized by the position of 212 species in the phylogenetic tree with seven genes and morphological characters.

Phytophthora species with factsheets in *Idphy*	Type[1]	Clade[2]	Asexual Phase[3]								Sexual Phase[4]				Colony Pattern[5]			Temperature[6]		
			PA	SSH	C	PE	PR	SPO	HS	CH	H	OOG	AN	OOS	V8-A	PDA	MEA	MIN	OPT	MAX
P. cactorum (1886)	EEpT	1a	P	E,Op,O,G	C	S	-	SS/CS	-	CH/-G,T,I	HO	S	P/A	P/A	ND	ND	ND	4	25	32
P. pseudotsugae (1983)	ET	1a	P	G,O,Op	C/-	S	-	UN/SS/IS	G,SG,R,C	-	HO	S	P/A	P/A	ND	ND	ND	3	18–25	27
P. ×*serendipita* (2012)	ET	1a	P	O,G	C	S	-	SS	-	-	HO	S	A/P	P	ST	-	-	7.5	27	31
P. hedraiandra (2004)	ET	1a	P	G,O,E,Op	C	S	-	SS/UN	HS/-G,SG,t	-	HO	S	P/A	SA	CH	ND	ND	6	22–24	30
P. idaei (1995)	ET	1a	P	G,E,O	-	-	E	SS	-	-	HO	S	P/A	A	sg	sg	sg	3	18–24	27
P. aleatoria (2019)	ET	1a	P	O,G,L	C	S	-	SS	G,IR	-	HO	S	A/P	A	sg	sg	sg	5	22	26
P. alpina (2020)	ET	1a	P	G,O,P	C	S	-	SS	I	G,T	HO	S	A/P	A	ND	ST	ST	2	20	32
P. clandestina (1985)	ET	1b	P	E,O,Op,Ob,tp	C/-	S	-	UN	HS/-SG	-	HO	S	P/A	P/A	sg	sg	sg	5	25	31
P. iranica (1971)	ET	1b	P	O,Op,E,SG,I	C/-	M/-	-	UN/SS	HS/-G,SG,R	CH/-G,I	HO	S	P/A	A	ST	ND	ND	9	24–30	33
P. tentaculata (1993)	ET	1b	P	O,Op,en	C	S	-	UN/SS	G,SG,C,R	G,SG,T,IT,r	HO	S	P/A	P/A	ND	ND	-	6	20–25	30
P. infestans (1876)	EEpT	1c	SP	L,E,O,Op,Ob,tb	C	S	-	CS	-	-	HE	S	A	P/A	sg	sg	sg	5	18	24
P. betacei (2018)	ET	1c	P	L,E,EI,D	C	S	EX	SS	C,E,G	-	HE	S	A	P	ND	sg	ND	10	20	25
P. andina (2010)	ET	1c	SP	E,O	C	S	-	CS	-	-	HE	S/tb	A	P	sg	sg	sg	5	24	30
P. ipomoeae (2013)	ET	1c	SP	E,Ob,I,tb,	C	S	-	CS	-	-	HO	S/tb	A	P/A	-	-	-	11	20	25
P. mirabilis (1986)	ET	1c	SP	L,E,O,Op,Ob,tb	C	S	-	CS	-	-	HE	S	A	A/P	ND	ND	-	6	18	24
P. urerae (2019)	ET	1c	P	E	C	S	-	CS	-	-	HE	S	A	A/P	ST	ST	ND	6	20	29
P. phaseoli (1889)	EEpT	1c	SP	L,E,O,Ob,I,tb	C	S/M	-	SS	-	-	S/HO	S	P/A	A	sg	sg	sg	9	15–20	27
P. nicotianae (1896)	EEpT	1d	P	O,G,Ob,Op,I	C/-	S	-	SS	G,SG,R	G,T,IT,I	HE	S	A	P/A	CH	ND	sg	9	24	33
P. ×*pelgrandis* (2009)	ET	1d	P	SG	-	-	-	SS	-	-	HO	S	A/P	A	-	ND	-	7.5	27	32
P. citrophthora (1925)	ET	2a	SP	E,O,Ob,I	-	-	-	SS/IB	-	G,SG,T,IT	S/HE	S	P	P	CH	CH	CH	6	24–28	33
P. multibullata (2021)	ET	2a	P	O,L,G,P	C/-	S	EX	SS	G	CH/-,G,T	HE	S	A	A/P	ST	ST	ND	7	27.5	32
P. himalsilva (2011)	ET	2a	P	E,Op,L	C/-	M/S	-	SS/UN	-	-	HO	S	P/A	A	CH	CH	CH	9	20–27	31
P. terminalis (2015)	ET	2a	SP	O,Op,D	C	M	-	SS	-	-	HO	S	P/A	P/A	ND	ND	ND	10	24	28
P. occultans (2015)	ET	2a	SP	O,Op,E,I	C	M	-	SS	-	-	HO	S	P/A	P/A	CH	ND	CH	10	25–27	32
P. mekongensis (2018)	ET	2a	SP	O,Op,E	C	M	-	SS	-	-	S	-	-	-	ST	ST	-	12	28	36
P. ×*vanyenensis* (2021)	ET	2a	SP	O,E,L,D	-	-	EX	SS	HS/-,IR	-	HE	S	A	P	ND	ND	ND	7	25	35
P. colocasiae (1900)	EEpT	2a	SP	E,O,Ot,Ob,D,tb	C	M/S	-	S/IB	HS/-G,SG,IR,C	G,T,IT	HE/HO	S	A	A/SA	ND	ND	ND	9	25–27	33

Table 5. (Continued).

Phytophthora species with factsheets in *Idphy*	Type[1]	Clade[2]	Asexual Phase[3]								Sexual Phase[4]				Colony Pattern[5]			Temperature[6]		
			PA	SSH	C	PE	PR	SPO	HS	CH	H	OOG	AN	OOS	V8-A	PDA	MEA	MIN	OPT	MAX
P. meadii (1918)	ENT	2a	P/SP	O,E,El,Op,G	C	M/L	-	SS	HS/-G,SG,E,I	CH/-G,SG,I,T	HE	S	A	SA/P	ND	ND	ND	6	25–30	32
P. insulinativitatica (2021)	ET	2a	P	L,O,P,Op	C	S	EX	U/CS	E,IR	G,T	HE	S	A	P	ND	ND	ST	7	27.5	35
P. botryosa (1969)	ET	2a	SP	G,O	C	M	-	SS	-	CH/-G,T	HE	S	A	P	CH	ND	-	9	26	32
P. capsici (1922)	ET	2b	P/SP	SG,O,Ob,E,D	C	S,M,L	-	SS/UN	HS/-G,SG,I,C	-	HE	S	A	P/A	ND	ND	ND	6	27	33
P. mexicana (1923)	EEpT	2b	P/SP	E,O,G,I	C	S,M,L	-	SS/UN	HS/-G,SG,I,C	G,T,IT,I	HE	S	A	A	ND	RA	ND	-	24–27	32
P. gloveri (2011)	ET	2b	P	O,Op,Obc,SG,I	-	-	-	SS	-	-	HO	S	P/A	A	sg	sg	sg	13	25	30
P. amaranthi (2016)	ET	2b	SP	G,O,Op	C/-	S/M	-	SS/CS	-	-	HO	S	A	A	ND	ND	ND	8	24	32
P. tropicalis (2001)	ET	2b	P	E,O,Op,Ob,I,tb	C	L	-	U/SS	-	G,SG,IT	HE	S	A	P	ND	CH	CH	6	27–30	33
P. aysenensis (2020)	ET	2b	P	O,G,L,D	-	-	-	SS	-	-	HO	S	A	P	ND	ND	ND	-	-	-
P. siskiyouensis (2008)	ET	2b	SP	O,E,R,I	C/-	S/M/L	-	UN/SS	-	-	HO	S/tb	P/A	P/A	CH	CH	CH	3	21–25	27
P. mengei (2009)	ET	2b	SP	E,O,I,c	-	-	-	SS/UN	-	-	HO	S/tb	P	P/A	ND	ND	ND	6	25	33
P. theobromicola (2021)	ET	2b	SP	O,Op,G,T	-	-	-	SS	-	G,T,L,IT	S	-	-	-	CH	CH	CH	5	25	35
P. citricola (1927)	ET	2c	SP	O,G,E,Op,I	-	-	-	SS	-	-	HO	S	P	P	CH	CH	CH	3	24	30
P. pachypleura (2014)	ET	2c	SP	O,E,Op,L,I	-	-	E	UN	HS/-Ginsp	-	HO	S	P	P	CH	CH	CH	5	25	35
P. pini (1925)	ET	2c	SP	O,E,I	-	-	-	UN/SS	HS/-G,IR	-	HO	S	P/A	P	ND	CH	ND	5	25	30
P. plurivora (2009)	ET	2c	SP	O,L,Op,E,Ob,I	-	-	EX	UN/SS	HS/-	-	HO	S/tb	P	P/A	CH	CH	CH	5	25	30
P. acerina (2014)	ET	2c	SP	O,L,Op,E,El-O,Ob,D	-	-	-	UN	G,SG	-	HO	S	P	P	CH	RO	ST	6	25	32
P. caryae (2016)	ET	2c	SP	O,E,Op,	-	-	-	SS	HS/-	-	HO	S/tb	P	P/A	-	-	-	10	22–25	35
P. emzansi (2021)	ET	2c	SP	O,E,P,Op	-	-	-	SS	-	-	HO	S	A	SA	ND	ND	ND	7,5	20	27.5
P. capensis (2010)	ET	2c	SP	L,O	-	-	-	UN	-	-	HO	S	P	P	-	-	-	5	23	28
P. multivora (2009)	ET	2c	SP	O,L,E,Op,I,	-	-	-	SS	-	-	HO	S/tb	P	P	ND	ND	ND	5	25	30
P. oleae (2018)	ET	2d	SP	O	-	-	-	SS	HS/-C,S	CH/-G	HO	S	P	P	ND	ST	-	10	20	25
P. acaciivora (2020)	ET	2e	SP	O,El,Ob,E,L	-	-	EX	SS	-	-	HE	S	A	A	ND	ND	ND	10	25	38
P. frigida (2007)	ET	2e	P	O,Op,D	C	S	-	SS	G,C	G,T,IT	HE	S	A	A	ST	ST	ST	9	24–30	33
P. acaciae (2019)	ET	2e	P	O,E,Op,D	-	-	-	SS	-	G,T,IT	HE	S	A	A	RO	-	-	6	21	36
P. bishii (2008)	ET	2e	SP	O,Op,Ot,G,I	-	-	-	UN	G,D	-	HO	S	P	A	sg	ND	ND	10	26	32

Table 5. (Continued).

Phytophthora species with factsheets in *Idphy*	Type[1]	Clade[2]	Asexual Phase[3]								Sexual Phase[4]				Colony Pattern[5]			Temperature[6]		
			PA	SSH	C	PE	PR	SPO	HS	CH	H	OOG	AN	OOS	V8-A	PDA	MEA	MIN	OPT	MAX
P. elongata (2010)	ET	2e	SP	O,Op,Ob,E,L	-	-	-	UN/SS	HS/-E	-	HO	S/tb	P	P/A	RO	RO	RO	5	25	32
P. multivesiculata (1998)	ET	2e	SP/NP	G,O,Op,I	-	-	-	UN/SS	G,SG,C,CL	-	HO	S/tb	P/A	A	ND	ND	ND	6	21–27	30
P. castanetorum (2017)	ET	12	SP	O,SG,G,Op,E,I	-	-	-	UN/SS	SG,L,C,R	G	HO	S	P	P/A	ND	ND	ND	-	25	30
P. quercina (1999)	ET	12	P	O,Op,G,E,I,en	-	-	-	SS	G,SG,EL,i,R,C	CH/-G,T,IT	HO	S/tb	P	P/A	ND	ND	ND	3	21	24
P. tubulina (2017)	ET	12	SP/NP	O,El,Op,L,SG,E	C/-	M	-	UN	SG,L,C,R	-	HO	S/tb	P	P/A	ND	ND	ND	-	25	30
P. versiformis (2017)	ET	12	P/SP	O,Op,E,G,D	-	-	-	UN	G,SG,C,I	-	HO	S	P	P	ND	ND	ND	4	20	28
P. alticola (2017)	ENT	4	P	O	-	-	-	SS	HS/-	-	HO	S/W	P	A	ND	ND	ND	10	25	32
P. boodjera (2015)	ET	4	P	O,L,D	-	-	-	UN,gs	HS/-C,R	-	HO	S	P	A	ND	ND	ND	4	25–30	35
P. arenaria (2011)	ET	4	P	O,E,Ob,D	-	-	-	UN,gs	G,SG	-	HO	W/tb	P	A	ND	ND	ND	10	28–30	35
P. quercetorum (2008)	ET	4	P	O,I	-	-	-	UN/SS	-	CH/-	HO	S/tb	P	A	RO	RO	RO	9	18–24	30
P. panamensis (2022)	ET	4	P	O,E,L	-	-	-	SS	-	-	HO	S	P	P	ST	CH	-	15	29	32,5
P. megakarya (2023)	ET	4	P	G,O,Op	C	M	-	SS	-	CH/-G	HE	S/tb	A	P/A	CH	ND	CH	10	24–26	30
P. litchii (2007)	ENT	4	P	G,O,E	C	S	-	E	HS/-	-	S/HO	S	P/A	A/SA	ND	ND	ND	12	27–28	30
P. palmivora (1919)	RS	4	P	G,O,Op,E,I,en	C	S	-	SS	G,SG,E,IR	G,SG,T,IT	HE	S	A	P/SA	ND	ND	ND	9	24–30	33
P. heterospora (2021)	ET	4	P	O,El-O,El-Ob,L	C	S	EX	UN/IB	G,T,IT,L	G,SG,IT,C	HE	S	A	A/P	RA	ND	ND	10	27.5	32
P. cathayensis (2020)	ET	4	SP	O,L	-	-	EX	SS	G	CH/-,G,T	HO	S	P	A/P	ST	ND	ST	4	25	30
P. ilicis (1957)	EEpT	3	SP	O,Ob,en	C	M/L	-	UN/SS	HS/-G,SG,C	CH/-GT,IT	HO	S/tb	A	P/SA	ST	ST	sg	3	20	25
P. nemorosa (2003)	ET	3	SP	O,E,Op,Ot,Ob,I	C	M	-	SS	HS	G,SG,T,I,CT	HO	S	A	P/A	RO	ND	sg	3	15–20	21
P. psychrophila (2002)	ET	3	SP	E,O,Op	C/-	S/M	-	UN/SS	-	G,T,IT	HO	S/tb	A	P/A	ND	ND	ND	3	15	21
P. pseudosyringae (2003)	ET	3	SP	L,E,O,Op,I	C/-	S/M	-	SS	G,SG,EL,C	-	HO	S/tb	P/A	P/A	RO	RO	RO	5	20	25
P. pluvialis (2013)	ET	3	SP	O,I	C/-	M	-	SS	HS/-G,R	-	HO	S	A	A	RO	RO	RO	5	20	25
P. transitoria (2022)	ET	13	NP	O,BO,SG,Op	-	-	-	UN	-	CH	S	-	-	-	ND	ND	-	5	22.5	30
P. agathidicida (2015)	ET	5	P	G,O-E	-	-	I	UN	S	-	HO	S/W	A	P	ND	ND	ND	6	21	25
P. cocois (2015)	ET	5	P	G,O	-	-	-	UN	-	-	HO	O	A	P	ND	ND	ND	10	22	30
P. castaneae (1976)	ET	5	P	L,O,Op,Ot,I	-	-	-	IB	HS/-	CH/-G	HO	O	A	SA	sg	ND	sg	6	22	30
P. heveae (1929)	ET	5	P	G,O,Op,I,en	-	-	-	SS	-	-	HO	S/tb	A	A	ND	ND	ST	9	24	27
P. podocarpi (2022)	ET	15	NP/SP	O,Op,L	C/-	S	-	SS/CS	C	-	HO	S	P	P	ST	-	-	3	17	24

Table 5. (Continued).

Phytophthora species with factsheets in *Idphy*	Type[1]	Clade[2]	Asexual Phase[3]								Sexual Phase[4]				Colony Pattern[5]			Temperature[6]		
			PA	SSH	C	PE	PR	SPO	HS	CH	H	OOG	AN	OOS	V8-A	PDA	MEA	MIN	OPT	MAX
P. kwongonina (2018)	ET	6a	NP	O,E	-	-	I	UN	G,R	-	HO	S/W	P	P/A	RO	RO	RO	4	25	35
P. cooljarloo (2018)	ET	6a	NP	O,EI,L,E	-	-	I	UN	-	-	HO	S/W	P/A	A	RO	RO	RO	4	25	35
P. rosacearum (2009)	ET	6a	NP	O,E,Ob,tb	-	-	-	UN	HS/-G,SG,C,R	-	HO	S	P	P/A	ND	ND	ND	3	27	33
P. pseudorosacearum (2018)	ET	6a	NP	O,EI	-	-	I	UN	G	G	HO	W/tb	P	A	RO	RO	RO	4	30	37
P. oreophila (2019)	ET	6a	NP	O,L,D	-	-	I,NE	UN	HS/-,G	-	HO	W	P	P	RO	RO	RO	4	20	25
P. condilina (2018)	ET	6a	NP	O,EI	-	-	I	UN	G,R	G	HO	S/W	P	A	RO	RO	RO	4	25	37
P. humicola (1985)	ET	6a	NP	O,Op	-	-	I	UN	G,SG,R	-	HO	S	P/A	SA	RO	RO	RO	9	28–30	32
P. inundata (2003)	EEpT	6a	NP	O,Op,tb	-	-	I,NE	UN/SS	G,SG,IR,I,C,R	-	S/HE	S	A	P/A	ND	CH	CH	3	27–30	36
P. balyanboodja (2018)	ET	6a	NP	O,EI	-	-	I	UN	-	-	S	-	-	-	ND	ND	ND	4	32	37
P. chesapeakensis (2019)	ET	6a	NP	O	-	-	I,E	UN	G,C	-	S	-	-	-	-	CH	-	5	30	38
P. personensis (2020)	ET	6a	NP	O,E,L,Op	-	-	I,NE	UN	C,G	G,T	S	-	-	-	ND	ND	ND	4	25	39
P. aquae-cooljarloo (2020)	ET	6a	NP	E,O,L,Ob	-	-	I,NE	UN	-	G,T	HO	S	P	A	ND	ND	ND	4	30	35
P. gemini (2011)	ET	6a	NP	Ob,E,O,Op,tb	-	-	-	UN	E,C,CL	-	S	-	-	-	CH	CH	CH	5	24–27	33
P. moyootj (2014)	ET	6b	NP	O,L,E,G,I	-	-	I,E	UN	-	-	S	-	-	-	RO	ND	-	-	25–30	32
P. fluvialis (2011)	ET	6b	NP	O,L,E,Ob	-	-	I	UN	EL	-	S	-	-	-	RO	RO	-	10	31	38
P. thermophila (2011)	ET	6b	NP	O,E,L,EI,P,Op,tb	-	-	I	UN	G,E	G	S/HO	S	P	A	RO	RO	RO	10	33	35
P. litoralis (2011)	ET	6b	NP	O,EI,L,E,P,Op,Ob	-	-	I	UN	G,E,IR,C	CH/-G	S	-	-	-	RO	RO	RO	5	30	32
P. amnicola (2012)	ET	6b	NP	O,L,E,Op,P	-	-	I	UN	E,C,CL	-	S	-	-	-	ST	sg	-	10	25–32	37
P. crassamura (2015)	ET	6b	NP	O,Op,D	-	-	I	UN	G,SG,I,C,CLbig	-	HO	S	P/A	A	ND	ND	ND	5	25	33
P. megasperma (1931)	EEpT	6b	NP	EI,E,Op,I,tb	-	-	I	UN/SS	G,SG,C,CL,R	-	HO	S	P	P/A	ND	ND	ND	3	18	27
P. gonapodyides (1927)	EEpT	6b	NP	E,O,I,tb	-	-	EX,I,NE	UN	G,SG,EL,I,C	-	S	-	-	-	RO	RO	RO	3	24–27	30
P. ornamentata (2015)	ET	6b	NP	O,Op,E	-	-	I	UN	G,E,C	-	HO	O	P/A	A	ND	ND	ND	5	25	33
P. mississippiae (2013)	ET	6b	NP/SP	O,Op,E	-	-	I	UN	G,EI,C,IR	-	S/HE	O/tb	A	P	ND	CH	CH	5	25–30	35
P. chlamydospora (2015)	ET	6b	NP	Op,O,EI	-	-	I	UN/SS	G,SG,E,CL	G,T,IT	S	-	-	-	RO	RO	RO	-	25–28	37
P. ×stagnum (2014)	ET	6b	NP	O,E,Op,D	-	-	I,NE	UN	C,G	G,IT	HE	O	A	P	ST	RO	RO	5	25	35

Table 5. (Continued).

Phytophthora species with factsheets in Idphy	Type[1]	Clade[2]	Asexual Phase[3]								Sexual Phase[4]				Colony Pattern[5]			Temperature[6]		
			PA	SSH	C	PE	PR	SPO	HS	CH	H	OOG	AN	OOS	V8-A	PDA	MEA	MIN	OPT	MAX
P. pinifolia (2008)	ET	6b	NP	O,Op	C/-	M	-	SS	HS/-G,R	-	S	-	-	-	ND	ND	-	3	15	18
P. borealis (2012)	ET	6b	NP	O,Op	-	-	I	UN	-	-	S	-	-	-	RO	-	-	-	20	30
P. gibbosa (2011)	ET	6b	NP	O,E,L,P,Op	-	-	I	UN	HS/-G	-	HO	S/W	A	A	ND	ND	ND	7	30	33
P. gregata (2011)	ET	6b	NP	O,El,E,L,P,Op	-	-	I	UN	R	-	HO	S/tb	P/A	A	ND	ND	ND	8	25	32
P. bilorbang (2012)	ET	6c	NP	L,Ltb,E,O,Op	-	-	I	UN	G,E,C	-	HO	S	P	P	ST	RA	ST	4	25	32
P. lacustris (2013)	ET	6d	NP	O,Op	-	-	I	UN	SG,E	-	S	-	-	-	CH	CH	CH	3	28–30	37
P. riparia (2012)	ET	6d	NP	O,Op	-	-	I	UN	-	-	S	-	-	-	CH	CH	CH	4	25–30	35
P. asparagi (2012)	ET	6e	NP	O,Op	-	-	I,EX	UN	-	-	HO	S	A	A	ST	-	-	5	25	30
P. ×multiformis (2023)	ET	7a	NP	E,O,Ob	-	-	I	UN	-	-	HO	O	P/A	P	ND	ND	ND	3	21–24	30
P. ×incrassata (2017)	ET	7a	NP	O,L,E,P	-	-	I,NE	UN	IR,C	-	HE	O	A	P	ST	ND	ND	5	20	32
P. ×alni (2004)	ET	7a	NP	G,O,Ob,E	-	-	I	UN	-	-	HO	O/tb	A	P	ND	ND	ND	3	23–25	29
P. ×cambivora (1927)	NT	7a	NP	O,Op,E	-	-	I	UN	HS/-CR,IR	-	HE	O	A	P	ND	ND	ND	2	22–24	32
P. formosa (2017)	ET	7a	NP	O,El,E,Op,L,S-G,P,Ot	-	-	I	UN	-	-	HO	S	P	P	ND	ND	ND	-	25	30–35
P. intricata (2017)	ET	7a	NP	O,El,Op,L,E,P,SG	-	-	I	UN	-	-	HO	S	P	P	ND	RO	ST	5	30	35
P. uniformis (2023)	ET	7a	NP	E,O,Ob,Op	-	-	I	UN	-	-	HO	O/S	A	P	ND	ND	ND	3	24–27	30
P. ×heterohybrida (2017)	ET	7a	NP	O,L,Op,E,tp	C/-	S	I,NE	UN	IR,C	-	HE	O	A	P	ST	RO	ND	5	25	32
P. fragariae (1940)	EEpT	7a	NP	Op,O,E,tb	-	-	I,NE	UN/SS	G,SG,EL,i,C	-	HO	S/tb	P/A	P/A	ND	ND	ND	3	18	27
P. rubi (2007)	ET	7a	NP	O,Op,E,tb	-	-	I	SS	-	-	HO	S/tb	P/A	A	ND	ND	ND	4	10–22	25–28
P. attenuata (2017)	ET	7a	NP	O,El,Op,L,E,SG	-	-	I	UN/SS	HS/-L	-	HO	W/tb	P/A	A	RA	ND	ND	5	25	30–35
P. abietivora (2019)	ET	7a	NP	O,E	-	-	I,N	UN	C,IR	G,T,IT	HO	S	A/P	P	-	-	-	-	-	-
P. flexuosa (2017)	ET	7a	NP	O,El,E,Op,L	-	-	I	UN	G,CR	-	HO	S/W,tb	P	P	ND	ND	ND	5	25	35
P. europaea (2002)	ET	7a	NP	E,O,Op,tb	-	-	I	UN/SS	HS/-E,IR,C	-	HO	S	P	P/A	ND	ND	ND	3	21	27
P. uliginosa (2002)	ET	7a	NP	O,Op,El,I,tb,c	-	-	I	UN	IR,C,CL	-	HO	S/tb	P/A	P/A	ND	sg	ND	-	18	29
P. tyrrhenica (2017)	ET	7a	NP	E,El,L,O,Op	-	-	I	UN	G,SG,C,IR	-	HO	S	P	P	ND	ND	sg	-	20	30
P. vulcanica (2017)	ET	7a	NP	O,El,E,L,P,Op	-	-	I	UN	SG,C,I	-	HO	S	P/A	P/A	ND	ND	ND	-	15	30
P. parvispora (2014)	ET	7c	NP	G,O,E	-	-	I	SS	G,IR,CL	CH/-G	HE	S	A	A	CH	sg	sg	10	27	37

Table 5. (Continued).

Phytophthora species with factsheets in *Idphy*	Type[1]	Clade[2]	Asexual Phase[3]								Sexual Phase[4]				Colony Pattern[5]			Temperature[6]		
			PA	SSH	C	PE	PR	SPO	HS	CH	H	OOG	AN	OOS	V8-A	PDA	MEA	MIN	OPT	MAX
P. mediterranea (2021)	ET	7c	NP	O,E,D	-	-	EX	UN	G,I,C	G,T	S/HE	-	-	-	ND	ST	RO	9	32	38
P. cinnamomi (1922)	ET	7c	NP	E,O,I	-	-	I	UN/SS	G,SG,I,CR,CL	G,T,IT	HE	S	A	P	ND	RO	RO	9	27	30
P. asiatica (2014)	ET	7b	NP	E,Op,Ot,D	-	-	I	UN	HS/-C	-	HO	S	P/A	A	ST	ST	ST	5	28	35
P. pisi (2023)	ET	7b	NP	O,E	-	-	EX,I,NE	UN/SS	HS/-G,I	-	HO	S	A	A	ND	ND	ND	4	25–30	37
P. sojae (1958)	EEpT	7b	NP	O,E,Op,Ob,tb	-	-	I	UN/SS	SG,IR	-	HO	S/tb	P/A	P/A	ND	ND	ND	10	23–30	33
P. niederhauseri (2014)	ET	7b	NP	E,Op,O,I	-	-	I	UN/SS	L	-	HE	S	A	P	ND	ND	ND	10	30	37
P. cajani (2023)	ET	7b	NP	O,Ob,E	-	-	EX,I,NE	UN	G,SG,C,IR	-	HO	S	A	A	ND	ND	-	9	27–33	36
P. vignae (1957)	EEpT	7b	NP	O,Op,tb	-	-	I	UN/SS	IR	G,T,IT	HO	S	A	A	ND	ND	-	10	24	32
P. melonis (1976)	ET	7b	NP	O,E	-	-	I	UN	HS/-G,R	-	HE	S	A	P/A	ND	ND	ND	9	28–32	37
P. pistaciae (2001)	ET	7b	NP	E,O,P,Ob,I,tb	-	-	I	UN	G,SG,R	-	HO	S	P/A	A	ND	ND	ND	9	27	33
P. variabilis (2022)	ET	7b	NP	O,BO,E	-	-	EX,I,NE	UN	-	-	HO	S	A/P	A	ST	ND	-	7	27.5	33
P. fragariaefolia (2014)	ET	7d	NP	E,G,D	-	-	I	UN/SS	G,SG,L	G,IT	HO	S/tb	P	A	ND	ND	ND	5	28	33
P. nagaii (2014)	ET	7d	NP	E,tb	-	-	I	UN/SS	G,SG	G,IT	HO	S/tb	P/A	A	ND	ND	ND	5	28	33
P. lilii (2015)	ET	11	NP	Op,L,El,E,O,D	-	-	I	UN/SS	G,IR	G,I	HO	S/tb	P/A	A	ND	ND	ND	5	28	33
P. cryptogea (1919)	ET	8a	NP	E,O,Op,D,tb	-	-	I	UN/SS	G,E,C	-	HE	S	A	P	RO	RO	RO	3	24	30
P. erythroseptica (1913)	EEpT	8a	NP	E,O,Ob,D,tb,WC,	-	-	EX,I,NE	UN/SS	G,SG,C,CLbig	-	HO	S	A	A	ND	CH	CH	6	21	30
P. pseudocryptogea (2015)	ET	8a	NP	E,O,Op,I,tb	-	-	-	UN	G,IR	-	HE	S	A	P/A	CH	CH	CH	3	25	35
P. kelmanii (2021)	ET	8a	NP	O,Op,E,P	-	-	I,NE	SS	C	G,T	HE	S	A	A/P	ND	RO	ND	3	25	35
P. drechsleri (1931)	EEpT	8a	NP	E,O,D,tb	-	-	I	UN/SS	G,SG,C,CLbig	-	HE	S	A	P/A	ND	ND	ND	3	27–33	36
P. sansomeana (2009)	ET	8a	NP	O,Op,E,Ob,I,tb	-	-	I	UN	G,SG,EL,C,CL,R	-	HO	S	P/A	P/A	CH	CH	CH	3	24–30	33
P. medicaginis (1991)	ET	8a	NP	E,O,Op,tb	-	-	I	UN/SS	SG,EL,I,i,R	G,SG,IT	HO	S	P/A	P/A	ND	ND	ND	3	27	33
P. trifolii (1991)	ET	8a	NP	O,Op,E,I,tb	-	-	I	UN/SS	G,SG,C,CL,R	-	HO	S	P/A	A	ND	ND	ND	5	20–25	30
P. porri (1931)	EEpT	8b	SP/NP	O,Op,E,I,tb	C/-	M	-	SS	G,SG,EI,I,C	-	HO	S	P/A	A	ND	ND	ND	3	15	18
P. primulae (1952)	EEpT	8b	NP	E,O,Op,I,tb	-	-	-	UN	G,C	-	HO	S	P/A	A	ND	ND	ND	3	15–21	27
P. cichorii (2013)	ET	8b	SP/NP	O,Op,D	-	-	-	SS	SG,EL,IT	-	HE	S	A	A	ND	ND	-	5	21	27
P. brassicae (2002)	ET	8b	SP/NP	G,O	C/-	S	-	SS/UN	G,C	-	HO	S	P/A	A	ND	sg	ND	3	21	27

Table 5. (Continued).

Phytophthora species with factsheets in *Idphy*	Type[1]	Clade[2]	Asexual Phase[3]								Sexual Phase[4]				Colony Pattern[5]			Temperature[6]		
			PA	SSH	C	PE	PR	SPO	HS	CH	H	OOG	AN	OOS	V8-A	PDA	MEA	MIN	OPT	MAX
P. lactucae (2013)	ET	8b	SP/NP	O,E,Op,D,tb	-	-	-	UN	G,D	CH/-G,I	HO	S	P/A	A	ND	ND	-	3	18	24
P. pseudolactucae (2015)	ET	8b	SP/NP	O,Op,E,El,D,tb	-	-	-	UN/SS	-	CH/-G,SG,IT	HO	S	P/A	A	ND	ND	-	3	20–23	25
P. dauci (2013)	ET	8b	SP/NP	O,E	-	-	-	UN	SG,E,C	G,T,IT	HO	S/O	P	P/A	ND	ND	-	3	15–18	23
P. austrocedri (2007)	ET	8d	SP	O,Op,L,E	-	-	-	UN	G,SG,C,D	-	HO	S	A	A	sg	sg	sg	3	15–21	24
P. obscura (2012)	ET	8d	SP	O,G,L	-	-	-	UN/SS	-	-	HO	S/tb	P	P/A	ND	RO	-	2	20–25	28
P. syringae (1905)	ENT	8d	SP	O,Op,E,I,tb	-	-	-	SS	G,SG,IR,C,R	-	HO	S	P/A	P/A	CH	CH	-	5	18–20	25
P. marrasii (2021)	ET	8e	NP	O,E,El,D,tb	-	-	I	UN	G,T	-	HO	S	A/P	P/A	ND	ST	ST	3	23	28
P. lateralis (1942)	ET	8c	SP/NP	O,Op,E,Ob,I	C/-	S	I	SS/UN	-	G,SG,I,T,IT	S	-	-	-	ND	RA	ND	3	20	25
P. ramorum (2001)	ET	8c	SP	O,E,G,tb	C	S	-	SS	-	G,SG,T,IT,I	HE	S	A	P	ND	ND	ND	3	15–21	27
P. hibernalis (1926)	EEpT	8c	SP/NP	E,O,Op,Ob,tb	C	M/L	-	UN/U/SS	-	-	HO	S	P/A	P/A	ND	ND	ND	6	15–21	24
P. foliorum (2006)	ET	8c	SP/NP	O,Ob,Op,D,tb	C/-	S	I	SS	D	G,SG,I,T,IT	HO	S	P	P	CH	CH	CH	2	25	30
P. stricta (2014)	ET	17	NP	O,L,Op,E,P,Ob	C/-	S/M/L	I	UN	-	G	HE	S	A	P	ND	ND	ND	9	25–30	33
P. virginiana (2013)	ET	9a	NP	O,Op,L,E,D	-	-	I	UN	D	G,IT	S	-	-	-	CH	CH	CH	-	-	-
P. rhizophorae (2016)	ET	9a	NP	O,Op	-	-	I	UN	G,SG,IR	-	S	-	-	-	-	-	-	-	30	35
P. parsiana (2008)	ET	9a	NP	O,Op,E,I,tb	-	-	I	UN	SG,E	-	HE	S	A	A	RO	RO	ND	10	28–30	37
P. honggalleglyana (2023)	ET	9a	NP	O,Op	-	-	I,NE	UN	IR	G,T	HE	S	A/P	P	-	RO	-	7.5	30	38
P. hydrogena (2014)	ET	9a	NP	O,Op,L,E	-	-	I	UN	-	CH/-G	HE	S	P/A	P	ND	sg	sg	5	30	37
P. irrigata (2008)	ET	9a	NP	O,G,Ob	-	-	I	UN	-	-	HE	S	A	P/A	ND	RO	RO	5	30	35
P. estuarina (2016)	ET	9a	NP/SP	O,Op,El	-	-	I	UN/SS	G,TL	-	S	-	-	-	-	-	-	-	30	35
P. macilentosa (2014)	ET	9a	NP	E,Op	-	-	I	UN	HS/-C,E	-	S/HE	-	-	-	-	-	-	10	30	37
P. chrysanthemi (2011)	ET	9a	NP	E,O,P	-	-	I	UN/SS	EL,IR,G	G,T,IT	HO	S	P/A	A	ND	ND	ND	6	30	35
P. aquimorbida (2012)	ET	9a	NP	O,El	-	-	I	UN	C,R	-	HO	S/tb	A	P	RO	RO	RO	5	30	40
P. prodigiosa (2018)	ET	9b	NP	O,Op	-	-	I	UN	E,G,IR,C	G,Op	S	-	-	-	RO	RO	-	12	32	36
P. insolita (1981)	ET	9b	NP	O,Op,E,tb	-	-	I	UN	G,SG,E,C	CH/-G	S	-	-	-	CH	CH	CH	9	32	38
P. polonica (2006)	ET	9b	NP	O,Op	-	-	I	UN	G,SG,IR,C	G	HO	S	P/A	P/A	RO	RO	RO	6	24–27	33
P. pseudopolonica (2023)	ET	9b	NP	O,P	-	-	I,NE	UN	G,C	G,T	HO	S	P	A/P	ND	RO	RO	5	30	35

Table 5. (Continued).

Phytophthora species with factsheets in *Idphy*	Type[1]	Clade[2]	Asexual Phase[3]								Sexual Phase[4]				Colony Pattern[5]			Temperature[6]		
			PA	SSH	C	PE	PR	SPO	HS	CH	H	OOG	AN	OOS	V8-A	PDA	MEA	MIN	OPT	MAX
P. macrochlamydospora (1991)	ET	9c	NP/SP	E,Op	-	-	I	UN	G,E,I,C	G,T,IT	S	-	-	-	ND	CH	CH	6	26–30	34
P. richardiae (1927)	ET	9c	NP	G,O,E	-	-	I	UN	G,EL,R	-	HO	S	P/A	P	ND	ND	ND	10	25	32
P. quininea (1947)	ET	9c	NP	O,Op,I,tb	-	-	I	SS	G,SG,I,C	G,SG,T,IT,I	S	-	-	-	CH	CH	CH	9	21–25	30
P. docyniae (2021)	ET	9c	NP	E, O	-	-	I,NE	UN	G,SG,C,CL	G,IT	S	-	-	-	CH	CH	ND	15	30	35
P. cacuminis (2019)	ET	9d	NP	O,G,L	-	-	I,NE	UN	-	G,T	S	-	-	-	ST	ND	ND	4	20	25
P. fallax (2006)	ET	9d	NP	O,Ob,D,WC,en	-	-	I	SS	-	CH/-G,T	HO	S	P/A	P/A	RO	RO	RO	2	25	30
P. captiosa (2006)	ET	9d	NP	O,E	-	-	I	UN	-	-	HO	S	A	P/A	-	-	-	2	25	30
P. constricta (2011)	ET	9d	NP/SP	O,T	-	-	I	UN,GS	HS/-E	-	HO	S/tb	P	P/A	RO	RO	RO	5	23	32
P. chilensis (2022)	ET	10a	P	O,El,L,Op,SG	C	S	-	SS	HS/-	-	HO	S	A	P/A	RA	RA/sg	-	-	20	24
P. pseudochilensis (2022)	ET	10a	P	O,El	C	S	-	SS	HS/-	-	HO	S/tb	A	P/A	RO	RO/sg	-	-	15	24
P. pseudokernoviae (2022)	ET	10a	P	O	C	S	-	SS	HS/-	-	HO	S/tb	P/A	P	ND	ND	-	-	15	24
P. kernoviae (2005)	ET	10a	P	E,O,Op,L,I	C	M/L	-	SS/UN	-	-	HO	S/tb	P/A	P	RO	RO	RO	3	21	24
P. morindae (2010)	ET	10a	P	E,Op,I,tb	C	M	-	U	-	-	HO	S	P/A	P/A	CH	CH	CH	6	21–25	27
P. javanensis (2022)	ET	10a	P	O,L	C	S/M	-	SS	-	-	HO	S	A	P/A	RO	ND	-	-	20	29
P. multiglobulosa (2022)	ET	10a	P	O,L	C	S/M	-	SS	-	-	HO	S	A	P	RA	ND	-	-	20	29
P. celebensis (2022)	ET	10a	P	O,L	C	M/S	-	SS	-	-	HO	S	A	P	ND	ND	-	-	25	29
P. boehmeriae (1927)	ET	10a	P	G,O,E,Ob,I	C	S	-	UN/SS	-	-	HO	S	A	P/A	ND	CH	CH	5	25	33
P. gondwanensis (2015)	ET	10a	P	G,O,L,Ot,Op	C	S	-	SS	-	-	HO	S	A	P	ND	ND	ND	5	25–30	32
P. gallica (2008)	ET	10b	NP	Op,O,Ot,L,I	-	-	I	UN	G,SG,E,IR,C	G,SG,T,IT	S	-	-	-	ND	ND	ND	5	20	30
P. subarctica (2022)	ET	10b	NP	O,El	-	-	NE,E	UN	HS/-	-	S	-	-	-	RA	sg	-	-	25	32
P. ukrainensis (2022)	ET	10b	NP	O,Op	-	-	NE,E	UN	G,L	-	S	-	-	-	RA	sg	-	-	30	34
P. pseudogallica (2022)	ET	10b	NP	O	-	-	NE,E	UN/SS	`	G	S	-	-	-	ND	sg	-	-	20	27
P. tonkinensis (2022)	ET	10b	NP	O,SG	-	-	NE,E	UN	IR,C	-	HO	S	P	P/A	ND	sg	-	-	20	24
P. afrocarpa (2021)	ET	10b	NP	O,E,Op	-	-	I,E	UN	G	G,T	S	-	-	-	CH	ST	ND	4	25	30
P. intercalaris (2016)	ET	10c	NP	O,E,L,P,Op	C/-	L	I	UN/SS	HS/-IR,R	G,T,IT	HE	O	A	Aborted	ST	-	-	5	25–30	34

Table 5. (Continued).

Phytophthora species with factsheets in *Idphy*	Type[1]	Clade[2]	Asexual Phase[3]								Sexual Phase[4]				Colony Pattern[5]			Temperature[6]		
			PA	SSH	C	PE	PR	SPO	HS	CH	H	OOG	AN	OOS	V8-A	PDA	MEA	MIN	OPT	MAX
P. scadinavica (2022)	ET	*10c*	NP	O,Op	-	-	NE,E	UN	E,SG,D	-	HO	S	P	P/A	RO	RO	-	-	20	32
P. ludoviciana (2022)	ET	10d	NP	O,El	-	-	E	UN	HS/-	-	S	-	-	-	RA	RO	-	-	27	34
P. tenuimura (2022)	ET	10d	NP	O,El,E	-	-	NE,E	UN	HS/-	-	HO	S	P	P	RA	sg	-	-	27	32
P. procera (2022)	ET	10d	NP	O,El,E	-	-	NE,E	UN	HS/-	-	S	-	-	-	RA	RO	-	-	25	34

[1] Type cultures: ET = ex-type, ENT = ex-neotype, EEpT = ex-epitype, RS = representative strain.

[2] Clade: Different colors denote Clade and Sub-clades.

[3] Asexual phase: SPORANGIA: PA = PAPILLAE (different brown colors to denote that this is an important character for identification): P = papillate (3.5 µm or more), SP = semipapillate (less than 3.5 µm), NP = nonpapillate. SSH = SPORANGIA SHAPE: G = globose, SG = subglobose, E = elipsoid, El = elongate, L = limoniform, O = ovoid, Ob = obovoid, P = pyriform, Op = obpyriform, R = reniform, T = turbinate, Ot = obturbinate, Obc = obclavate, S = sickle -shaped, I = irregular, D = distorted shapes, WC = with constricted middle, tp = tapered base, en =elongated neck. C = CADUCITY: C = Caducous - = non caducous C/- = ocassionally caducous. PE = PEDICEL: S = short (5 µm long or less), M = medium (between 5–20 µm long), L = long (20 µm or more), M/L = medium and long pedicels, S/M = short and medium pedicels, - = no pedicel. PR = PROLIFERATION: I = internal proliferation, N = nested, E = extended, NE = nested and extended, EX = external, - = no proliferation. SPO = SPORANGIOPHORE: UN = unbranched, CLS = close sympodium, SS = simple sympodial, CS = compound sympodial, U = umbellate, IB = irregularly branched, E = erected. Downy mildew-like, IS = intercalary sporangia, GS = globose swellings. HS = HYPHAL SWELLINGS: HS = present, HS/- = occasionally, - = absent, G = globose, SG = subglobose, E = elongate, Op = obpyriform, Obv = obovate, TL = toruloid, lobate, D = distorted shapes = Irregular, S = simple with slight swellings, I = Individual, T = terminal, IT = intercalary, C = catenulate, CR = coralloid, R = radiate, CL = clustered. CH = CHLAMYDOSPORES: CH = present, CH/- = occasionally, - = absent, G = globose, SG = subglobose. I = individual, L = lateral, T = terminal, IT = intercalary.

[4] Sexual phase: H = HOMOTHALLISM: HO = homothallic, HE = heterothallic, S = sterile. OOG = OOGONIUM: S = smooth wall, S/tb = smooth wall, tapered base, SW = slight wavy, O = ornamented, O/tb = ornamented wall/ tapered base, O/S = variable, ornamented and smooth. AN = ANTHERIDIA: P = paragynous, A = amphigynous, P/A = predominantly paragynous, P/A = predominantly amphigynous. OOS = OOSPORE: P = plerotic, A = aplerotic, SA = slightly aplerotic, P/A = plerotic and aplerotic.

[5] Colony pattern: V8-A = Clarified V8 juice agar, PDA = Potato Dextrose Agar (30 g Difco), CMA = Corn Meal Agar, CH = chrysanthemum, RO = rozette or petaloid, RA = radiate, ST = stellate, ND = no distinctive pattern, sg = slow growth, U = undetermined.

[6] Temperature: MIN = minimun temperature, OPT = optimum temperature, MAX = maximun temperature, - = undetermined.

Agar media for isolation and purification of cultures

Various media amended with antibiotics allow the isolation of *Phytophthora* species from infected plant material including roots, stems, leaves, trunks, or fruits (Erwin & Ribeiro 1996, Martin *et al.* 2012, Sarker *et al.* 2020, Pérez-Sierra *et al.* 2022). A recent publication by Pérez-Sierra *et al.* (2022) presented a variety of techniques for successful sampling methods for soil, roots, bark cankers, and waterbodies, and for baiting, isolation, purification, and conservation of pure cultures. The work with species for this manuscript and *IDphy* online resource has been done with selective agar PARPH Medium (Kannwischer & Mitchell 1978) which includes antibiotics (pimaricin, ampicillin, rifampicin, pentachloronitrobenzene and hymexazol) added into base medium of corn meal agar (CMA), Coffey's pea agar, V8 juice agar (V8-A) or oatmeal agar (OMA) and is one of the most used for original isolations from different plant tissues (*IDphy*: SOP-PID-06.01 and SOP-PID-07.01). The addition of nystatin (pimaricin) into the base media has been used extensively in surveys and monitoring *Phytophthora* species in natural ecosystems (Pérez-Sierra *et al.* 2022). However, it should be noted that the carcinogenic properties of pentachloronitrobenzene (EPA 2006), which was a component of the original formulation, means that this compound has been eliminated by many researchers (Sarker *et al.* 2020). The Synthetic Mucor Agar (Elliott *et al*. 1966) added with pimaricin, ampicillin, rifampicin and hymexazol is also a good *Phytophthora* selective medium (Brasier *et al*. 2005, Scanu *et al*. 2014). The technique of the pancake method to ensure pure cultures (Sleeth 1945) for isolation of *Pythium* species free from bacterial contamination is also handy for the culture of *Phytophthora* species.

Cultural characteristics

Colonies on V8 juice agar (V8-A), Potato Dextrose Agar (PDA) and Malt Extract Agar (MEA) are the most used for characterization of colony morphology. Different shapes of colony patterns can be observed in this media including no distinct, stellate, radiate, chrysanthemum, and petaloid patterns *IDphy* v. 2 (https://idtools.org/phytophthora/index.cfm?pageID=1878). Colony morphology is determined by growing the isolates for 7 and 14 d at room temperature (20–25 °C) in the indicated culture media or other adequate media. Minimum, optimum, and maximum temperatures for growth can be tested in plates growing at the indicated media at 5, 10, 15, 20, 25, 27, 30, 32, 35, and 37 °C. Radial growth is recorded after 7–14 d, before colonies reach the margin of the Petri dishes.

Sporangia production for *Phytophthora* species

Formation of sporangia was stimulated by incubating specimens in water cultures under continuous fluorescent light. The water systems could also be used for symptomatic small part of plants. The process consists in placing pieces of agar medium or small part of plants in Petri dishes containing liquid cultures at room temperature (22–26 °C) under continuous light for 48 h to 5 d, depending on the species. The water cultures are prepared by transferring small plugs from the edge of active cultures growing for 3–7 d in Coffey's pea agar, hemp seed agar, 5 % V8 juice agar, carrot agar, lima bean agar, or cornmeal agar into water blank cultures (see *IDphy* protocol SOP-PID-06-01 and Supplementary file S1). Using an empty plate, deposit a few blocks from the culture, and add water to the agar level. Different kind of liquid cultures can be used depending on the species including distilled deionized H_2O, unsterilized or sterilized rainwater, pond water, sterilized or unsterilized soil solution (10 %), or mixes of 50/50 rainwater / 10 % soil solution (*IDphy*: SOP-PID-06.01 and SOP-PID-07.01). In our experiences most species were more active if unsterilized soil solution is added, and in combinations of soil solution with rainwater. Changing the water every 12–24 h may stimulate sporangia development. It is crucial to not overflow the culture to prevent the lack of oxygen. Sporangia may be observed at the margin of the colony. The water blanks system is advantageous for observing sporangiophore shapes as the blanks are less disturbed than microscopic glass slide preparations. For release of zoospores, it is recommended to incubate the water systems containing sporangia in a refrigerator under 4 °C for 5 min and bring back to room temperature. Sometimes it is necessary to repeat the temperature cycles a few times. Sporangia production and zoospore release for most species can be achieved using mycelial mats growing in pea broth under any of the water systems mentioned above and under continuous light for 24–48 h. Mycelium is first grown in pea broth after being scraped from cultures on pea agar, V8 agar, carrot potato agar or other adequate media. For some species, such as *P. cinnamomi*, that may be reluctant to produce sporangia, a saline solution can be used instead of water (Chen & Zentmyer 1970).

Hyphal swellings and chlamydospores production for *Phytophthora* species

Hyphal swellings and chlamydospores are produced by some species and can be useful structures for species identification. They are often produced in liquid cultures. Hyphal swellings are thin-walled structures showing different shapes like globose, sub-globose, lobate, radiated, irregular, catenulated, clustered, *etc*. Chlamydospores are thick-walled long-term survival structures that are produced in nature under water or soil conditions. They can be terminal, intercalary, globose, sub-globose, lobate, radiated, irregular, catenulated, clustered, etc. The main difference in these structures is that hyphal swellings are thin-walled and not delimited by hypha while chlamydospores are thick-walled delimited by hyphae structures (See *IDphy*: https://idtools.org/phytophthora/index.cfm?pageID=1878).

Gametangia production for *Phytophthora* species

Oospores of homothallic species were produced in hemp seed agar, lima bean agar, baby carrot agar, malt extract agar and V8 agar. Production of oospores in heterothallic species requires the addition of a strain of the opposite mating type (A1 or A2). The addition of sterols (*i.e*., β-sitosterol), and fatty acids may be used to stimulate oospore production in some *Phytophthora* species (Hendrix 1970, Elliot & Math 1983, Jee & Ko 1997, Ko 1998, Martin *et al.* 2012). In our studies with homothallic and heterothallic species of *Phytophthora* we have found that the use of hemp seed agar with omega-3, -6, -9 fatty acids (alpha-linolenic, linoleic, gamma-linoleic, and oleic) in the product Udo's Oil (made with organic flax, sesame and sunflower seed oils, manufactured by Flora, INC, Lynden, WA, USA) at 200 µL in 400 mL base medium is an ideal medium to enhance the production of oospores. Plates of homothallic or heterothallic species with pairings (A1 × A2) are incubated in the dark at 20 ºC. Compared to other oils, macadamia oil also works very well to produce oospores (Abad Z.G. pers. comm., *IDphy*: SOP-PID-06.01). Selfed gametangia may be induced in polycarbonate membrane tests with an opposite mating type tester strain of *Phytophthora* using carrot agar (Scanu *et al*. 2021).

Maintenance and storage of cultures

The rye vials are used for prolonged storage of *Phytophthora* species following the protocol provided by Paul Tooley (USDA-ARS). It consists of placing 4–8 grains of whole grain rye (available at health food stores) into about 10 mL of distilled water in a 20 mL Wheaton vial and autoclave (Recommended: Wheaton Science Products 225288 clear borosilicate glass sample vial in lab file with 14B rubber lined cap, 20 mL capacity). When cool, store refrigerated until use. Place several small agar pieces containing the *Phytophthora* species into the vial, let grow for about a week (we grow at 18–20 ºC in the dark) until you see mycelium growing out from around the seeds and up into the water. Then tighten the cap, and (optional) wrap parafilm around the cap to prevent evaporation if they are to be stored for a long time. Store at 18–20ºC for up to 2 yr. Some will even go longer than that, depending on the species. For additional information of this method see *IDphy*: SOP-PID-06.01. A method for the use of hemp seed vials for storage of *Phytophthora* species was also used and it was provided by Juanita Ciampini from the Vegetation Health Service (VHS) at the Department of Biodiversity, Conservation and Attractions (DBCA) in Kensington, Western Australia. The protocol consists of sterilizing five hemp seeds in 15 mL DI water in a glass McCartney bottle during two consecutive days (~10–15 min). Cut some strips out of the plate and add to McCartney bottles from a clean isolate growing on a plate of CMA. Leave them to grow on the bench for at least 1 mo then store in a 20 ºC incubator. Numerous references exist on the short, medium, and long-term maintenance and storage of *Phytophthora* cultures (Erwin & Ribeiro 1996). One easy and effective technique for temporarily storing *Phytophthora* is using agar plugs immersed in sterile water in plastic vials. All species can be stored on lima bean or cornmeal agar disks in sterile water with sterile hemp seed for long-term storage (10–12 ºC). The most used methods for long-term storage are liquid nitrogen or ultra-cold conditions (-80 ºC) (Tooley 1988).

MOLECULAR DATA AND ANALYSIS

Protocols for aspects related to molecular identification are presented in five protocols (SOP-PID-01 to SOP-PID-05) in the Molecular Section of *IDphy* (https://idtools.org/tools/1056/index.cfm?pageID=1877). In order to facilitate the work of researchers with no access to our online resources we are presenting the most relevant Molecular Protocols as Supplementary Files S2 & S3.

Generation and compilation of sequence data

Multi-locus phylogenies of the genus *Phytophthora*, employing seven loci (ITS rDNA, *COI*, *YPT1*, *β-tub*, *EF1α*, *L10*, and *HSP90*), were inferred (Table 4). The primary source of sequence data consisted of over 1 320 publicly available nucleotide accessions in the nucleotide collection of GenBank. About 90 % of these sequences were generated during the implementation of the *IDphy* online resource (Abad *et al.* 2023) and sequences generated for this manuscript (Table 2). Total genomic DNA was extracted from fresh mycelia grown in pea broth at room temperature for about 7–12 d (depending on the species) and using the suggested Qiagen Dneasy Plant Mini Kit (see SOP-PID-02.01). All primers used in the current study are listed in Table 1, molecular identification section at the *IDphy* online resource and a previous publication (Abad *et al.* 2023). PCR amplification was performed as described by Blair *et al.* (2008), Kroon *et al.* (2004), Robideau *et al.* (2011) and White *et al.* (1990) and modified by Abad *et al.* (2023). Most of the PCR amplicons were purified and Sanger sequenced at the GENEWIZ sequencing facility in Maryland, USA. The forward and reverse reads were paired, and consensus sequences calculated in Geneious Prime v. 2020.0.5 (https://www.geneious.com). All sequences have been uploaded to GenBank and accessions are available in Table 2.

If no sequences for the seven genes were available at the NCBI, the genome-sequencing data from the available strain was used (Table 3); genomic data was mined for the missing loci using the methods of Bourret *et al.* (2018). Genome-sequencing data from *Phytopythium* and *Nothophytophthora* species were used as outgroups (Supplementary Table S1). The data set comprised 212 described *Phytophthora* species, three undescribed, provisional *Phytophthora* species and the two outgroups for a total of 217 taxa. Complete coverage was available at the ITS locus, and coverage of the other six loci ranged from 213 (98 % coverage) to 180 taxa (83 % coverage) (Table 4). The final alignment contained a total of 6 102 nucleotide positions and 726 binary indel “gap” positions.

The beta-tubulin accessions of the ex-types of *P. amnicola*, *P. marrasii* and *P. mediterranea* all contained single spurious, frameshifting indels that were omitted from the final alignment. The quality of the *P. cinnamomi* ex-type translation elongation factor 1-alpha accession was deemed insufficient to include in the analysis based on a profusion of apparent single nucleotide variants (SNVs); the heat shock protein 90 accession from the *P. primulae* ex-type was omitted because it was identical to the accession from *P. cryptogea*. The three distinct ex-type ITS accessions from *P.* ×*stagnum* were combined into a single version for the analysis.

Phylogenetic inference

Loci were aligned individually with MAFFT v. 7.5 using the L-ins-I option (Katoh *et al.* 2005, Katoh & Standley 2013) and manually improved within AliView v. 1.28 (Larsson 2014); ITS was aligned with the MAFFT option X-ins-I (Katoh & Toh 2008). FastGap v. 1.2 (Borchsenius 2009) was used to encode binary data sets from the gap-rich ITS and *YPT1* alignments which were used for the maximum likelihood (ML) inference. The ITS alignment was partitioned by separating the ITS1, 5.8S rDNA and ITS2 regions, and protein coding loci were partitioned by codon position. Still partitioned by codon position, the exons of the *YPT1* locus were combined into three subsets and the introns left as separate subsets. IQ-TREE2 v. 2.1.2 (Chernomor *et al.* 2016, Kalyaanamoorthy *et al.* 2017, Minh *et al.* 2020) was used to combine subsets with branch lengths estimated separately for each final subset using the corrected Akaike information criterion with the PartitionFinder function invoked by the parameters -Q -merge greedy -AICc -merge-model all -merge-rate all. The maximum likelihood (ML) best-tree was estimated with –allnni -czb and support values estimated using the ultrafast bootstrap approximation with -B 1000. Bayesian trees were inferred using MrBayes v. 3.2.7 (Ronquist *et al.* 2012) using a partitioning scheme determined by PartitionFinder2 v. 2.1.1

(Lanfear *et al.* 2017) with a combined branch length estimation. After 20 million generations the runs had sufficiently converged, and maximum potential scale reduction factor was below 1.01. Trees were visualized and figures created with TreeGraph2 (Stöver & Müller 2010) and InkScape v. 1.2 (www.inkscape.org).

To illustrate the higher-level phylogenetic placement of *Phytophthora*, a *Peronosporales* data set was constructed by augmenting the ITS, *COI*, and *β-tub* alignments with additional accessions from representative taxa (Supplementary Table S1, Figs. S1, S2). To illustrate the phylogenetic relationships of some obligate biotrophs of the *Peronosporaceae* that were not included in the seven-loci data set, a five-loci data set was constructed from the seven-loci, omitting ITS and *YPT1* and adding accessions from representative taxa, including sequences derived from DM genomic data (Supplementary Table S1, Fig. 2). The data set was *β-tub*-anchored and taxa without representative accessions were not included. Maximum likelihood trees were inferred from these data sets using the same methods as the primary seven-loci data set (Figs 1, 2).

Multi-locus phylogeny of *Phytophthora*

The trees inferred from the 7-loci data set generally had very high support for most relationships. All non-singleton clades and subclades received maximum support of 100 % ML bootstrap and 1.0 Bayesian posterior probability values, with two exceptions: Subclade 2e, which received 99 % ML bootstrap support, but was not monophyletic in the Bayesian tree, with *P. multivesiculata* separated from the rest of the subclade (Fig. 3, Supplementary Fig. S3), and Clade 10, which received 93 % / 0.94 support. The support for Subclades 10a–c was somewhat stronger at 96 % / 1.0, and like Jung *et al.* (2022) we did not find consistent support to include *P. intercalaris* and *P. scandinavica* in a monophyletic Subclade 10b, necessitating a new subclade to accommodate the pair (Subclade 10c). Due to topological differences, we reassigned Subclade 10a of Jung *et al.* 2022 to our Subclade 10d in case future studies choose to separate the early-diverging Subclade 10d as its own numbered clade (Fig. 3). Four subclades were named within Clade 9 (Fig. 3). Other new subclades were added for pairs or singleton taxa in Clades 1, 2, 6 and 8. The provisional species *P.* taxon juniperus formed a larger clade with the two species in Clade 11 in the multi-locus tree, but due to the deep branch, as well as a separate placement from *P. lilii* in the *EF1α*-only tree, we declined to place *P.* taxon juniperus in a numbered clade until more data is available.

Relationships within the clades were also well-supported with exceptions occurring within species clusters and complexes. As with previous multi-locus, genus-wide phylogenies (Blair *et al.* 2008, Martin *et al.* 2014, Yang *et al.* 2017, Bourret *et al.* 2018), the phylogenetic backbone of the genus (*i.e.*, the relationships between the clades) were not strongly supported. However, the following relationships between clades did receive maximum support: Clades 9+10, as well as the rest of the genus (Clades 1–8+11–13+15+17) (Fig. 3). There was also maximal support for a larger clade containing Clades 1–5+12–13+15, and a smaller one with Clades 1–4+12–13. Within the smaller clade, the pairings of Clades 3+13 and Clades 4+12 also received 100 % / 1.0 support. With the exception of the placement of Clade 12, these relationships are generally congruent with the more mitochondrially-influenced data sets of Martin *et al.* (2014) and Bourret *et al.* (2018), as well as the nuclear-only data sets of Blair *et al.* (2008) and Yang *et al.* (2017). The placement of the obligate biotroph-containing clades (Clades 14–16) in our five-loci tree was not congruent with the results of Bourret *et al.* (2018), with all obligate biotrophs forming a monophyletic clade along with an early-diverging *P. podocarpi* (Fig. 2). Relevant phylogenetic data, including multi-sequence alignments, data partitioning schemata and trees are available in the Mendeley Data repository (doi: 10.17632/yg2rmfzstw.1).

Although it allowed for the illustration of all taxa, the inclusion of incongruent sequence accessions and hybrid taxa likely resulted in lower support values and a potential reduction in phylogenetic performance. Because of the presence of hybrids with nuclear or mitochondrial genomes identical to other species, no single locus was able to resolve all 212 described species. The topologies of the single-locus trees inferred from ITS, *YPT1* and *β-tub* and most resembled the multi-loci tree (Supplementary Figs. S4, S6, S7), although most individual loci were able to recover most clades and subclades. In the *YPT1*-only tree, the *Phytopythium* outgroup was placed on a long branch with *P. asparagi* within Clade 6, and Clade 10 was polyphyletic (Supplementary Fig. S6). In the *HSP90*-only tree Clade 5 was nested within Clade 7, and Clades 9 and 10 were polyphyletic (Supplementary Fig. S10). The *EF1α*-only tree could not be rooted with the outgroups, had *P. asparagi* separated from the rest of Clade 6, had polyphyletic Clades 4 and 10, and Clade 9 was paraphyletic with respect to Clade 11 (Supplementary Fig. S8). The *L10*-only tree could not be rooted with the outgroups and had many polyphyletic and paraphyletic clades. Two Clade 9 species, *P. estuarina* and *P. rhizophorae* had phylogenetically distinct, incongruent *COI* sequences, which were placed outside the rest of *Phytophthora* in the *COI*-only tree (Supplementary Fig. S5) and resulted in extremely long branches in the multi-locus tree. These incongruences were likely responsible for the relatively lower support values within Subclade 9a in the seven-loci tree (Fig. 3). *Phytophthora chesapeakensis* also had an incongruence that placed it as sister to Clade 11 rather than within Clade 6 in the *COI*-only tree, and the *COI* of *P. asparagi* was nested within Clade 6 rather than the species' typical early-diverging placement. In the *COI*-only tree Clade 10 was polyphyletic and Clades 2, 3 and 13 were nested within a paraphyletic Clade 4.

CHARACTERISTICS OF THE PHYLOGENETIC CLADES

Table 5 presents the *Phytophthora* tabular key organized by the position of 212 species at the phylogenetic tree with seven genes and the morphological characters. Following are the most relevant characteristics of the clades and subclades. Clades 14–16 (Fig. 2) have been allocated to downy mildews (Bourett *et al.* 2018) and will not be discussed here. The recently described species *P. podocarpi*, a non-papillated/semi-papillate, persistent/caducous, homothallic species, is basal to Clade 15 (Fig. 2, Table 5). Bourret *et al.* (2018) found clade 15 to contain *P. podocarpi* and three of the four DM groups. In our study, *P. podocarpi* was the early-diverging member of Clades 14–16 which contains all the obligate biotrophs included in the study (DMs and *Phytophthora cyperi*) (Fig. 2). To date, *P. podocarpi* is widespread in New Zealand, where it has been recovered from diseased needles and shoots of native *Podocarpus totara* (Dobbie *et al.* 2022). It is a slow-growing species with low-temperature optima and maxima. Another provisional species *Phytophthora* taxon juniperus has not been assigned to a Clade (Fig. 3).

Fig. 3. Seven-loci *Phytophthora* phylogeny featuring 212 described species. Maximum likelihood best-tree inferred with IQ-TREE v. 2. Ultrafast ML bootstrap approximation support values > 50 % are shown, and bipartitions receiving a 1.0 posterior probability in a Bayesian analysis are thickened. Taxa in bold were re-described or newly described in the present manuscript. Clades and subclades are indicated with bold numerals and letters. The length of the *Phytopythium* outgroup branch was halved for display purposes. ET = ex-type; EEpT = ex-epitype; ENT = ex-neotype; SE = selected specimen. Sequence accessions are listed in Table 2.

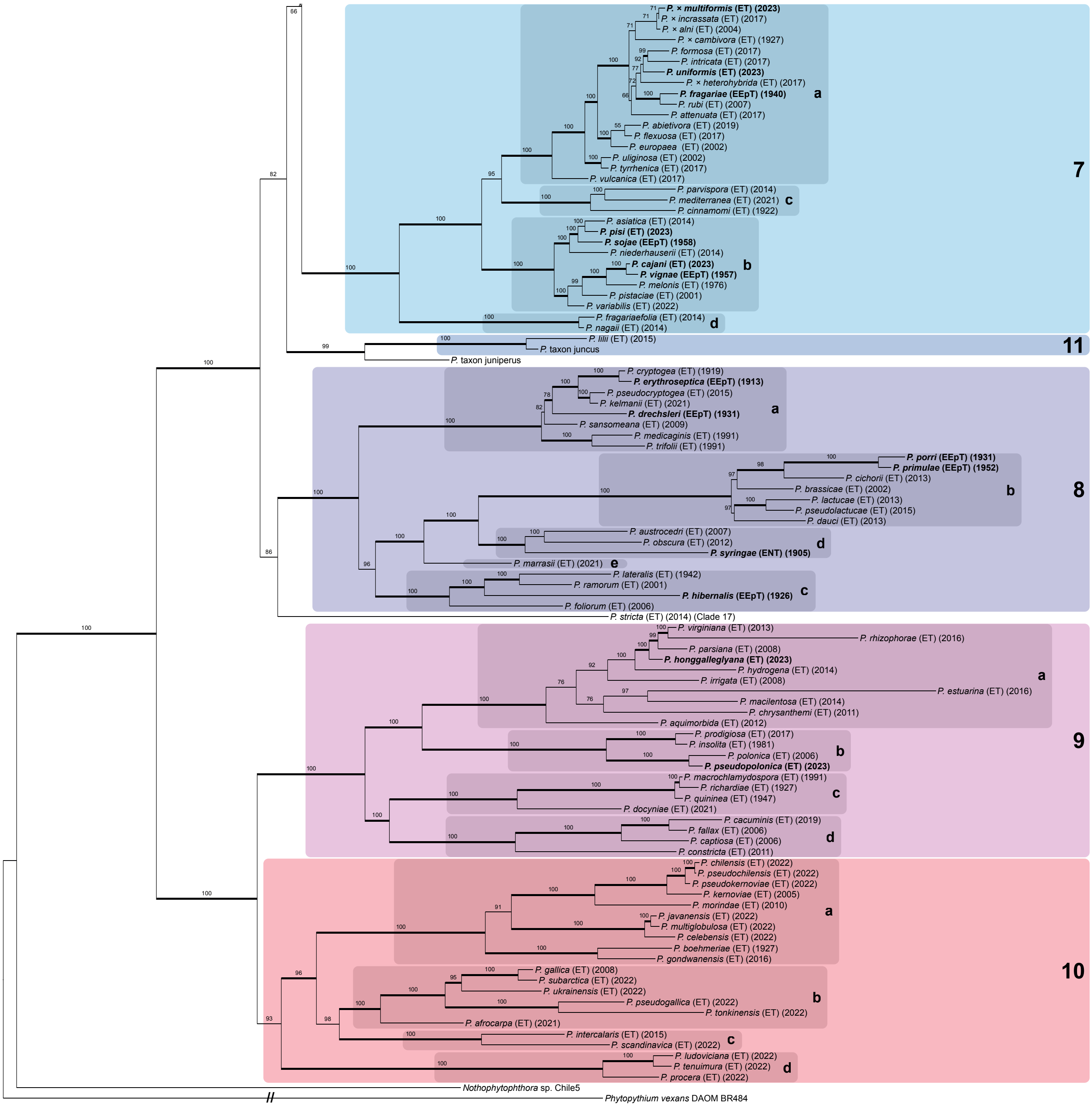

Fig. 3. (Continued).

Clade 1

Clade 1 consists of 17 species and two hybrids in four subclades (Fig. 3, Table 5). Species in this clade have papillate sporangia except for *P. infestans* and species in Subclade 1c which are semi-papillate. Proliferation after the release of zoospores is rare. Most of the species in Clade 1 are caducous; the most notable exceptions are *P. idaei* which is persistent with a short pedicel that does not break from the sporangiophore and *P. nicotianae* with some, but not all, isolates producing a proportion of caducous sporangia. Subclades 1a and 1b contain homothallic species, while most of Subclade 1c (except *P. ipomoeae* and *P. phaseoli*) and *P. nicotianae* are heterothallic; *P. nicotianae* has been variously reported as homothallic or heterothallic (Erwin & Ribeiro, 1996).

Subclade 1a contains *P. aleatoria*, *P. alpina*, *P. cactorum*, *P. hedraiandra*, *P. idaei*, *P. pseudotsugae* and *P. ×serendipita*. *Phytophthora cactorum* and *P. hedraiandra* have a broad host range and distribution, while the remaining species have a restricted host range and distribution. *Phytophthora cactorum* was one of the first species to be described and has a cosmopolitan distribution and an extensive host range that includes both annual and perennial crops, most commonly causing root rots and crown rots (Erwin & Ribeiro 1996). *Phytophthora hedraiandra* causes diseases of ornamental plants and has not been recovered from natural ecosystems (De Cock & Lévesque 2004). For a long time, *P. pseudotsugae* was known only as a pathogen of *Pseudotsuga menziesii* in north-western USA (Hamm & Hansen 1983) however, it has now been recovered from other hosts in California (Bourret *et al.* 2022b). To date, *P. aleatoria* is only known as causal agent of a root and collar disease of *Pinus radiata* in New Zealand (Scott *et al.* 2019b). *Phytophthora idaei* is a root pathogen only found in Europe on a single host, *Rubus idaeus* (raspberry) (Kennedy & Duncan 1995). *Phytophthora alpina* has only been recovered from stem cankers and rhizosphere soil of *Alnus viridis* in alpine regions of Italy (Bregant *et al.* 2020).

Subclade 1b contains three species: *P. clandestina*, *P. iranica* and *P. tentaculata.* The known distribution of *Phytophthora clandestina* is limited to Australia, where it is found in association with subterranean clover in pastures (Taylor *et al.* 1985). *Phytophthora iranica* was described as a pathogen of eggplant from Iran. *Phytophthora tentaculata* causes root and stem rot of ornamentals in Europe, Asia, and the USA, and has recently been recovered as a severe invasive pathogen in Californian natural ecosystems, especially at restoration sites, and it is thought to have been introduced to these sites with planting stock (Rooney-Latham *et al.* 2019).

Subclade 1c contains *Phytophthora infestans* and closely related species *P. andina*, *P. betacei*, *P. ipomoeae*, *P. mirabilis*, *P. phaseoli*, and *P. urerae*. Species in Subclade 1c are mostly heterothallic (except *P. ipomoeae* and *P. phaseoli* that are homothallic) and are phylogenetically very similar (Fig. 3) and differ primarily in host specialisation. All species in this clade have a limited host range and geographical distribution. Except for *P. infestans,* the other species have only been reported from one country or region.

Like other serious agricultural pathogens *P. infestans* and *P. cactorum, P. nicotianae* (synonym *P. parasitica)* was one of the first described species, initially known as the causal agent of black shank of tobacco. It is now known from numerous hosts, including annual and perennial crops, ornamental plants in nurseries and gardens and natural ecosystems and has a global distribution. Phylogenetically it resides separately from other species in Subclade 1d.

There are two named hybrids in Clade 1: *P.* ×*serendipita* (Subclade 1a) and *P.* ×*pelgrandis* (Subclade 1d). *Phytophthora* ×*serendipita* is a hybrid between *P. cactorum* and *P. hedraiandra*, and *P.* ×*pelgrandis* is a hybrid between *P. cactorum* and *P. nicotianae* (Man in 't Veld *et al.* 2012). The parent species are commonly found together, especially in ornamental nurseries, and it is not clear if these are stable hybrids that are now on their own evolutionary trajectory (similar to *P.* ×*alni*), or if they are a product of continuous hybridization event (as is the case for many hybrids in Subclade 6b) (Burgess 2015).

Clade 2

Clade 2 consists of 36 formally described species and numerous provisionally named taxa in five subclades, of which 27 have been described since 2000 (Fig. 3, Table 5). Most species in Clade 2 produce papillate to semi-papillate sporangia (except *P. multivesiculata* that produces semi-papillate and non-papillate sporangia). Sporangia may be bi- and tri-papillate and occasionally bi- or tri-lobate. Usually, they are persistent, but some species produce caducous sporangia in favourable conditions. Most species in this clade are homothallic, while those that are heterothallic, *P. citrophthora*, *P. mekongensis* and *P. theobromicola*, are functionally sterile. All Clade 2 species occur in terrestrial habitat, and most are aggressive plant pathogens; in humid environments, some can adapt to an aerial lifestyle and infect the aboveground organs of the plant. Many species in this clade are polyphagous and have an intercontinental distribution, while others have a very restricted host range and geographical distribution.

Subclade 2a contains eleven species: *P. botryosa*, *P. citrophthora*, *P. colocasiae*, *P. himalsilva*, *P. insulinativitatica*, *P. meadii*, *P. mekongensis*, *P. multibullata*, *P. occultans*, *P. terminalis*, and *P.* ×*vanyenensis*. Species of Subclade 2a most probably originate from Asia (Puglisi *et al.* 2017, Jung *et al.* 2020, Dang *et al.* 2021), and the current geographical distribution of most of these species is consistent with this hypothesis. Exceptions include *P. citrophthora*, which is a widespread pathogen of *Citrus* globally (and affects numerous other woody plants of ornamental and horticulture importance), *P. meadii*, which has been reported from Asia, Europe and the Pacific Islands, *P. occultans*, which has been reported from Europe and USA, and *P. colocasiae*, the causal agent of a Taro (*Colocasia esculenta*) leaf blight across the topics. These species likely spread from their centre of origin to other continents through the plant trade; records outside Asia are prevalently from horticultural crops, managed tree plantations and nurseries. Polyphagous species, such as *P. meadii* and *P. occultans*, are considered plant pathogens of concern for the USA (Reeser *et al.* 2015).

Subclade 2b encompasses eight validly described species: *P. amaranthi*, *P. aysenensis*, *P. capsici*, *P. glovera*, *P. mengei*, *P. siskiyouensis*, *P. theobromicola*, *P. tropicalis* and *P. mexicana which is redescribed in the current study*. *Phytophthora capsici* was this clade's first described and most commonly recovered species. It is a cosmopolitan pathogen with numerous horticultural hosts causing diseases such as Phytophthora blight, Phytophthora crown and root rot and Phytophthora fruit rot. *Phytophthora tropicalis*, a species long been confused with *P. capsici* (Aragaki & Uchida 2001), also has a broad host range and geographical distribution, although records from colder climates are limited to glasshouses; many *P. tropicalis* isolates may have been misidentified as *P. capsici* prior to the molecular era (Bourret *et al.* 2022a). The remaining species in Subclade 2b have a restricted host and geographic distribution. *Phytophthora siskiyouensis* has been recovered from stem cankers on *Notholithocarpus densiflorus* (*Fagaceae*) and *Umbellularia californica* (*Lauraceae*), but little is known about its pathogenicity (Reeser *et al.* 2007). *Phytophthora aysenensis* was first isolated from the root and collar rot of *Aristotelia chilensis*, a native plant from Chile (Crous *et al.* 2020a). Although described in 1923 (Hotson & Hartge 1923), *P. mexicana* records are limited to tomatoes in Mexico and Argentina and Chili pepper var. 'Latigo' from Texas. The specimen selected to be the epitype for *P. mexicana* was isolated from symptomatic roots of Chili pepper var. 'Latigo' in Texas (USA). *Phytophthora mengei* is a pathogen of avocado (*Persea americana*) in California (USA) (Hong *et al.* 2009), while *P. theobromicola* is a recently described species responsible for Black Pod Disease of cocoa in Brazil (Decloquement *et al.* 2021).

Subclade 2c comprises taxa of the *P. citricola* complex, including nine validly described species, *P. acerina*, *P. capensis*, *P. caryae*, *P. citricola*, *P. emzansi*, *P. multivora*, *P. pachypleura*, *P. pini* and *P. plurivora* as well as several informally designated taxa. *Phytophthora citricola*, the first species described in this clade, was considered to have a cosmopolitan distribution and a wide host range. However, after the description of several new species in the clade and extensive phylogenetic re-evaluation, *P. citricola* appears to be associated with a very narrow list of hosts including *Citrus* and hybrid Verbena (Abad *et al.* 2023). In contrast, the other species of this group can cause root rot, bark cankers, and shoot dieback on multiple hosts from different genera and families. In particular, both *P. multivora* and *P. plurivora* have an extensive geographical distribution and host range, including dicotyledons and conifers. They are considered invasive, having established in many natural and forest ecosystems outside their putative geographical location area of origin. *Phytophthora plurivora* has been reported predominantly in the northern hemisphere (Schoebel *et al.* 2014), while *P. multivora* is more common in the southern hemisphere (Tsykun *et al.* 2022). *Phytophthora acerina* was first recovered from the severe dieback of a native tree, *Acer pseudoplatanus,* in plantations of Northern Italy (Ginetti *et al.* 2014) and has since been recovered from additional hosts. In the north-eastern USA, *P. pini* is frequently associated with bleeding canker disease on European beech (*Fagus sylvatica*). Compared to the other members of the *P. citricola* complex, *P. caryae* is an exception as it is only weakly pathogenic (Brazee *et al.* 2017). While there is evidence that *P. acerina*, *P. citricola* and *P. plurivora* are native to eastern Asia, and *P. multivora* and *P. emzansi* are native to Southern Africa (Bose *et al.* 2021), both *P. caryae* and *P. pini* are believed to be native to eastern USA (Brazee *et al.* 2017). Many isolates submitted to GenBank as *P. citricola* will require re-identification (Abad *et al.* 2023).

Phytophthora oleae is basal to Subclades 2a–c and is the only species in Subclade 2d. It was reported as a causal agent of fruit rot of olive (*Olea europaea*) in Italy (Ruano-Rosa *et al.* 2018) and was found to be associated with the roots of declining wild olive trees in Spain (González *et al.* 2019). More recently, it was recovered from rhizosphere soil of southern live oak (*Quercus virgilianae*) in Sicily (southern Italy) (Riolo *et al.* 2020). The origin and the actual geographical distribution of this species are not known.

Subclade 2e includes six species: *P. acaciae*, *P. acaciivora*, *P. bishii* (formerly *P. bisheria*), *P. elongata, P. frigida*, and *P. multivesiculata*. Some phylogenies place *P. multivesiculata* in its own clade with the taxon informally named *P.* taxon aquatilis (Yang *et al.* 2017). *Phytophthora acaciivora* and *P. acaciae* have limited host range and are involved with the dieback of *A. mangium* in Vietnam (Burgess *et al.* 2020) and gummosis of black wattle on *A. mearnsii* in Brazil (Alves *et al.* 2019), respectively. The latter is often associated with *P. frigida,* first described as causing collar and root rot of *Eucalyptus*, but also known as a pathogen of *Acacia* spp. (Maseko *et al.* 2007, Alves *et al.* 2016). *Phytophthora elongata* is associated with many hosts in Australia but only causes wilting and dieback of young eucalypts (Rea *et al.* 2010). *Phytophthora bishii* causes root and basal rot of strawberry (*Fragaria ×ananassa*), raspberry *(Rubus idaeus*) and rose cuttings in the USA, Netherlands, and Australia, respectively. *Phytophthora multivesiculata* has only been recovered from *Cymbidium* orchids in Australia and Europe and is considered a species of concern for the USA.

Clade 3

Clade 3 currently comprises five species: *P. ilicis*, *P. nemorosa*, *P. pluvialis*, *P. pseudosyringae* and *P. psychrophila* (Fig. 3, Table 5). All species in Clade 3 produce semi-papillate, caducous sporangia and have a homothallic mating system. They have low-temperature optima and maxima and are only found in temperate climates. All Clade 3 species have only a few hosts, and their distributions are limited to either North America or Europe. *Phytophthora ilicis*, *P. nemorosa* and *P. pluvialis* were all described from the north-western USA. *Phytophthora ilicis* is a host specific pathogen on *Ilex* spp. (*Aquifoliaceae*) originally recorded from holly orchards in northern America and more recently gardens and natural environments in Europe (Scanu *et al*. 2014). *Phytophthora nemorosa* and *P. pseudosyringae* are often found on the same foliar and canker hosts as *P. ramorum* but do not cause widespread mortality (Hansen *et al.* 2017). *Phytophthora nemorosa* has been found in the forests of the Pacific northwest of the USA and appears endemic to the region. *Phytophthora pseudosyringae* and *P. psychrophila* were described from European forests (Jung *et al.* 2002, Jung *et al.* 2003). *Phytophthora pseudosyringae* is more pathogenic and has been reported to be associated with decline of oak stands and as a causal agent of stem bleeding cankers on Southern beech (*Nothofagus obliqua*), European beech (*Fagus sylvatica*) and Ink disease of European chestnut (*Castanea sativa*) (Motta *et al*., 2003; Scanu and Webber 2016). Subsequently, this species has also been found in North America and Chile (Wickland *et al.* 2008, Fajardo *et al.* 2017). The results of a comparative AFLP analysis of two sets of *P. pseudosyringae* isolates, from USA and Europe, respectively, suggest the hypothesis that this species has been introduced into USA from Europe (Linzer *et al*., 2009). *Phytophthora pluvialis* a primarily foliar species (Reeser *et al.* 2013), is a major invasive pathogen of *Pinus radiata* (*Pinaceae*) in New Zealand (Brar *et al.* 2018) and recently emerged as a pathogen of *Tsuga heterophylla* in the United Kingdom (Pérez-Sierra *et al.* 2022).

Clade 4

Clade 4 consists of ten described species: *P. alticola*, *P. arenaria*, *P. boodjera*, *P. cathayensis*, *P. heterospora*, *P. litchii*, *P. megakarya*, *P. palmivora*, *P. panamensis* and *P. quercetorum* (Fig. 3, Table 5). The species in this clade are all papillate, while *P. litchi*, *P. megakarya*, *P. palmivora* and *P. heterospora* are caducous. Besides caducous sporangia, *P. heterospora* also produces caducous pseudo conidia, conidia-like, non-papillate sporangia named because of their morphological and functional similarity to fungal conidia (Scanu *et al.* 2021) and *P. litchii* produces downy mildews-like sporangiophores. Regardless of these morphological characters for these two species, both and all members in Clade 4 have the typical characters of species in the genus.

Phytophthora palmivora is a widely distributed species known to infect several economically important plant species (Mchau & Coffey 1994). However, the remainder of the species in this clade have limited numbers of known hosts and/or limited geographical distribution. *Phytophthora heterospora* is closely positioned to *P. palmivora* in the ITS phylogenetic tree. While described from Italy, Iran, and Vietnam phylogenetic reassessment of ITS sequences of *P. palmivora* available on GenBank suggests that it has a wider distribution including Africa. *Phytophthora megakarya* was long confused with a *P. palmivora* (Brasier & Griffin 1979); it causes black pod disease of *Theobroma cacao* (cacao) and is restricted to western Africa (Akrofi 2015). *Phytophthora litchii,* previously known as *Peronophythora litchii*, exhibits downy mildew-like features such as reduced gene family size, low GC content and streamlined genome (Ye *et al.* 2016). *Phytophthora cathayensis* was recently described from *Carya cathayensis* (Chinese hickory) in China and includes isolates designated as *Phytophthora* sp. pecan from *Carya illinoinensis* (pecan) in the United States (Morales-Rodríguez *et al.* 2021).

Phytophthora arenaria and *P. boodjera* are currently only known from Australia. The distribution of *P. arenaria* is restricted to the proteaceous kwongan vegetation of the Western Australian sandplains, where it can cause disease following excessive summer rain (Rea *et al.* 2011). *Phytophthora boodjera* was first found associated with diseased eucalypts in a native plant production nursery (Simamora *et al.* 2015) but has since been recovered in remote regions of Western Australia (Burgess *et al.* 2021). *Phytophthora alticola* is closely related to *P. boodjera* but has only been reported from South Africa. In fact, *P. boodjera* was formerly described because the original description of *P. alticola* was based on mixed species making its species description invalid. Additional isolates of *P. alticola* were later recovered in South Africa, and the species description was amended with a neotype (Bose *et al.* 2017). However, these two species' morphological features and molecular data now overlap, and they could potentially represent lineages of the same species.

Clade 5

Clade 5 consists of only four described species: *P. agathidicida*, *P. castanae*, *P. cocois* and *P. heveae* (Fig. 3, Table 5). All species are homothallic and produce papillate, non-caducous sporangia. *Phytophthora castanae* is a pan-tropical pathogen causing trunk and fruit rot in chestnuts and fruit and heart rot in coconuts. *Phytophthora cocois* also causes coconut fruit and heart rot and has only been reported from Hawaii and the Ivory Coast (Weir *et al.* 2015). However, several isolates from Australia originally designated as *P. castanae* have now been re-identified as *P. cocois* (Burgess *et al.* 2021). *Phytophthora heveae* is responsible for several tropical tree crop diseases, including black stripe of rubber, bud rot, and coconut nut fall. It is found primarily in Asia and South America, but there have been reports from North Carolina and Tennessee in the United States. The fourth species, *P. agathidicida*, is only found in New Zealand and causes dieback in kauri (*Agathis australis*) trees. Species in Clade 5 appear to have a pan-tropical origin, and new species may be uncovered from natural ecosystems within the region.

Clade 6

Clade 6 comprises 32 species, one described hybrid and informal taxa placed in five subclades with *P. asparagi* basal to all other species in the clade (Fig. 3, Table 5). All species produce non-papillate, non-caducous sporangia on unbranched sporangiophores. Internal proliferation of sporangia is observed for all species except *P. pinifolia* which also produces some caducous sporangia with medium pedicels. A few species produce chlamydospores, and most have hyphal swellings. Many species appear functionally sterile, and those that produce oospores are mostly homothallic.

Subclade 6a contains thirteen species and can be divided again into two species clusters. The first cluster contains *P. rosacearum*, *P. cooljarloo*, *P. kwongonina*, *P. pseudorosacearum* and *P. oreophila*. *Phytophthora rosacearum* was recovered from rosaceous fruit trees in North America and has since been recovered from several locations in Europe and Australia. *Phytophthora cooljarloo*, *P. kwongonina*, *P. oreophila* and *P. pseudorosacearum* have a restricted distribution within natural ecosystems of Australia and have not been associated with disease (Burgess *et al.* 2018, Khaliq *et al.* 2019). The second species cluster in Subclade 6a contains *P. inundata*, *P. humicola*, *P. condilina*, *P. aquae-cooljarloo*, *P. balanboodja*, *P. personensis*, *P. gemini* and *P. chesapeakensis. Phytophthora inundata* was named in 2003 to accommodate isolates from various European riparian habitats (Brasier *et al.* 2003) and has since been reported from Argentina, Australia, Chile, Iran, Norway, Tunisia, Turkey, and the United States. This species has also been reported as an opportunistic pathogen of crop trees such as olive and peach in flooded soils. *Phytophthora humicola* was first described from citrus orchard soil in Taiwan (Ko & Ann 1985), but it is also known from Japan and a single record in Tuscany, Italy. *Phytophthora condilina*, *P. balyanboodja* and *P. aquae-cooljarloo* are only known from Western Australia. *Phytophthora gemini* and *P. chesapeakensis*, recovered from seagrass in the northern hemisphere, are closely related to *P. aquae-cooljarloo* and *P. balyanboodja*, respectively. *Phytophthora personensis* has been isolated from various hosts in Australia and has also been recovered in North America. Based on their close phylogenetic relationships and association with natural ecosystems in the southwest of Western Australia and their patchy distribution elsewhere in the world, all these species in Subclade 6a may be endemic to Australia (Burgess *et al.* 2018).

Subclade 6b contains fifteen species and one described hybrid (*P.* ×*stagnum*), most of which are aquatic specialists in temperate climates. Many species have high-temperature optima, a likely adaptation to their aquatic lifestyle. They are mostly considered to be weak pathogens. There is generally low support for species clusters within the subclade in the phylogeny. However, one well-supported cluster can be recognized, and it contains several related species recovered from rivers, streams, and ponds in Western Australia; *P. amnicola*, *P. fluvialis*, *P. litoralis*, *P. moyootj*, and *P. thermophila (Burgess et al. 2021)*. Of these, *P. thermophila* has the broadest distribution and recovered from rhizosphere soil in riparian vegetation. There are reports of *P. thermophila* from Italy and California, USA.

Phytophthora gonapodyides and *P. chlamydospora* (= *P.* taxon PgChlamydo) are widely distributed aquatic specialists from Subclade 6b found commonly in rivers, streams, lakes, and ponds in the northern hemisphere. Reports of these species in the southern hemisphere are less common, as other species seem to dominate the aquatic environment in these regions. *Phytophthora mississippiae* has only been found in irrigation reservoirs in Mississippi, USA. *Phytophthora borealis* was recovered initially from waterways in Alaska, but based on GenBank sequences it has now been recovered in California and China. *Phytophthora gibbosa* and *P. gregata* are closely related species described simultaneously from Australia. Sequences in GenBank identical to *P. gregata* corresponds to isolates from China, Japan, Vietnam, and the United States (Oregon). In the sub-alpine region of Australia, *P. gregata* has been implicated in dieback of a native shrub, *Pimelea bracteata* (McDougall *et al.* 2018). *Phytophthora ornamentata* is a recently described species recovered from *Pistacia lentiscus* in Sardinia, Italy; most isolates recovered were from wetlands or ponding water (Scanu *et al.* 2015). *Phytophthora ornamentata* has now also been recovered in Australia from trees planted on a water-gaining, ex-pasture site (Burgess *et al.* 2021).

While most of the species in Subclade 6b are considered aquatic specialists and weak pathogens, there are three exceptions: *P. pinifolia*, *P. megasperma* and *P. crassamura.* In Chile, a pine needle blight disease (Daño Foliar del Pino) of the major plantation species *Pinus radiata* is caused by *P. pinifolia.* The population in Chile is clonal (Durán *et al.* 2010), suggesting it has been introduced; however, to date, the species has yet to be discovered elsewhere. *Phytophthora megasperma*, first identified in 1931 as a pathogen of hollyhock (*Althaea rosea*), has a global distribution and numerous reported hosts. However, because the morphology accommodated multiple additional records from a variety of hosts, including isolates from alfalfa, clover, and soybean, variations or *formae speciales* were used to distinguish groups demonstrating host specificity. *Phytophthora megasperma sensu stricto*, the legume pathogens *P. medicaginis*, *P. sojae*, and *P. trifolii*, and two species later named *P. rosacearum* and *P. sansomeana* (Hansen *et al.* 2009) were identified after a thorough investigation of a large number of isolates (Hansen & Maxwell 1991). Another species from the *P. megasperma* complex, not included in the study of Hansen & Maxwell (1991), is *P. crassamura. Phytophthora crassamura* was described in 2015 from Sardinia, Italy (Scanu *et al*. 2015), and is common in restoration sites (Sims *et al.* 2019) and orchards in California, misidentified as *P. megasperma* prior to the molecular era (Bourret *et al.* 2022a). Additionally, in Australia, numerous isolates previously considered to be *P. megasperma* have been re-identified as *P. crassamura* (Burgess *et al.* 2021). Many isolates submitted to GenBank as *P. megasperma* will require reclassification.

Subclade 6c consists only of *P. bilorbang*, a species first described from Australia as a pathogen associated with blackberry decline (Aghighi *et al.* 2012). *Phytophthora bilorbang* is well established in Europe, and it has been associated with severe dieback and mortality of olive and wild olive trees in Italy (Santilli *et al.* 2020, Deidda *et al*. 2022). *Phytophthora bilorbang* is phylogenetically identical to *P.* taxon Oaksoil, a species widely distributed in waterways of the pacific northwest of USA (Reeser *et al.* 2011). The only distinction is that *P. bilorbang* is homothallic, whereas *P*. taxon Oaksoil is sterile. Subclade 6d contains two species, *P. lacustris* (= *P.* taxon Salixsoil) and *P. riparia.* As with many Subclade 6b species, they are aquatic specialists; *P. lacustris* is widespread in the northern hemisphere, while *P. riparia* has been recovered only in Oregon and California, USA. *Phytophthora asparagi* positions outside of the main cluster of Clade 6 and was initially identified as a pathogen responsible for spear and root rot of asparagus in Michigan, USA (Saude *et al.* 2008). *Phytophthora asparagi* accessions from Australia, California, USA, Italy, Japan, the Netherlands, South Africa, and Switzerland and sequences from China (submitted as *P. infestans*) are all available from GenBank.

Many species in Clade 6 can readily hybridize; although the stability of the hybrids is unknown, generally, they have poor survival in culture, and may be transient in nature (Nagel *et al.* 2013, Burgess 2015) as such, most of the hybrids observed from this clade have not been named.

Clade 7

Clade 7 consists of 30 species in four subclades, of which 23 have been described since 2000 (Fig. 3, Table 5). All species produce non-papillate sporangia on unbranched, simple sporangiophores. After the release of zoospores, the proliferation of the sporangiophores leading to new sporangia is found in all species. Of all the species in Clade 7, only *P. ×heterohybrida* produces caducous sporangia, and most are homothallic.

Subclade 7a contains 17 species, four of which are described as hybrid species: *P. abietivora*, *P. attenuata*, *P. europaea*, *P. flexuosa*, *P. formosa*, *P. fragariae*, *P. intricata*, *P. rubi*, *P. tyrrhenica*, *P. uliginosa*, *P. uniformis*, *P. vulcanica*, *P. ×alni*, *P. ×cambivora*, *P. ×heterohybrida*, *P. ×incrassata* and *P. ×multiformis. Phytophthora ×cambivora* has a global distribution causing root and canker disease of numerous woody hosts (Erwin & Ribeiro 1996). Conversely, the closely related species *P. fragariae* is associated with only one disease, red core root disease of strawberry (Hickman 1941). *Phytophthora rubi* has a cosmopolitan distribution but also causes a single disease, red raspberry root rot. The severe disease named alder dieback in Europe is caused by *Phytophthora ×alni* and related species, *P. ×multiformis* and *P. uniformis* (Brasier *et al.* 2004, Ioos *et al.* 2006, Husson *et al.* 2015). Only *P. uniformis* has been recovered outside Europe, in Alaska and Oregon (Aguayo *et al.* 2013). The remaining species in Subclade 7a have limited distribution. Except for *P. fragariae* the other species in Subclade 7a are associated with forests and fruit trees.

Subclade 7b contains nine species: *P. asiatica*, *P. cajani*, *P. melonis*, *P. niederhauserii*, *P. pisi*, *P. pistaciae*, *P. sojae*, *P. variabilis* and *P. vignae.* All species in this clade cause diseases of economically important crops. *Phytophthora sojae* and *P. niederhauserii* have a broad host range; the known host range for the other species is much more limited. Subclade 7b contains several important pathogens. Most of the species cause diseases of field crops in the *Fabaceae*; *P. asiatica on kudzu* (*Pueraria lobata*) (Rahman *et al.* 2014a), *P. cajani* on pigeon pea (*Cajanus cajan)* (Amin *et al*. 1978) and P. pisi on common pea (Pisum sativum) (Heyman *et al*. 2013). *Phytophthora melonis* is a pathogen of peas (*Fabaceae*) but is better known as a significant pathogen of cucumber (*Cucurbitaceae*) (Ho *et al.* 2007). The remaining species (*P. niederhauserii* and *P. pistaciae*) are pathogens of orchard trees. *Phytophthora niederhauserii*, although only described recently, is already widely distributed globally, causing stem cankers and gummosis of numerous fruit trees. Moreover, *P. niederhauserii is an emerging pathogen in nurseries of ornamentals in Europe and USA. Phytophthora pistaciae,* causes similar symptoms but on a single host *genus, Pistacia* (Mirabolfathy *et al*. 2001).

Subclade 7c contains *P. cinnamomi* and related species *P. parvispora* and *P. mediterranea*. Before their description, the latter two species were confused with *P. cinnamomi. Phytophthora cinnamomi* is a highly aggressive soilborne pathogen listed among the 100 worst invasive alien species. It has numerous host species and is found on annual crops, ornamentals, orchards, gardens, and natural ecosystems (Burgess *et al.* 2017). Records for *P. parvispora* tend to be from warmer climates, and although not as widely distributed as *P. cinnamomi,* it can be a severe pathogen of tropical fruit trees, Mediterranean plant species and ornamentals (Scanu *et al*. 2014). *Phytophthora mediterranea* is a recently described species recovered from root and collar rot of *Myrtus communis*, one of the few species in the *Myrtaceae* endemic in the northern hemisphere (Bregant *et al.* 2021a). *Phytophthora mediterranea* is identical to *Phytophthora* sp. ax recovered from *Prunus* and *Pistacia* in California, USA. Subclade 7d contains two unusual species, *P. fragariaefolia* and *P. nagaii;* both were described from Japan from single hosts, strawberries, and roses, respectively (Rahman *et al.* 2014b).

Clade 8

Phytophthora Clade 8 comprises 23 described species in four previously established subclades, containing all except the most recently described species, *P. marrasii* (Bregant *et al.* 2021b) (Fig. 3, Table 5). Although placed in Subclade 8c in the original description, in our phylogenies, *P. marrasii,* an agricultural pathogen in Italy, was placed in an intermediate position between Subclades 8c and 8d with strong support and has now been placed in Subclade 8e (Fig. 3). Clade 8 has a worldwide distribution, mostly restricted to temperate climates. Most species in Clade 8 are homothallic and produce non- or semi-papillate non-caducous sporangia. In many ways, Clade 8 is a microcosm of *Phytophthora*, since it contains species with both wide and narrow host ranges, attacking above and below ground plant tissue and with prominence in agriculture, horticulture, and natural ecosystems.

Subclade 8a contains eight species producing non-papillate sporangia: *P. cryptogea*, *P. drechsleri*, *P. erythroseptica*, *P. kelmanii*, *P. medicaginis*, *P. pseudocryptogea*, *P. sansomeana* and *P. trifolii*. Members of Subclade 8a almost exclusively cause root diseases, resulting in a collar rot of non-lignified crops. Three Subclade

8a species, *P. sansomeana*, *P. medicaginis* and *P. trifolii*, form a tight cluster (Fig. 3) and were separated from the *P. megasperma* morphospecies in two studies (Hansen & Maxwell 1991, Hansen *et al.* 2009). *Phytophthora sansomeana* was initially isolated from conifer seedlings but has exhibited a broad host range, including legumes; both *P. medicaginis* and *P. trifolii* exhibit host preference for legumes. The remaining five species in Subclade 8a correspond to the *P. cryptogea* species complex (Safaiefarahani *et al.* 2015). Although *P. cryptogea* and *P. erythroseptica* were both originally isolated from *Solanum*, all five species in the complex are regarded as having wide host ranges. These species are heterothallic, except for *P. erythroseptica*, which is homothallic. There is a long history of systematic and diagnostic difficulty within the complex, which appears to have been alleviated by the addition of two modern species, *P. kelmanii* and *P. pseudocryptogea* (Safaiefarahani *et al.* 2015, Crous *et al.* 2021a). *Phytophthora pseudocryptogea* appears to be the most widely distributed and pathogenic member of the species complex based on recent studies (Khdair *et al.* 2020b, Bourret *et al.* 2022a, Aloi *et al.* 2023). Species within Subclade 8a readily hybridize (Safaiefarahani *et al.* 2016). Some isolates submitted to GenBank as *P. erythroseptica* and *P. cryptogea* will require re-identification (Abad *et al.* 2023).

Subclade 8b comprises the most highly derived culturable *Phytophthora* species (Fig. 3), suggesting rapid evolution putatively related to host specialization (Bertier *et al.* 2013a, b, Bourret *et al.* 2018). All seven described species, *P. brassicae*, *P. cichorii*, *P. dauci*, *P. lactucae*, *P. porri*, *P. primulae* and *P. pseudolactucae*, and several informal species in Subclade 8b exhibit high levels of host specialization and attack root tissue of non-woody hosts. These hosts are commonly temperate crops, and all the species in this clade have low-temperature optima and maxima. All species are homothallic except for *P. cichorii*. Speciation and host-adaptation of Subclade 8b through allopolyploid hybridization was characterized by Bertier *et al.* (2013b).

Subclade 8c contains four species: *P. foliorum*, *P. hibernalis*, *P. lateralis* and *P. ramorum*. Unusually for Clade 8, all species except *P. lateralis* produce caducous sporangia. Subclade 8c is notable for containing several species that facultatively or primarily attack foliage and disseminate sporangia through the air or airborne water and includes two of the most important invasive forest pathogens in the genus, *P. lateralis* and *P. ramorum* (Hansen *et al.* 2000, Grünwald *et al.* 2012). *Phytophthora ramorum*, the causal agent of Sudden Oak death (SOD), is known to affect a wide host range of woody ornamentals in Europe and North America causing blights, cankers, and diebacks. This pathogen is thought to have originated in Asia although, to date, the invasive lineages have not been recovered in Asia (Jung *et al.* 2021). This pathogen is one of the most important species of the present time with national regulatory surveys occurring in different areas of the world including Europe and the USA. *Phytophthora hibernalis* is a cool-season *Citrus* pathogen responsible for brown rot of fruit, leaf, and twig blight. While first described from Western Australia (Carne 1925), this species has a global distribution and was likely introduced to Australia with *Citrus* germplasm. More recently, *P. foliorum* was detected in horticultural settings in the United States, isolated from the leaves of cultivated rhododendrons (Donahoo *et al.* 2006).

Subclade 8d contains three species: *P. austrocedri*, *P. obscura* and *P. syringae*. *Phytophthora syringae* is one of the earliest-described species in the genus. The species has a long history with agriculture (particularly *Rosaceae* orchards) and served as the type species for the rejected genus *Phloeophthora* (Waterhouse 1963). *Phytophthora obscura* is also associated with horticulture, having been discovered in European and North American plant production prior to its description (Grünwald *et al.* 2011). Like *P. syringae*, *P. obscura* appears to attack both the roots and foliage of hosts. *Phytophthora austrocedri* was discovered to cause dieback of native *Austrocedrus* conifers in South America (Greslebin *et al.* 2007). The pathogen is also associated to juniper in UK (Green *et al.* 2015).

Clade 9

Clade 9 comprises 21 species with deep branches separating them into four subclades (Fig. 3, Table 5). Almost all species produce non-papillate, non-caducous sporangia on unbranched sporangiophores (*P. estuarina*, *P. macrochlamydospora* and *P. constricta* also produce semi-papillate sporangia). Internal proliferation of sporangia is observed for all species. In each subclade, some species produce chlamydospores, and most have hyphal swellings. Some species appear to be functionally sterile, and those that produce oospores are mostly homothallic with few heterothallic exceptions (Table 5). No Clade 9 species are considered significant pathogens.

Subclade 9a contains 10 described species and numerous designated but undescribed taxa separated by relatively short branch lengths: *P. aquimorbida*, *P. chrysanthemi*, *P. estuarina*, *P. hydrogena*, *P. honggalleglyana*, *P. irrigata*, *P. macilentosa*, *P. parsiana*, *P. rhizophorae* and *P. virginiana.* Many of these species have a similar aquatic lifestyle to species in Subclade 6b, although with a tendency to be recovered from irrigation water in warmer climates. Another similarity is the ability to hybridize readily. Much more research is needed to determine the species boundaries within this clade and their pathogenicity and origin. Many isolates submitted to GenBank as *P. parsiana* will require re-identification (Abad *et al.* 2023).

Subclade 9b contains four species: *P. insolita*, *P. polonica*, *P. prodigiosa* and *P. pseudopolonica. Phytophthora insolita* was described from Taiwan and now reported from India and Australia and has mainly been recovered from irrigation water and nursery soil. *Phytophthora prodigiosa* causes brown rot of pomelo in southern Vietnam (Puglisi *et al.* 2017). *Phytophthora polonica* is known only from Europe (and a single report from the USA), where it has been reported from declining alder stands, although its involvement in the decline is unknown. *Phytophthora pseudopolonica* has been recovered from a subtropical forest stream in China (Li *et al.* 2017).

Subclade 9c contains four species: *P. docyniae*, *P. macrochlamydospora*, *P. quininea* and *P. richardiae*. *Phytophthora quininea* is only known from Peru and a single host genus (*Cinchona* spp.) (Crandal 1947). *Phytophthora macrochlamydospora* was described from Australia as associated with soybeans but has recently been recovered from asymptomatic natural vegetation (Burgess *et al.* 2021). Additionally, on GenBank, there is a single sequence from Vietnam recovered by water baiting (Jung *et al.* 2020). *Phytophthora richardiae* was described in 1927 from calla lily (*Zantedeschia aethiopica*) in the Netherlands, Japan, and the USA, and there are few records of this species. Many isolates submitted to GenBank as *P. richardiae* will require re-identification (Abad *et al.* 2023). *Phytophthora docyniae* was recently described from Vietnam (Dang *et al.* 2021).

Subclade 9d currently contains four described species: *P. cacuminis*, *P. captiosa*, *P. constricta* and *P. fallax. Phytophthora captiosa* and *P. fallax* were described as minor pathogens of *Eucalyptus* leaves in New Zealand (Dick *et al.* 2006). *Phytophthora fallax* has since been recovered from the soil beneath asymptomatic vegetation in sub-alpine regions of eastern Australia and Tasmania (Khaliq *et al.* 2019). *Phytophthora cacuminis* was recovered from sub-alpine vegetation in Tasmania (Khaliq *et al.* 2019). *Phytophthora constricta* is common in Western Australia's proteaceous heathland and has been linked to occasional episodic dieback (Rea *et al.* 2011). While *P. captiosa* has not yet been found in Australia, given that its host is *Eucalyptus*, it is expected that it, like the other species in Clade 9d, is native to the country (Burgess *et al.* 2021).

Clade 10

With the recent description of 14 new species (Jung *et al.* 2022), Clade 10 now consists of 21 species, placed into four well-supported subclades (Fig. 3, Table 5) three of which were recognized by Jung *et al.* (2022). The addition of the phylogenetically distinct Subclade 10d lowers the statistical support for the entire clade as a whole, whereas the clade containing Subclades 10a–c received higher support (Fig. 3). Species in Subclade 10b–d have persistent, non-papillate sporangia while in contrast the species in Subclade 10a have caducous, papillate sporangia. Species in Subclades 10b–d have mostly been isolated from water and none of these species have been associated with disease.

Subclade 10a consists of ten papillate, caducous species: *P. boehmeriae*, *P. celebensis*, *P. chilensis*, *P. gondwanensis*, *P. javanensis*, *P. kernoviae*, *P. morindae*, *P. multiglobulosa*, *P. pseudochilensis* and *P. pseudokernoviae*. All Subclade 10a species are homothallic and do not have chlamydospores. A few species (*P. chilensis*, *P. pseudochilensis* and *P. pseudokernoviae*) sometimes produce hyphal swellings. Apart from *P. kernoviae* and *P. boehmeriae*, two well-known pathogens, and *P. gondwanensis* recovered from rainforest soil in Australia, the remaining species in this clade have been recovered from water and have a limited geographic distribution (Jung *et al.* 2022). *Phytophthora kernoviae*, an invasive pathogen, was described in 2006 from the UK (Brasier *et al*. 2005) however, isolates recovered in New Zealand in the 1970s were subsequently found to be P. *kernoviae* (Scott & Williams 2014). A recent genomic analysis of isolates from New Zealand and Chile supported the New Zealand origin of *P. kernoviae* (Studholme *et al.* 2019). *Phytophthora kernoviae* has now been found in South America (Sanfuentes *et al.* 2016, Vélez *et al.* 2020) and related species, *P. pseudokernoviae*, *P. chiliensis* and *P. pseudochiliensis* have also been recovered (Jung *et al.* 2022). *Phytophthora boehmeriae* was described in 1927 from a leaf of *Boehmeria nivea* in Taiwan; since then, it has been associated with several diseases and reported from Asia and across the southern hemisphere. However, many of these records are doubtful as the sequence available has 100 % identity with *P. gondwanensis*, a species described recently from Australia. Additionally, there are other clusters of isolates, usually from the same country, which could represent new species (Abad *et al.* 2023)

Species in Subclades 10b–d have mostly been isolated from water and none of these species have been associated with disease. Many species in these subclades are mostly functionally sterile, except for *P. tonkinensis*, *P. scandinavica* and *P. tenuimura* that are homothallic and *P. intercalaris* which is heterothallic. Subclade 10b consists of six species *P. afrocarpa*, *P. gallica*, *P. pseudogallica*, *P. subarctica*, *P. tonkinensis* and *P. ukrainensis* with restricted distributions; *P. gallica* in Europe (Jung & Nechwatal 2008), *P. afrocarpa* in southern Africa (Bose *et al.* 2021), *P. pseudogallica* and *P. tonkinensis* in Vietnam, *P. subarctica* in Sweden, and *P. ukrainensis* from Ukraine (Jung *et al.* 2022). Subclade 10c contains *P. intercalaris* and *P. scandinavica.* Subclade 10d contains three recently described species, *P. ludoviciana*, *P. procera*, *P. tenuimura* recovered from water in Louisiana, USA.

Clade 11

Clade 11 consists of a single described species, *P. lilii*, a pathogen causing stem rot of Easter lilies cultivated in Okinoerabu Island, a remote island in southern Japan (Rahman *et al.* 2015) (Fig. 3, Table 5). Another species in the same clade is *Phytophthora* taxon juncus, which has not yet been formally described (Fig. 3). This species was isolated in California, USA during a survey of restoration out plantings.

Clade 12

Clade 12 contains four described species: *P. castanetorum*, *P. quercina*, *P. tubulina* and *P. versiformis* (Fig. 3, Table 5). *Phytophthora quercina* was the first species described from Clade 12 and was initially attributed to Clade 3b (Cooke *et al.* 2000), then placed in Clade 4 (Blair *et al.* 2008) and then Clade 1 (Martin *et al.* 2014). However, the addition of new species cemented the position of Clade 12 as sharing a common nuclear ancestor with Clade 4 (Fig. 3). Sporangia are papillate or semi-papillate, proliferation is not observed, and the mating system is homothallic. All species in Clade 12 grow slowly, are difficult to isolate and have a low-temperature optima. All species have a limited host range and a restricted geographic distribution. Pathogenicity has only been demonstrated for *P. quercina* and *P. castanetorum* in soil infestation trials, although considerably less so than other *Phytophthora* species such as *P. cinnamomi* and *P.* ×*cambivora* (Delatour *et al.* 2000, Jung *et al*. 2017a). *Phytophthora versiformis* has been recovered from the rhizosphere soil a single host, *Corymbia calophylla*, in Western Australia and has not been associated with any disease (Paap *et al.* 2017).

Clade 13

Phytophthora transitoria, a non-papillate, sterile species was described by Jung *et al.* (2022a) [Chen *et al.* (2022)] as residing in Clade 3 (Fig. 3, Table 5). However, along with the undescribed species, *P. taxon mugwort*, it forms its own clade designated here as Clade 13 (Bourret *et al.* 2018). It was recovered from nursery soil in the Czech Republic but has not been associated with a disease.

Clade 17

Clade 17 is another single species clade. *Phytophthora stricta*, a non-papillated, persistent/caducous, heterothallic species, has only been recovered from aquatic environments in the USA: irrigation reservoirs in Mississippi, and streams in Virginia (Yang *et al.* 2014a) (Fig. 3, Table 5). Phylogenetically, the species formed a well-supported clade along with Clade 8 (Fig. 3). It is a fast-growing, high-temperature species.

TAXONOMY

Tabular and Lucid Identification keys

The Tabular Key organized by the position of 212 species in the 7-gene phylogenetic tree and morphological characters is presented in Table 5. It has been implemented using the information of the morphology generated from cultures of the ex-types in our work and/or the characters presented in the original publications (Tables 1, 2). The Tabular Key contains the characters of the asexual morph including shape of the papilla of sporangia, which is a strong character for identification of species in the genus, shape of the sporangia (not very informative), caducity or persistence of sporangia, size of the pedicel when caducous, sporangia proliferation, shape of sporangiophore, hyphal swellings and chlamydospores. The sexual morph includes the homothallic or heterothallic or sterile characters and the characters of the oogonia, antheridia and oospores. In addition, colony pattern and temperature conditions are included to help in the process of species identification. In the past, tabular keys have been published by Newhook *et al*. (1978) and Stamps *et al*. (1990) but these keys have not been implemented based in the characters of the types of the species.

The Lucid Key for 212 species is also the first implemented with the information of the cultures of the ex-types and is posted at the *IDphy* online resource (https://idtools.org/tools/1056/index.cfm?pageID=1803). Information about this key is also available in Abad *et al.* (2023).

Phytophthora and the redescription or validation of twenty-eight species

Phytophthora de Bary, J. Roy. Agric. Soc. England 12: 240. 1876.

Classification: *Straminipila*, *Oomycota*, *Peronosporomycetes*, *Peronosporales*, *Peronosporaceae*.

Type species: *Phytophthora infestans* (Mont.) de Bary

Phytophthora infestans (Mont.) de Bary, J. Roy. Agric. Soc. England. ser. 2, 12: 240. 1876. MycoBank MB 232148.

Holotype of *Botrytis infestans*: **France**, from leaves of *Solanum tuberosum* "Sur les fanes de pomme de terre" M. Vernois, collected by Montagne, deposited by Montagne on 18. Aug. 1845, (FUSION 94490 in PC).
Epitype (designated in Chen *et al.* 2022, MBT 10005612): **Netherlands**, from infected *Solanum tuberosum*, 1993, A. Drenth (CBS H-24657). Ex-epitype: CBS 147289 = T30-4, TJ1504. Barcode sequence for ex-epitype GenBank: MZ753914 (ITS). Other sequences provided in Table 2.
Ex-epitype genome sequenced strain: *Phytophthora infestans* CBS 147289 = T30-4. This Whole Genome Shotgun project has been deposited at GenBank under the accession Genome ASM14294v1 reference (genome size 240 Mbp; BioProjec PRJNA17665; BioSample SAMN02953670; Haas *et al.* 2009). Additional information for the ex-epitype genome in Table 3.

Phytophthora cajani K.S. Amin, Baldev & F.J. Williams *ex* Abad, ***sp. nov.*** MycoBank MB 846822. Fig. 4.
[originally described as: *Phytophthora cajani* K.S. Amin, Baldev & F.J. Williams, Mycologia 70 (1): 174. 1978. (*nom. inval*., Art. 8.4. Shenzhen). MycoBank MB 320473.]

Etymology: Refers to the host genus, *Cajanus*.

Holotype: **India**, collected from pigeon pea (*Cajanus cajani*) in Hyderabad, collection date and collector unknown (ATCC 44388, preserved in a metabolically inactive state).
Ex-type cultures: ATCC 44388 (MCI). Other strains S&T BL 116, N516. Other duplicates of the ex-type in Table 2. Barcode sequences for ex-type GenBank: MG783386 (ITS); MH136859 (*COI*). Other collections and sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* non-papillate, persistent, ovoid, obpyriform, ellipsoid, bluntly ellipsoid (42–83 × 29–46 µm); showing internal, internal extended, external, and nested proliferation; originated in unbranched *sporangiophores* sometimes showing swellings. *Hyphal swellings* terminal and intercalary with finger-like projections. *Chlamydospores* absent. *Sexual morph*: *Homothallic. Oogonia* smooth-walled (37–48 µm diam); *antheridia* amphigynous, occasionally with digital projections; oospores *aplerotic*.

Culture characteristics: Colony morphology after 7 d of growth on V8 agar, PDA and MEA with no distinct pattern. Minimum temperature for growth 9 °C, optimum 27–33 °C, and maximum 36 °C.

Notes: The original publication of Amin *et al.* (1978) only mentioned "pure cultures" as type material. As there is no other evidence that the cultures were preserved metabolically inactive, the name was invalidly published and is validated here. Furthermore, the authors incorrectly indicated the presence of plerotic oospores. Interestingly, fig. 3C–G in Amin *et al.* (1978: 174) shows only young oogonia with non-differentiated oospores. Isolate S&T BL 116 (duplicate of N516) produces typical aplerotic oospores.

Phytophthora honggalleglyana Abad, ***sp. nov.*** MycoBank MB 844805.
[originally described as: *Phytophthora hydropathica* C.X. Hong & Gallegly, Pl. Pathol. 59: 916. 2010. (*nom. inval*., Art. 40.7. Shenzhen). MycoBank MB 514043.]

Etymology: Refers to C.X. Hong & M.E. Gallegly, the authors of the original invalid name *P. hydropathica*.

Holotype: **USA**, Virginia, collected from irrigation water of ornamentals, 2000, H. Hong (VPI 11736, preserved in a metabolically inactive state).
Ex-type cultures: CBS 142610 = ATCC MYA-4460. Barcode sequence for ex-type GenBank: EU583793 (ITS). Other sequences provided in Table 2.

Detailed description and figures: Hong *et al.* (2010).

Description: *Asexual morph*: *Sporangia* non-papillate; persistent; spherical, to ovoid and obpyriform (43–60 × 33–47 µm), frequently obpyriform with well-rounded bases; showing frequently internal and nested proliferation and originated in unbranched long *sporangiophores*. *Hyphal swellings* irregular, obovate in clusters or at the end of hyphae in hemp-seed agar, and small catenulate in water cultures. *Chlamydospores* globose (37 µm diam), terminal and thin-walled. *Sexual morph*: *Heterothallic. Oogonia* smooth (43 µm diam), *antheridia* predominantly amphigynous, and globose when paragynous; *oospores* plerotic (38 µm diam) and golden colour in hemp seed agar.

Culture characteristics: Colony morphology after 7 d of growth on PDA with petaloid (rosette) pattern. Minimum temperature for growth is 7.5 °C, optimum 30 °C, and maximum 38 °C.

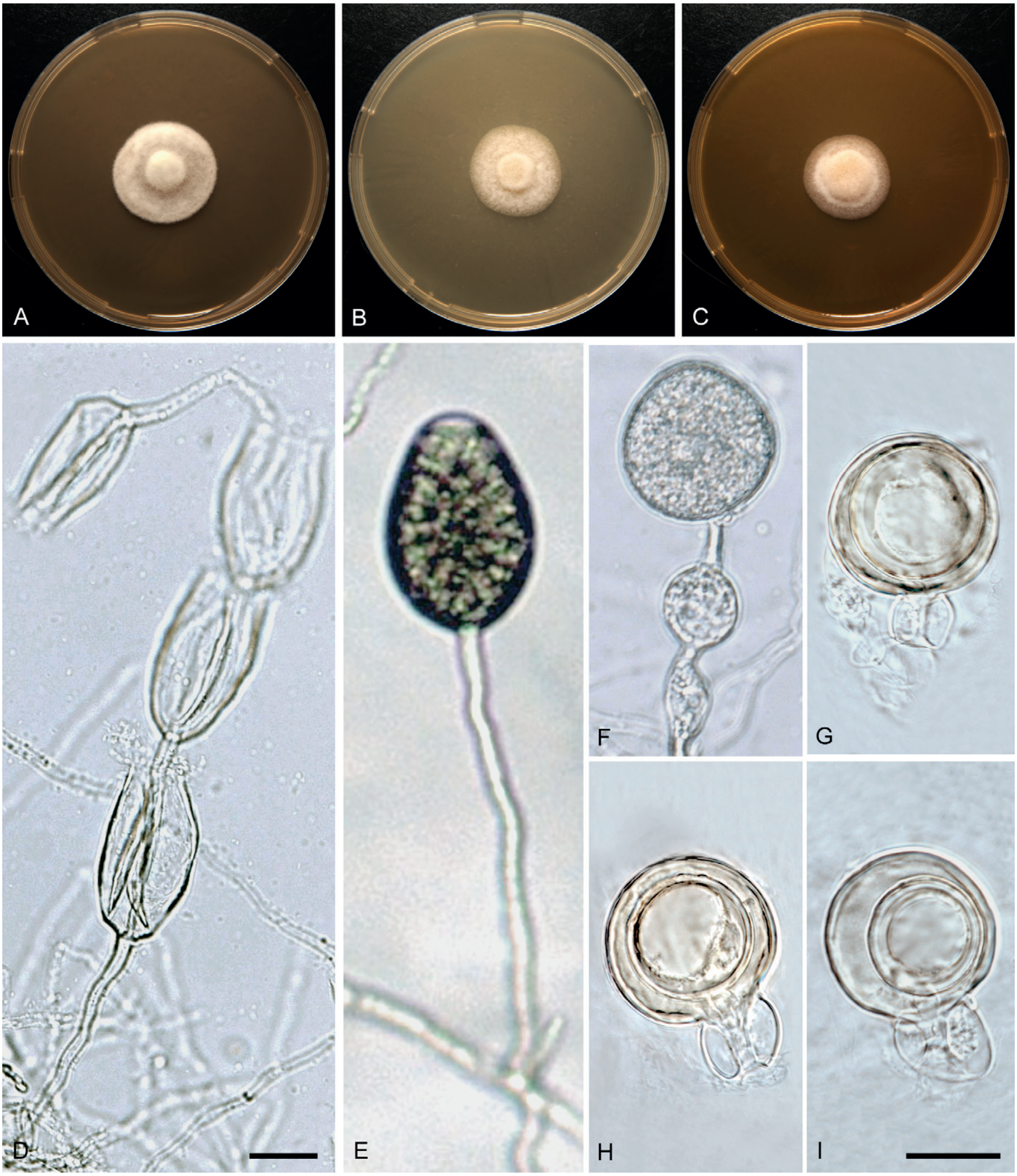

Fig. 4. *Phytophthora cajani* ex-type culture ATCC 44388. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D.** Empty sporangia with internal and extended proliferations. **E.** Ovoid sporangium originated in an unbranched sporangiophore. **F.** Globose sporangium originated in a sporangiophore showing hyphal swellings. **G–I.** Smooth-walled oogonia with amphigynous antheridia. **I.** Oogonium with highly aplerotic oospore. Scale bars = 20 µm; D applies to D–F; I applies to G–I.

Notes: Hong *et al.* (2010) failed to indicate the holotype for '*Phytophthora hydropathica*', thereby rendering the species name invalid (Art. 40.7). We validate the name herein. A detailed description, culture characteristics and the most typical characters were presented in Hong *et al.* (2010: 916–918).

Phytophthora megakarya Brasier & M.J. Griffin ex Abad, ***sp. nov.*** MycoBank MB 844806. Fig. 5.
[originally described as: *Phytophthora megakarya* Brasier & M.J. Griffin, Trans. Brit. Mycol. Soc. 72: 137. 1979. (*nom. inval.*, Art. 40.2; see Ex. 1. Shenzhen). MycoBank MB 320483.]

Etymology: Referring to the huge nuclei of the species.

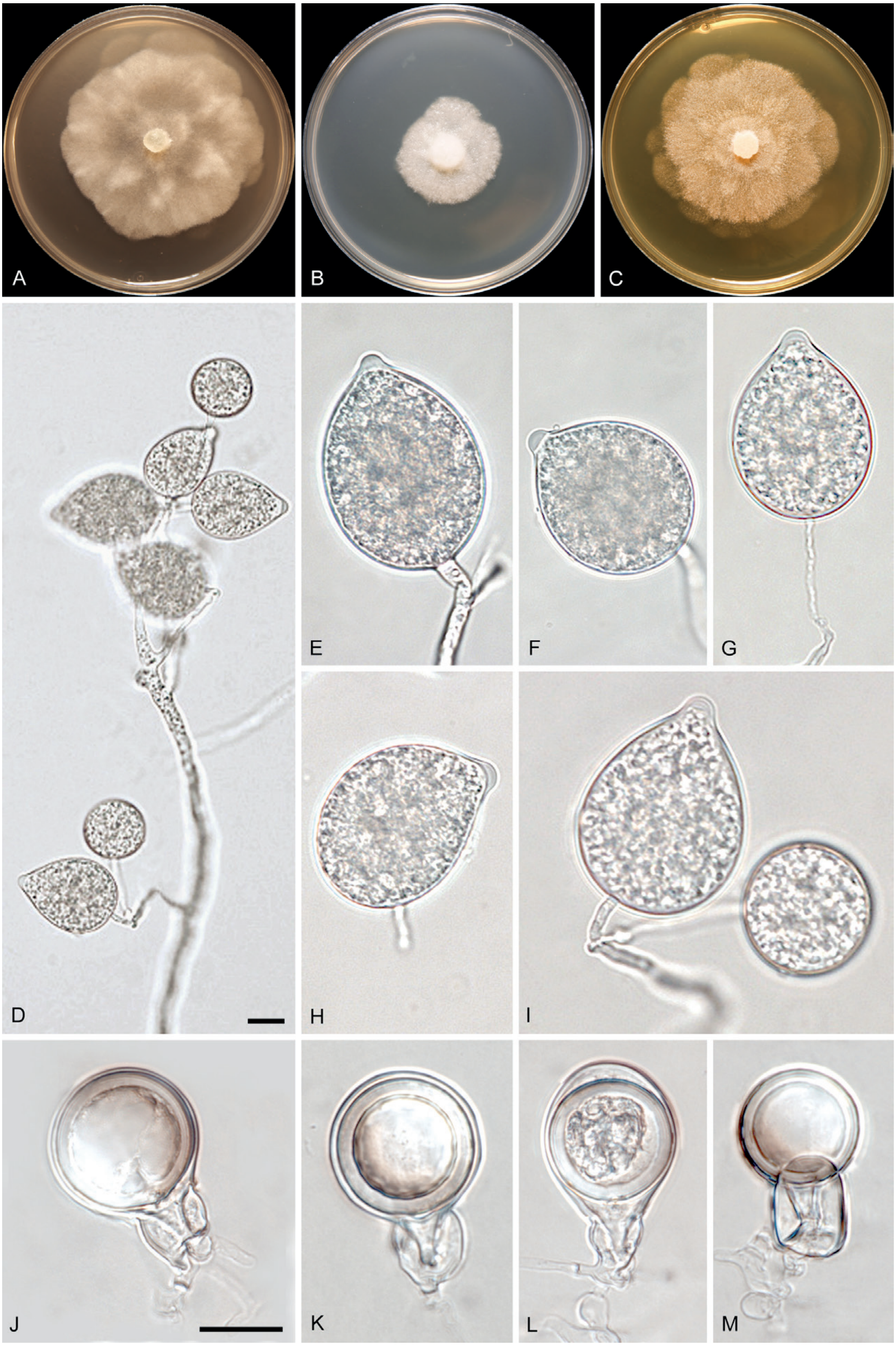

Fig. 5. *Phytophthora megakarya* ex-type culture CBS 238.83 (IMI 202077). **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D, I.** Ovoid, globose to limoniform sporangia originated in sympodial sporangiophores. **E–G**. Papillate sporangia with well-rounded bases. **H.** Caducous sporangium with medium and lateral attached pedicel. **J–M.** Gametangia with smooth-walled oogonia and amphigynous antheridia. **K, L.** Oogonia with thick-walled oospores. **L.** Oogonium with slightly aplerotic oospore and tapered base. Scale bars = 20 µm; J applies to E–M.

Holotype: ***Cameroon***, collected from cocoa (*Theobroma cacao*) in 1975 by unknown collector (IMI 202077).
Ex-type cultures: CBS 238.83 = NRRL 64259 = ATCC 42100 (MCI). Other strains S&T BL 73, P184 (A2) L, ex B. Boccas, no. 36. Other duplicates of the ex-type in Table 2. Barcode sequences for ex-type GenBank: MG865534 (ITS); MH136929 (*COI*). Other collections and sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* papillate (frequently with one papilla, rarely 2 or 3); caducous with medium pedicel (10–30 µm); frequently obpyriform with well-rounded bases, sometimes globose, ovoid, or elongate-ovoid, or ellipsoid (20–60 × 13–41 µm). Sporangia originated in loose sympodial *sporangiophores*. *Hyphal swellings* absent. *Chlamydospores* are very rare but occur both in agar as well as in water cultures and are mostly terminal (20–44 µm diam). *Sexual morph*: *Heterothallic*. *Oogonia* smooth (19–37 µm diam), some with tapered bases; *antheridia* amphigynous, situated either well down the oogonial stalk or high up as a collar, depending on the degree of taper of the oogonium (10–16 µm); *oospores* plerotic (18–34 µm diam) to almost plerotic.

Culture characteristics: Colony morphology after 7 d of growth on V8 agar and MEA with light chrysanthemum pattern, on PDA with no distinct pattern. Minimum temperature for growth is 10 °C, optimum 24–26 °C, and maximum 30 °C.

Notes: When Brasier & Griffin (1979) described ‘*Phytophthora megakarya*’, the name was not validly published because two gatherings (from Nigeria and Cameroon) were designated as type (see Art. 40.2, Ex. 1; Shenzhen Code, Turland *et al.* 2018). The name is validated herein by designating a holotype and providing an updated description.

Phytophthora ×multiformis (Brasier & S.A. Kirk) Abad, ***comb. nov.*** MycoBank MB 846426.
Basionym: *Phytophthora alni* subsp. *multiformis* Brasier & S.A. Kirk, Mycol. Res. 108 (10): 1177. 2004. MycoBank MB 488623.
Synonym: ‘*Phytophthora ×multiformis*’ (Brasier & S.A. Kirk) C. Husson, Ioos & Marçais, Fungal Genet. Biol. 77: 20. 2015. (*nom. inval*., Arts. 41.5., F.5.1. Shenzhen). MycoBank MB 631643.

Holotype: **The Netherlands**, isolated from *Alnus* sp. bark, 1994, H. van Kesteren (IMI 392316, dried culture on carrot agar).
Ex-type culture: P16202 (WPC). Other strain S&T BL 2. Other duplicates of the ex-type in Table 2. Barcode sequences for ex-type GenBank: MG783372 (ITS); MK493472 (*COI*). Other collections and sequences provided in Table 2.

Description and culture characteristics: Brasier *et al.* (2004).

Notes: Husson *et al.* (2015) did not cite an identifier for their new combination and failed to give a full and direct reference to the basionym name but cited the page range of the whole publication, which makes the name invalid. The combination is validated here.

Phytophthora pisi Heyman ex Abad, ***sp. nov.*** MycoBank MB 845099. Fig. 6.
[originally described as: *Phytophthora pisi* Heyman, Plant Disease 97(4): 466. 2013. (*nom. inval*., Art. 40.7. Shenzhen). MycoBank MB 801280.]

Etymology: Refers to the host plant, *Pisum sativum*, from which it was first isolated.

Holotype: **Sweden**, Skåne Län, Höganäs, isol. from roots of pea (*Pisum sativum*), 1997, M. Wikström, 97603 (CBS 130350, preserved in a metabolically inactive state).
Ex-type cultures: CBS 130350 = NRRL 64205. Other strain S&T BL 133. Other duplicates of the ex-type in Table 2. Barcode sequences for ex-type GenBank: MG865567 (ITS); MH477754 (*COI*). Other collections and sequences provided in Table 2.

Detailed description: Heyman *et al.* (2013).

Description: *Asexual morph*: *Sporangia* non-papillate; persistent; ovoid or ellipsoid (31–160 × 17–45 µm); showing occasionally internal nested or external proliferation and originated in unbranched or closely sympodial *sporangiophores*. *Hyphal swellings* globose and intercalary formed in hyphae and sporangiophores in liquid cultures. *Chlamydospores* absent. *Sexual morph*: *Homothallic. Oogonia* smooth-walled, globose (24–47 µm diam); *antheridia* amphigynous; *oospores* aplerotic (19–35 µm diam).

Culture characteristics: Colony morphology on V8 agar, PDA, and MEA with no distinctive pattern and slow growth. Minimum temperature for growth 4 °C, optimum 25–30 °C, maximum 37 °C. Sporangia and hyphal swellings produced in liquid media, and gametangia readily produced on culture media after 4 d.

Notes: Heyman *et al.* (2013) failed to indicate where the holotype was deposited and cited two living ex-type strains. This does not fulfil the requirements for a valid publication. The name is validated herein. In the original description of Heyman *et al.* (2013) it is stated that hyphal swellings are absent on sporangiophores. In the ex-type culture CBS 130350 we have observed the production of hyphal swellings, shown in Fig. 6D.

Phytophthora pseudopolonica W.W. Li, W.X. Huai & W.X. Zhao *ex* Abad & Kasiborski, ***sp. nov.*** MycoBank MB 844808. Fig. 7.
[originally described as: *Phytophthora pseudopolonica* W.W. Li *et al.*, Int. J. Syst. Evol. Microbiol. 67 (9): 3670. 2017 (*nom. inval*., Art. 40.7. Shenzhen). MycoBank MB 820722.]

Etymology: *pseudopolonica* refers to the similar ITS sequence with *Phytophthora polonica.*

Holotype: **China**, Sichuan, Xichang, from stream water, 24 Sep. 2012, L. Wenwen, H. Wenxia & Z. Wenxia (CBS H-25078).
Ex-type cultures: CBS 142610 = NRRL 64333. Other strains S&T BL 221 = LS06.3.2. Other duplicates of the ex-type in Table 2. Barcode sequence for ex-type GenBank: KY707115 (ITS). Other sequences provided in Table 2.

Description: *Asexual morph. Sporangia* non-papillate; persistent; ovoid, pyriform (32–55 × 28–44 µm), with internal or nested proliferation; originated in unbranched *sporangiophores*. *Hyphal swellings* globose, peanut-shaped to distorted, and single or catenulate. *Chlamydospores* spherical (12–46 µm), thin-walled, intercalary, lateral, and terminal, occasionally occurring on short stalks. *Homothallic. Oogonia* smooth walled, spherical, (18–22 µm), antheridia paragynous, some with masked paragynous giving the appearance to be amphigynous (Fig. 7K), *oospores* predominantly aplerotic containing big ooplasts when semi-mature to mature.

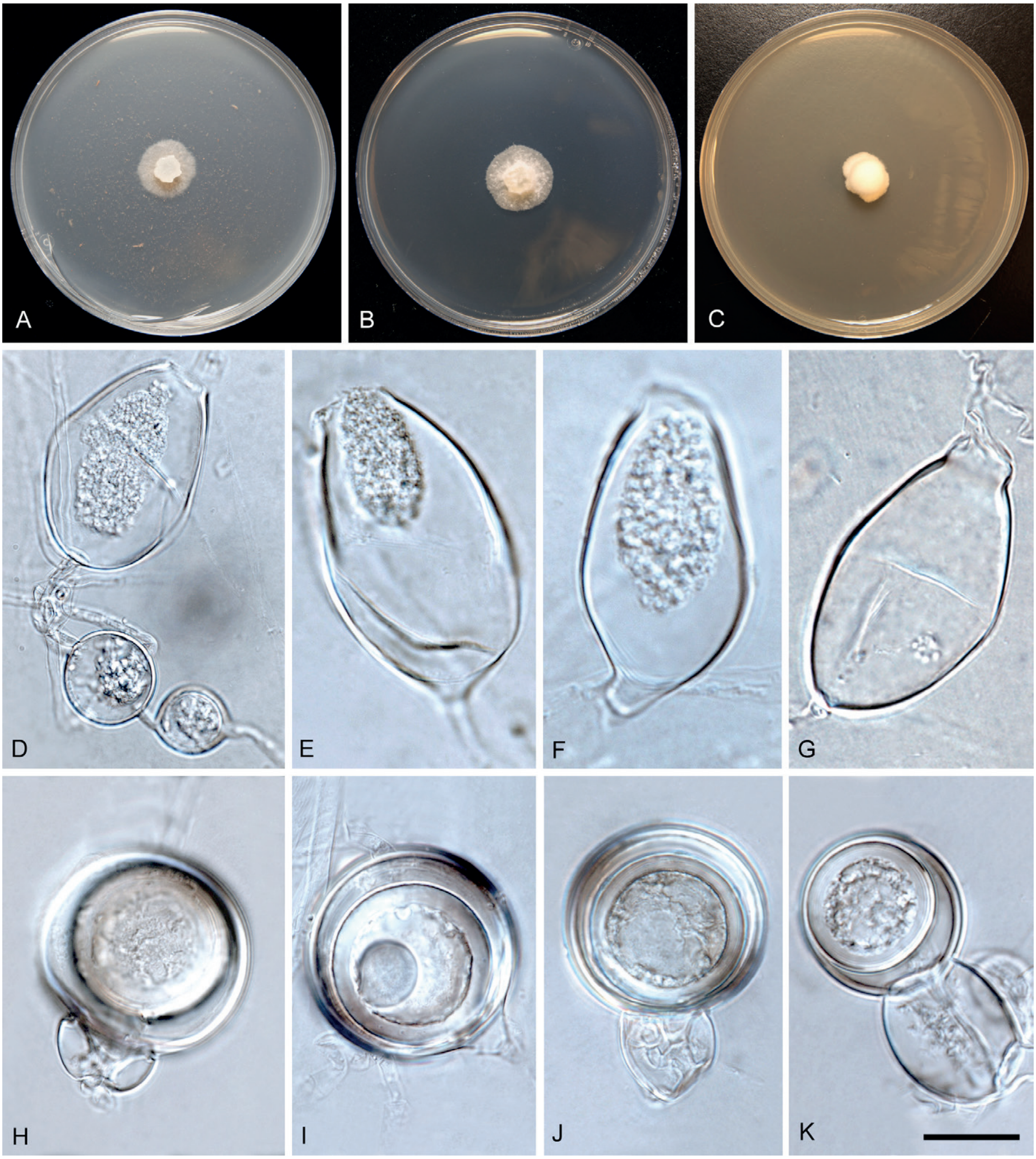

Fig. 6. *Phytophthora pisi* ex-type culture CBS 130350. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D–F.** Ovoid to ellipsoid persistent sporangia. **D.** Sporangium with globose catenulated hyphal swellings in the sporangiophore. **G.** Empty sporangium with direct germination from the apex. **H–K.** Gametangia showing smooth-walled oogonia; amphigynous antheridia and aplerotic oospores. Scale bars = 20 µm; K applies to D–K.

Culture characteristics: Colony morphology on PDA, and MEA with petaloid (rosette) pattern, on V8A with no distinct pattern. Minimum growth temperature 5 °C, optimum 30 °C, and maximum 35 °C.

Notes: Li *et al.* (2017) did not indicate the holotype for *Phytophthora pseudopolonica*, rendering the name invalid (Art. 40.7). Here we validate the name.

Phytophthora uniformis (Brasier & S.A. Kirk) Abad, ***comb. nov.*** MycoBank MB 846427.
Basionym: *Phytophthora alni* subsp. *uniformis* Brasier & S.A. Kirk, Mycol. Res. 108 (10): 1175. 2004. MycoBank MB 488624.
Synonym: '*Phytophthora uniformis*' (Brasier & S.A. Kirk) C. Husson, Ioos & Marçais, Fungal Genet. Biol. 77: 20. 2015. (*nom. inval*., Arts 41.5, F.5.1. Shenzhen). MycoBank MB 631645.

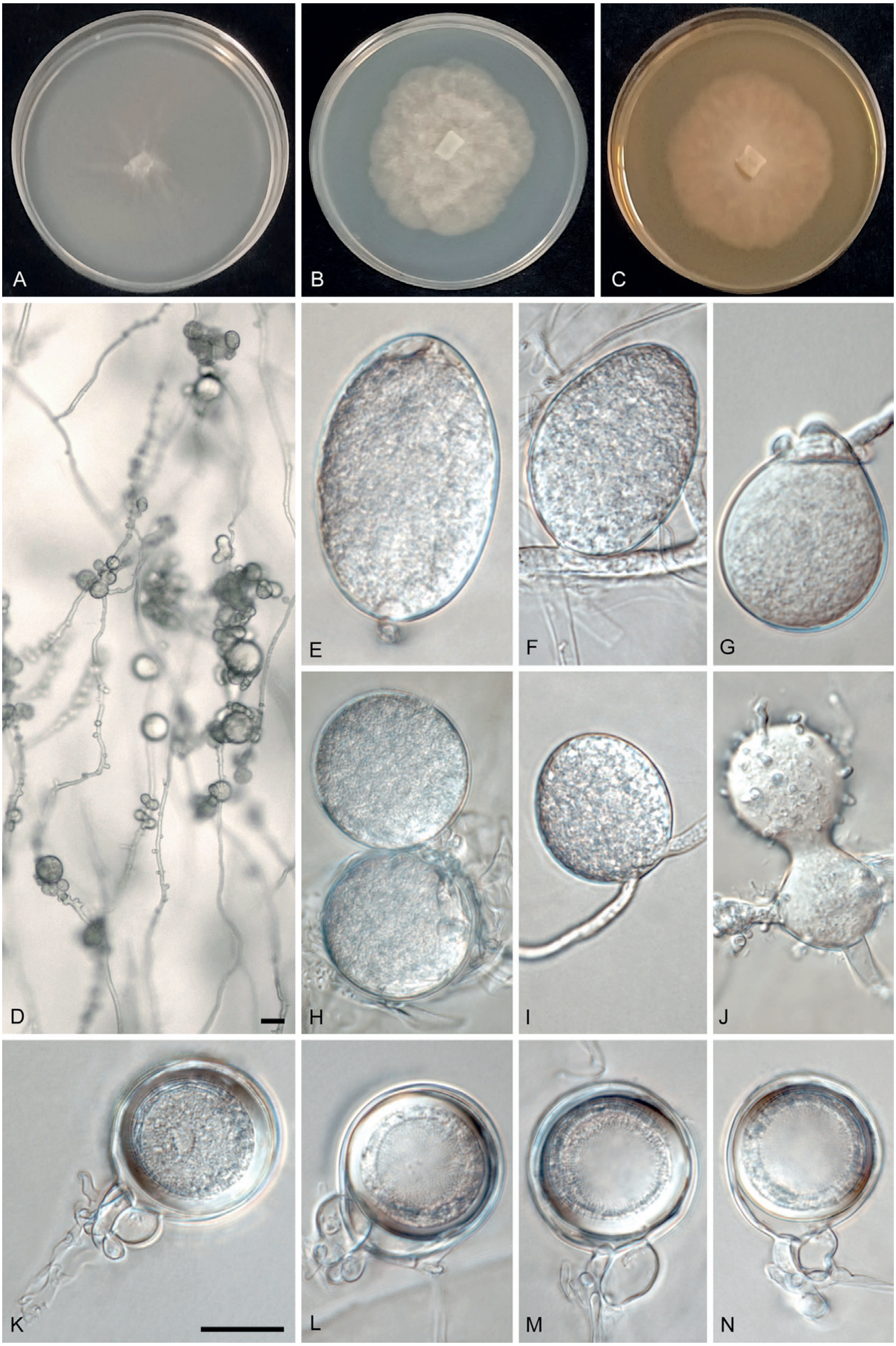

Fig. 7. *Phytophthora pseudopolonica* ex-type culture CBS 142610. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D.** Catenulate, globose to subglobose and irregular hyphal swellings. **E–G.** Ellipsoid to ovoid sporangia. **H, I.** Thin-walled chlamydospores. **J.** Germinating chlamydospores. **K–N.** Gametangia with smooth wall oogonia and paragynous antheridia. **M.** Comma-shaped oogonium with slightly aplerotic oospores containing a big ooplast. Scale bars = 20 µm; K applies to E–N.

Holotype: **Sweden**, Gothenberg, isolated from *Alnus* bark, 1996, C. Olsson, CH161 (IMI 392315, dried culture on carrot agar).
Ex-type cultures: CBS 149409 = NRRL 64373. Other strain S&T BL 3. Other duplicates of the ex-type in Table 2. Barcode sequences for ex-type GenBank: MK496514 (ITS); MH136992 (*COI*). Other collections and sequences provided in Table 2.

Description and culture characteristics: Brasier *et al.* (2004).

Notes: Husson *et al.* (2015) did not cite an identifier for their new combination and failed to give a full and direct reference to the basionym name but cited the page range of the whole publication which makes the name invalid. The combination is validated here.

Phytophthora cactorum (Lebert & Cohn) J. Schröt., in Cohn, Krypt.-Fl. Schlesien 3.1(2): 236. 1886. MycoBank MB 199322. Fig. 8.
Basionym: *Peronospora cactorum* Lebert & Cohn, Beitr. Biol. Pflanzen 1(1): 56. 1870. MycoBank MB 166699.
Synonyms: *Nozemia cactorum* (Lebert & Cohn) Pethybr., Sci. Proc. Roy. Dublin Soc. 13: 566. 1913. MycoBank MB 562134.
Phloeophthora cactorum (Lebert & Cohn) G.W. Wilson, Mycologia 6(2): 80. 1914. MycoBank MB 453641.
Phytophthora paeoniae D.C. Cooper & Porter, Phytopathology 18: 881. 1928. MycoBank MB 273265.

Lectotype (designated here, MBT 10008001): **Slovakia**, Bratislava, in the garden of Jacobi, intercellular in the parenquima of various diseased rotten cacti (*Cactacae*), 1868, plate on page 53, and plate on page 54 (line drawings) in Lebert & Cohn (1870), showing sporangia and oospore formation (https://www.biodiversitylibrary.org/item/27353#page/65/mode/1up).
Epitype (designated here, MBT 10008003): **The Netherlands**, isolated from lilac (*Syringa vulgaris*) (*Oleaceae*), unknown collection date and collector, isolated and identified by W.L. White (CBS H-25066).
Ex-epitype cultures: CBS 231.30 = MUCL 9638 = NRRL 64109. Other strain S&T BL 9. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: MG783385 (ITS); MH136858 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* papillate, caducous with short pedicels (less than 4 µm in length), ellipsoidal, obpyriform, ovoid, or globose (24–50 × 19–36 µm) borne in simple or in close or lax sympodial *sporangiophores*. *Hyphal swellings* absent. *Chlamydospores* terminal and intercalary, globose (17–55 µm diam). *Sexual morph*: *Homothallic*. *Oogonia* smooth-walled and usually hyaline (19–38 µm diam), some with tapered bases; *antheridia* paragynous (very rarely amphigynous), nearly spherical to club-shaped, and nearly always applied close to the oogonial stalk, very rare masked paragynous giving the appearance to be amphigynous can be observed; *oospores* plerotic and aplerotic (20–26 µm diam), with an average wall thickness of 2 µm.

Culture characteristics: Colonies in V8A, PDA, and MEA with no distinct pattern. The minimum temperature for growth is 4 °C, the optimum 24 °C, and the maximum 30 °C.

Notes: Original material could not be traced, therefore the two plates in the original publication of Lebert & Cohn (1870) are designated as lectotype here. In addition, an epitype is designated to support the selected lectotype and fix the application of this name. The epitype from *Syringa vulgaris* was selected based on the typical morphological characters of the specimen that fit to those presented for the isolate used in the original description of the species.

Phytophthora citrophthora (R.E. Sm. & E.H. Sm.) Leonian, Amer. J. Bot. 12 (7): 445. 1925. MycoBank MB 251464. Fig. 9.
Basionym: *Pythiacystis citrophthora* R.E. Sm. & E.H. Sm., Bot. Gaz. 42 (3): 215. 1906. MycoBank MB168281.

Lectotype (designated here, MBT 10012251): **USA**, California, parasitic on lemons, figs 2 & 3 in Smith & Smith (1906: 218–219).
Epitype (designated here, MBT 10012252): **USA**, California, La Habra, collected from a diseased lemon tree (*Citrus* sp.), collection date and collector unknown, isolated by P. Oudemans (CBS 950.87, preserved in a metabolically inactive state).
Ex-epitype cultures: CBS 950.87 = NRRL 64128. Other strains S&T BL 60, Fawcett 1309A. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: MG865476 (ITS), MH136872 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* semipapillate, some with two papillae; persistent; ovoid, limoniform, ellipsoid, globose, and with distorted shapes (17–48 × 20–110 µm), some with tapered bases, and with intercalary position, borne in simple sympodial or irregularly branched *sporangiophores*. *Chlamydospores* globose, subglobose, lateral, terminal, and intercalary (24–37 µm diam). *Hyphal swellings* absent. *Sexual morph*: Sterile-heterothallic; *oospores* rarely produced.

Culture characteristics: Colony morphology after 7 d on V8-A, PDA, and MEA with chrysanthemum pattern. Minimum growth temperature 6 °C, optimum 24–28 °C, maximum 33 °C.

Notes: In the original description by Smith & Smith (1906) the authors did not mention a single holotype but reported the species to be widespread in southern California found on lemons and occasionally on other *Citrus* fruits in orchards and packing houses. Large amounts of material and numerous cultures were studied but none of this original material could be traced. Therefore, two illustrations published in the protologue are designated as lectotype here. An epitype from the same country and host is selected.

Phytophthora colocasiae Racib., Paras. Alg. Pilz. Javas: 9. 1900. MycoBank MB 232219. Figs 10, 11.
Synonyms: *Phytophthora parasitica* var. *colocasiae* (Racib.) Sarej., Ann. Inst. Phytopathol. Benaki 2: 47. 1936. MycoBank MB 353071.
Kawakamia colocasiae (Racib.) Sawada, Agric. Mag., Formosa 38(5): 355. 1942. MycoBank MB 539096.

Lectotype (designated here, MBT 10008004): **Indonesia**, Java, Soekaboemi, in leaves of *Colocasia esculenta*, Apr. 1900, Raciborski (Raciborski, Crypt. Paras. Java no. 6, FH). ***Isolectotypes***: (BPI 186640, S-F178886).
Epitype (designated here, MBT 10008005): **Indonesia**, Java, on *Colocasia esculenta*, 1989, unknown collector (CBS H-25067).
Ex-epitype cultures: CBS 149404 = NRRL 64370. Other strains S&T BL 173 (S&T BL 35G). Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: MG865479 (ITS), MH136875 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* semi-papillate; caducous with medium and short pedicels (3–10 µm length); elongate,

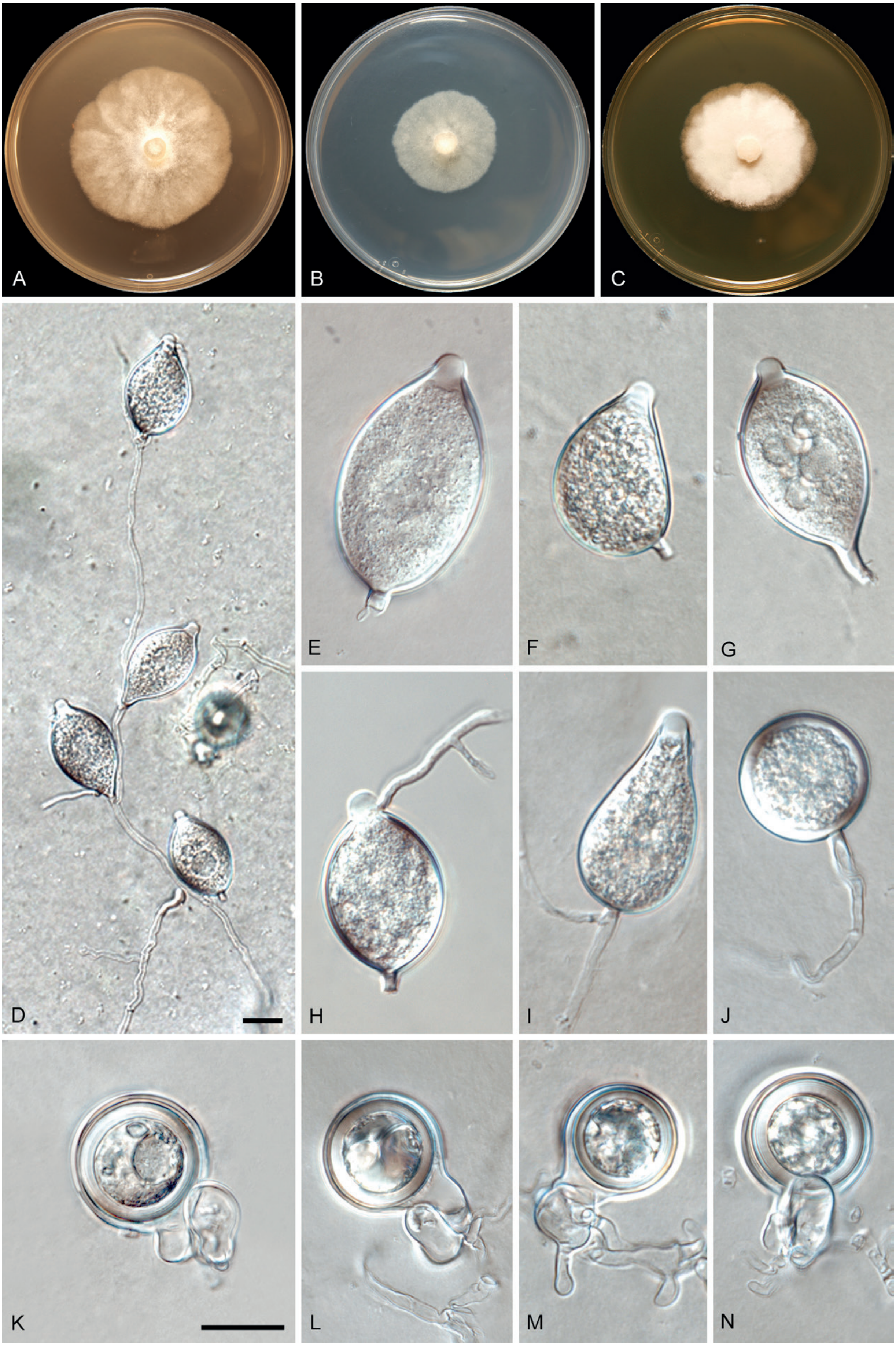

Fig. 8. *Phytophthora cactorum* ex-epitype CBS 231.30. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D.** Sporangia originated in lax sympodial sporangiophore. **E–H.** Limoniform to obpyriform papillate sporangia with short pedicels. **H.** Detached sporangium with direct germination through the apex. **I.** Persistent sporangium with an external proliferation. **J.** Terminal globose chlamydospore. **K–N.** Globose oogonia, with plerotic oospores and paragynous antheridia nearly spherical to club-shaped. **M.** A paragynous antheridium with finger-like projection. Scale bars = 20 µm; K applies to E–N.

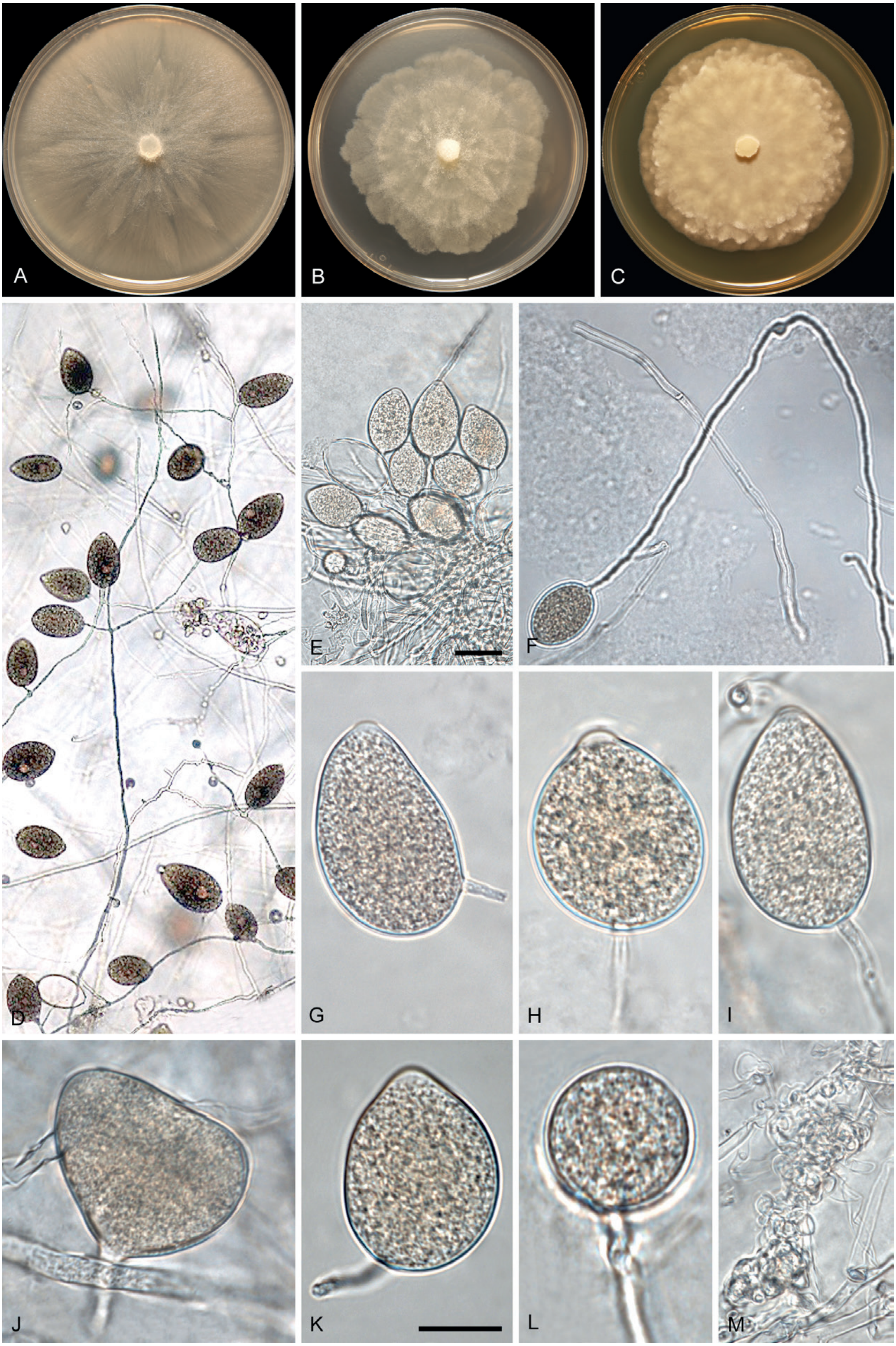

Fig. 9. *Phytophthora citrophthora* ex-epitype CBS 950.87. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D.** Persistent semipapillate sporangia originated in simple sympodial, individually or in irregularly branched sporangiophores. **E.** Sporangia originated in clusters. **F.** Sporangium originating individually in a log sporangiophore. **G–I.** Different shapes of sporangia. **J.** Sporangium with two papillae. **G, K.** Sporangia with caducous medium pedicels (rarely observed). **L.** Terminal globose chlamydospore. **M.** Clustered distorted shapes hyphal swellings. Scale bars = 20 µm; E applies to D–F; K applies to G–M.

Fig. 10. Lectotype of *Phytophthora colocasiae* preserved in FH.

ovoid, or ellipsoid (48–55 × 19–22 µm); some sporangia with tapered base or with lateral attachment; a conspicuous basal plug is observed in some sporangia; originated in simple or irregularly branched *sporangiophores*. *Hyphal swellings* globose, sub-globose, radiating hyphae, or irregular-shaped are occasionally observed. *Chlamydospores* globose, terminal, or intercalary, observed in some isolates and rare in others (23–31 µm diam). *Sexual morph*: *Heterothallic/Homothallic*. *Oogonia* with smooth wall (20–35 µm diam, av. 29.0 µm); *antheridia* amphigynous and subterminal; *oospores* aplerotic and semi aplerotic (18–30 µm diam, av. 23.0 µm).

Culture characteristics: Colony morphology after 7 d on V8-A, PDA, MEA with no distinct pattern. Minimum growth temperature 10 °C, optimum 22 °C, and maximum 30 °C.

Notes: *Phytophthora colocasiae* was described by Raciborski (1900, https://digitalgems.nus.edu.sg/shared/colls/blsea/files/ParRac.pdf) on leaves of *Colocasia esculenta* from Java. Raciborski issued material with his publication in a kind of exsiccatae, of which copies are available in several fungaria. The specimen in FH is here designated as lectotype (see Fig. 10). Material from the same host collected in Indonesia for which living cultures and sequence data are available is chosen here as epitype to support the selected lectotype and fix the application of this name. The isolate CBS 149404 = S&T BL 173 is homothallic, but some isolates of the species behave heterothallic.

Phytophthora drechsleri Tucker, Res. Bull. Missouri Agric. Exp. Sta. 153: 188. 1931. MycoBank MB 251892. Fig. 12.

Lectotype (designated here, MBT 10008006): **USA**, Idaho, isolated from rotting tubers of *Solanum tuberosum* by Charles Drechsler, Tucker no. 206, fig. 2 (asexual morph) and fig. 3 (sexual morph) in Tucker (1931: 8–9; https://mospace.umsystem.edu/xmlui/handle/10355/53359).
Epitype (designated here, MBT 10008007): **USA**, California, from *Beta vulgaris* var. *altissima*, unknown collection date and collector, isolated by C.M. Tompkins, no. 114 (CBS H-25068).
Ex-epitype cultures: CBS 292.35 (A2) = NRRL 64328. Other strain S&T BL 17. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: MG865484 (ITS), MH136879 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* non-papillate, persistent, ellipsoid, ovoid, irregular shapes, and some with tapered bases (23–34 × 36–59 µm), showing internal and external proliferation, and originated in unbranched and sometimes in simple sympodial *sporangiophores* with two or few sporangia. *Hyphal swellings* globose, catenulate (rosary shape), and frequently clustered. *Chlamydospores* absent. *Sexual morph*: *Heterothallic. Oogonia* with smooth wall, globose, some with slightly tapered bases (within antheridium), 25–40 µm diam; *antheridia* amphigynous, oval (9–16 µm); *oospores* almost plerotic to aplerotic (22–35 µm diam) with thin walls (2.5 µm).

Culture characteristics: Colonies on V8-A, PDA, and MEA with no distinctive pattern, on PDA and MEA with very light chrysanthemum pattern. Minimum temperature for growth 3 °C, optimum 27–33 °C, and maximum 36 °C.

Notes: Original specimens of *P. drechsleri* could not be traced. Therefore, illustrations provided in the protologue are here designated as lectotype. The authentic strain CBS 292.35, identified and deposited by the original author, C.M. Tucker, is designated as ex-epitype with a dried specimen preserved in the fungarium of the Westerdijk Fungal Biodiversity Institute. Jung *et al.* (2022a) [Chen *et al.* (2022)], Yang *et al.* (2017) and Yang & Hong (2018) considered strain CBS 292.35 to be the type of *P. drechsleri,* but that strain was isolated by C.M. Tompkins and deposited in the CBS culture collection in 1935 and can therefore not be regarded as ex-type material.

Phytophthora erythroseptica Pethybr., Sci. Proc. Roy. Dublin Soc. 13: 547. 1913. MycoBank MB 231826. Fig. 13.

Lectotype (designated here, MBT 10008008): **Ireland**, from *Solanum tuberosum*, plate XLIV, figs 17–22 in Pethybridge (1913, https://www.biodiversitylibrary.org/page/30514890#page/869/mode/1up), showing sporangia and oospore formation.
Epitype (designated here, MBT 10008009): **Ireland**, Dublin, Banon, isolated from potato (*Solanum tuberosum*), 1989, collector unknown (CBS H-25069).
Ex-epitype cultures: CBS 148925 = NRRL 64171. Other strain S&T BL 80. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: MG865486 (ITS); MH136882 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* non-papillate; persistent; ellipsoid, obpyriform, ovoid (23–87 × 14–36 µm), with rounded and tapered bases, ellipsoid frequently constricted in the

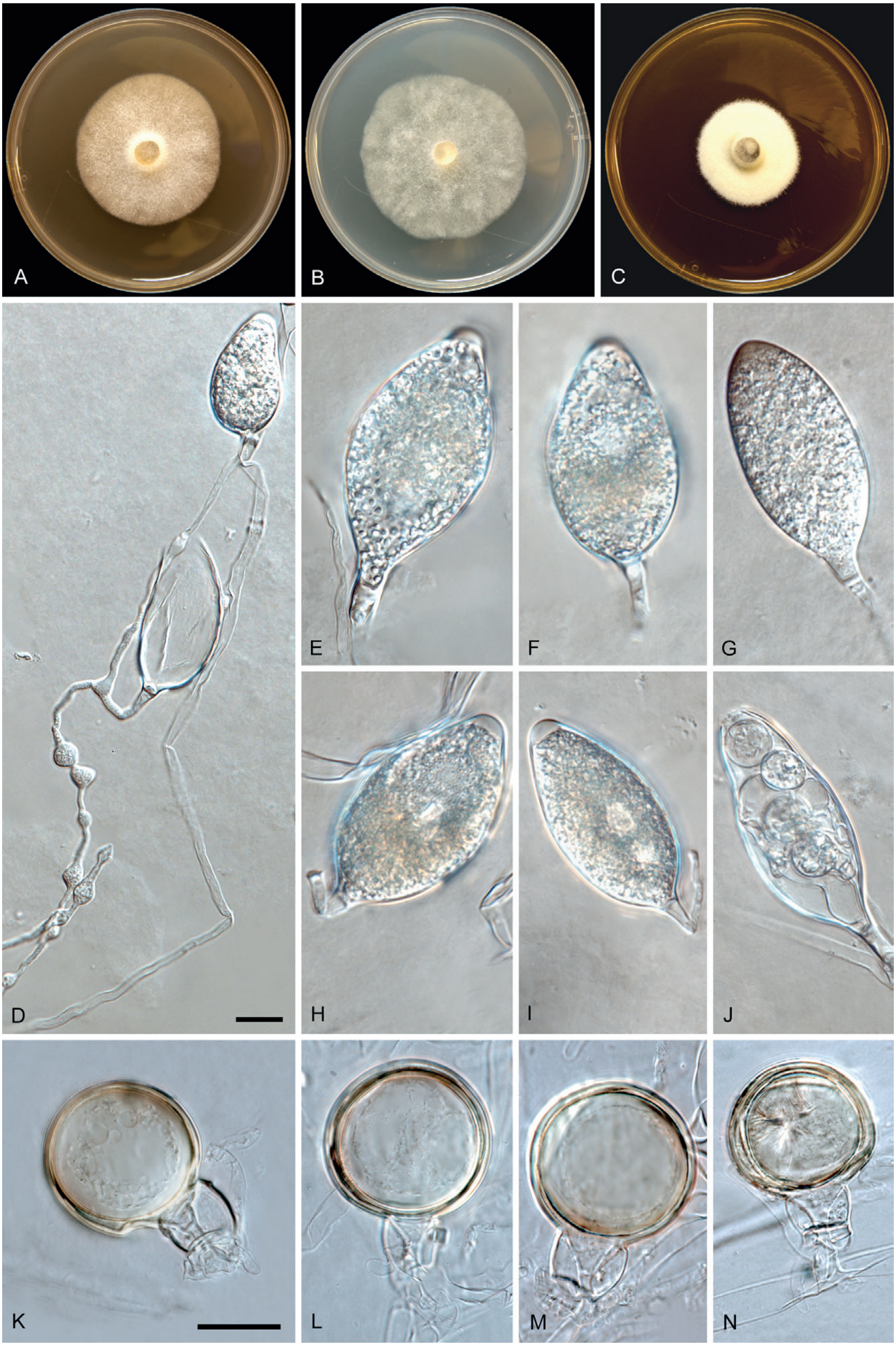

Fig. 11. *Phytophthora colocasiae* ex-epitype culture CBS 149404. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D.** Sporangia originated in a simple branched sporangiophore with globose catenulated hyphal swellings. **E–I.** Limoniform to ellipsoid sporangia with medium pedicels. **H, I.** Semipapillate sporangia with folded and comma-shaped pedicels. **J.** Sporangium with unreleased zoospores inside. **K–N.** Globose and smooth-walled oogonia with plerotic oospore and amphigynous antheridia. Scale bars = 20 µm; K applies to E–N.

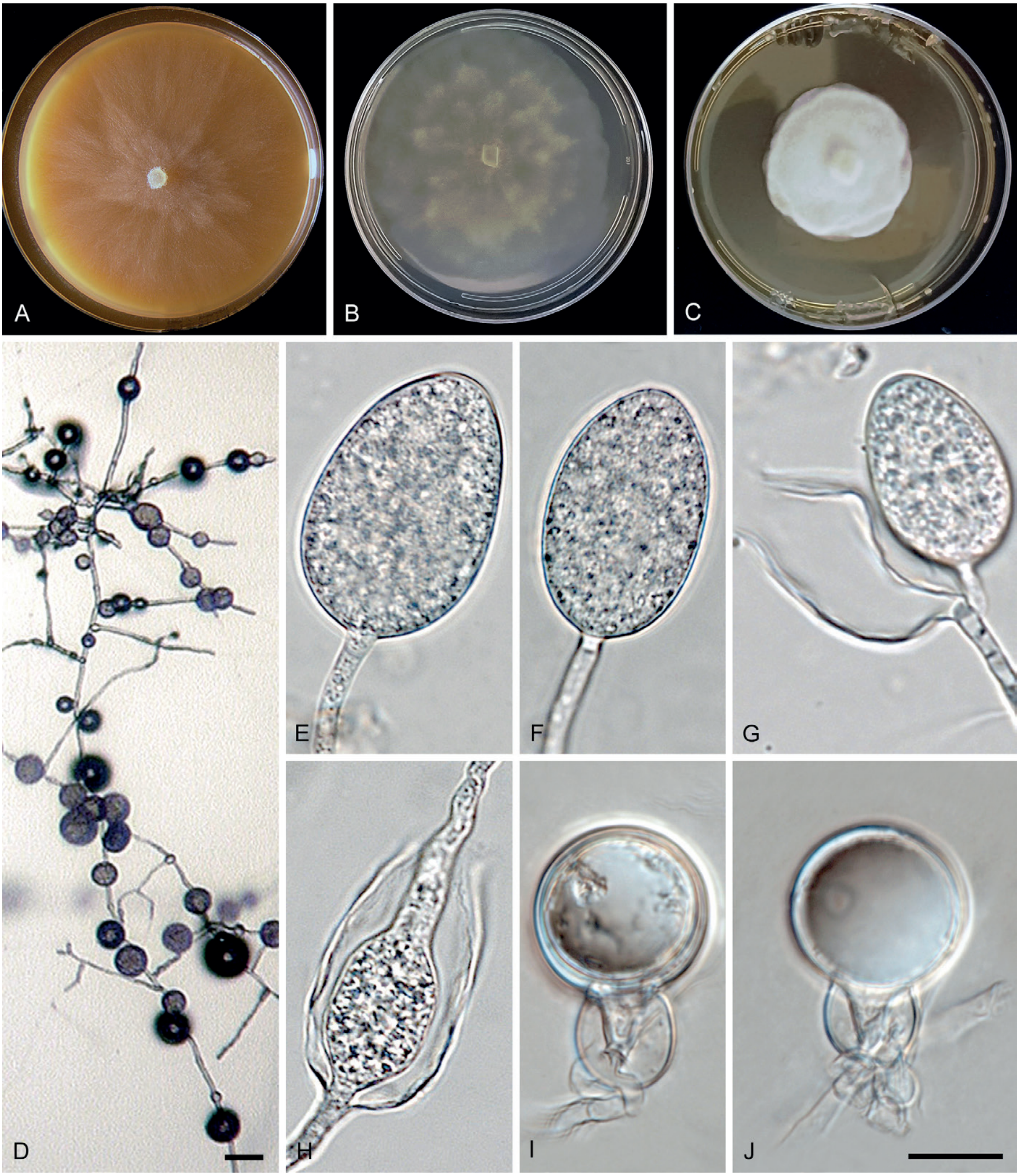

Fig. 12. *Phytophthora drechsleri* ex-epitype culture CBS 292.35 (A2). **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D.** Globose, catenulate and rosary shape hyphal swellings. **E–H.** Ovoid to ellipsoid persisted sporangia. **G.** Empty sporangium with external extended proliferation. **H.** Internal nested proliferation and direct germination. **I, J.** Globose oogonia with amphigynous antheridia. Scale bars = 20 µm; J applies to E–J.

middle or distorted; internal, external, and nested proliferation is observed. Sporangia produced in unbranched or simple sympodial *sporangiophores*. *Hyphal swellings* globose, subglobose, catenulate and clustered are common. *Chlamydospores* absent. *Sexual morph*: *Homothallic. Oogonia* with smooth wall, spherical (24–42 µm diam); *antheridia* predominantly amphigynous (10–18 × 12–16 µm), some with spine or digitate projections and aplerotic *oospores* (20–31 µm diam).

Culture characteristics: Colony morphology after 7 d on V8-A with no distinct pattern; on PDA and MEA with slight chrysanthemum pattern. Minimum growth temperature 6 °C, optimum 21 °C, and maximum 30 °C.

Notes: Type material of *P. erythroseptica* could not be traced in E (pers. comm. with Heleen Plaisier, herbarium RBGE). Therefore, illustrations provided in the protologue are chosen as lectotype

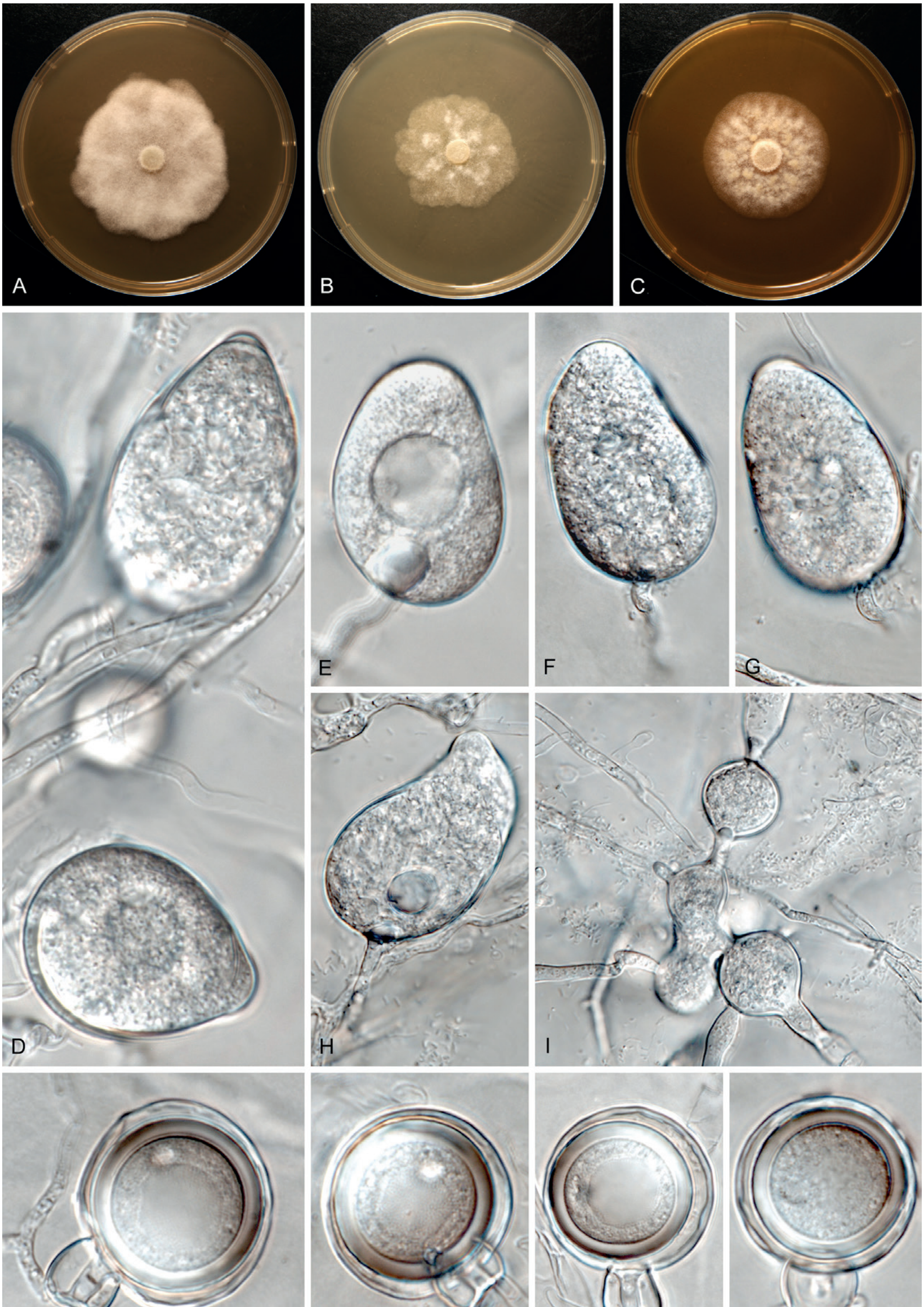

Fig. 13. *Phytophthora erythroseptica* ex-epitype culture CBS 148925. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D–H.** Nonpapillate, persistent, rounded bases sporangia originated in unbranched sporangiophores. **H.** Sporangium with distorted shape. **I.** Globose, subglobose and catenulate hyphal swellings. **J–M.** Gametangia showing typical smooth-walled oogonia, amphigynous antheridia and aplerotic oospores. Scale bar = 20 µm; J applies to D–M.

here. A specimen from the same host and country is designated as epitype to fix the application of this name.

Phytophthora fragariae Hickman, J. Pomol. Hortic. Sci. 18: 103. 1940. MycoBank MB 289688. Fig. 14.

Lectotype (designated here, MBT 10008010): **UK**, from roots and rootstocks of cultivated strawberries, figs. 9–10 in Hickman (1940: 97, 99), showing sporangia and oospore formation.
Epitype (designated here, MBT 10008011): **UK**, Scotland, collection date and collector unknown (CBS H-25070).
Ex-epitype cultures: CBS 309.62 Race 2 = NRRL 64315. Other strain S&T BL 213. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: HQ643231 (ITS); HQ708295 (*COI*). Other sequences provided in Table 2.
Ex-epitype genome sequenced strain: Phytophthora fragariae CBS 309.62. This Whole Genome Shutgun project has been deposited at GenBank under the accession Genome P.fr2.0 (genome size 75.98 Mbp; BioProjec PRJNA243070; BioSample SAMN02712365; Gao *et al.* 2015). Additonal information for the ex-epitype genome in Table 3.

Description: *Asexual morph*: *Sporangia* non-papillate; persistent; obpyriform, ovoid, ellipsoid (28–56 × 27–49 µm), often very markedly obpyriform in shape; with internal and nested proliferation and originated in unbranched or simple sympodial *sporangiophores*. *Hyphal swellings* coralloid, irregular shapes, globose, subglobose, some solitary, and others catenulate in chains. *Chlamydospores* absent. *Sexual morph*: *Homothallic*. *Oogonia* smooth-walled, originated in very short stalks; frequently globose (28–46 µm diam) with tapering base; *antheridia* amphigynous and some paragynous (16–30 × 12–22 µm); *oospores* plerotic and aplerotic, many showing a single globule and turning golden brown with age.

Culture characteristics: Colony morphology after 7 d on CMA, PDA, V8, with no distinct pattern. Minimum growth temperature 3 °C, optimum 18 °C, and maximum 27 °C.

Notes: Neither dried original specimens nor living ex-type strains could be located for *P. fragariae*. The two illustrations in the original paper are therefore designated as lectotype here. The epitype was selected based on the typical morphological characters of the specimen that fit to those presented for the isolate used in the original description of the species.

Strain CBS 209.46 = WPC P19539, isolated from *Fragaria ×ananassa*, in Cornwall, England is incorrectly cited as the type strain of *P. fragariae* in Yang *et al.* (2017), Yang & Hong (2018) and Jung *et al.* (2022a) [Chen *et al.* (2022)]. Hickman (1940) indicated that his newly described species was collected both in England and Scotland. Numerous isolates from different localities were made both before the species was formally described but probably also after. CBS 309.62 is from Scotland (no date given); it came into the CBS collection in 1962; while WPC P19539 is from Cornwall. For the latter one a date is given (1946) which postdates the protologue and therefore does not represent an ex-type.

Phytophthora gonapodyides (H.E. Petersen) Buisman, Meded. Phytopath. Lab. 'WCS' 11: 7. 1927. MycoBank MB 252402. Fig. 15.
Basionym: *Pythiomorpha gonapodyides* H.E. Petersen, Bot. Tidsskr. 29: 391. 1909. MycoBank MB 162746.

Lectotype (designated here, MBT 10008012): **Denmark**, from fallen, submerged fruits of *Malus domestica*, fig. VI in Petersen (1909: 391, https://www.biodiversitylibrary.org/page/5178796#page/403/mode/1up) showing sporangia formation.
Epitype (designated here, MBT 10008013): UK, England, collected from lake water, unknown collection date and collector (CBS H-25071).
Ex-epitype cultures: CBS 554.67 = NRRL 64034. Other strain S&T BL 214. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: HQ643233 (ITS); HQ708297 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* non-papillate; persistent; ellipsoid, ovoid, or distorted shapes with tapered base (36–71 × 21–32 µm) showing internal extended and nested proliferation and produced in unbranched *sporangiophores*. *Hyphal swellings* globose, sub globose, and elongate produced solitary or catenulate in chains. *Chlamydospores* absent. *Sexual morph*: Sterile. *Sporangia* and *hyphal swellings* are produced under water cultures.

Culture characteristics: Colony morphology after 7 d on PDA, V8-A, and MEA with rosette pattern. Minimum growth temperature 3 °C, optimum 24–27 °C, and maximum 30 °C.

Notes: According to Taxonomic Literature II (TL-2, https://www.sil.si.edu/DigitalCollections/tl-2/browse.cfm?vol=4#page/210) type material of Petersen is preserved at the University of Copenhagen, but none of the specimens mentioned in the original description of *Pythiomorpha gonapodyides* could be located there (pers. comm. with Christian Lange). Therefore, one of the original illustrations is selected here as lectotype. The epitype was selected based on the typical morphological characters of the specimen that fit to those presented for the isolate used in the original description of the species.

Phytophthora hibernalis Carne, J. Roy. Soc. W. Australia 12: 36. 1925. MycoBank MB 267110. Fig. 16.

Lectotype (designated here, MBT 10008014): Australia, on fruits, leaves and smaller branches of *Citrus* ssp., plate IV in Carne (1925, https://www.biodiversitylibrary.org/item/201421#page/77/mode/1up).
Epitype (designated here, MBT 10008015): Australia (WA), Pinjarra, on citrus (*Citrus sinensis*), unknown collection date and collector, isolated by R.F. Dorpel in 1958 (IMI 134760).
Ex-epitype cultures: CBS 114104 = NRRL 64317. Other strain S&T BL 41G. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: MG865506 (ITS), MH136900 (*COI*). Other sequences provided in Table 2.
Ex-epitype genome sequenced strain: *Phytophthora hibernalis* CBS 114104. This Whole Genome Shutgun project has been deposited at GenBank under the accession Genome USDA_Phib_BL41_1.0 reference (genome size 84.51 Mbp; BioProjec PRJNA605765; BioSample SAMN14078571; Srivastava *et al.* 2022). Additional information for the ex-epitype genome in Table 3.

Description: *Asexual morph*: *Sporangia* semi-papillate and non-papillate; caducous with medium to long pedicels (18–74 µm long); elongate, ellipsoid, ovoid, or obovoid (21–44 × 13–22 µm); produced in unbranched or in lax sympodial branching, or occasionally in umbellate *sporangiophores*. *Hyphal swellings* absent. *Chlamydospores* absent. *Sexual morph*: *Homothallic*. *Oogonia* smooth-walled (24–36 µm diam); *antheridia* predominantly paragynous, often intercalary, some with multiple radiating hyphae or spines; *oospores* plerotic with thick wall (22–30 µm diam).

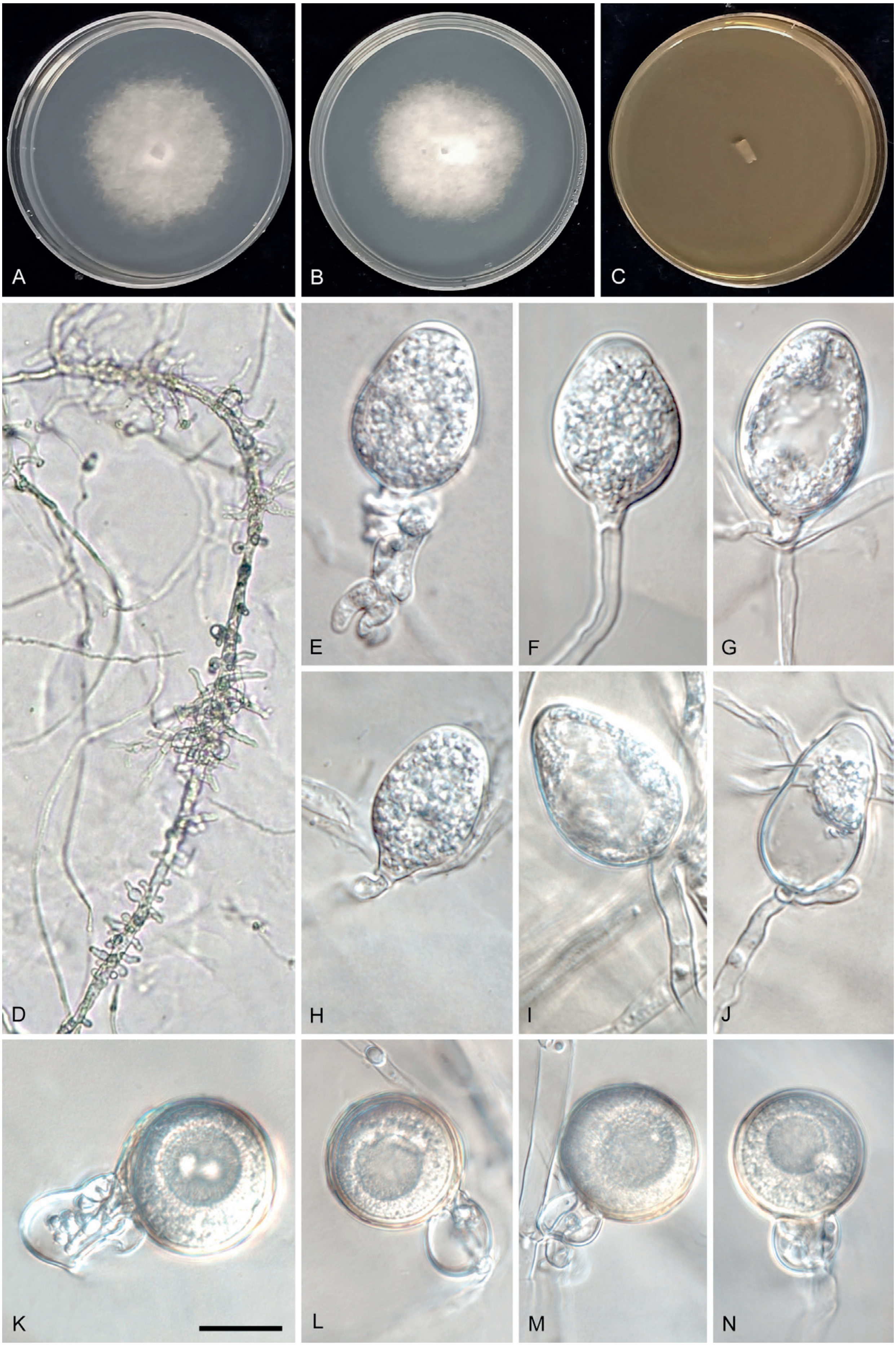

Fig. 14. *Phytophthora fragariae* ex-epitype culture CBS 309.62. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D.** Mycelium with hairy and coralloid hyphal swellings. **E–J.** Ovoid to ellipsoid, nonpapillate and persistent sporangia. **J.** Empty sporangium with external proliferation from the base. **K–N.** Smooth-walled golden brown oogonia with amphigynous antheridia, plerotic oospores and big ooplasts. Scale bar = 20 µm; K applies to D–N.

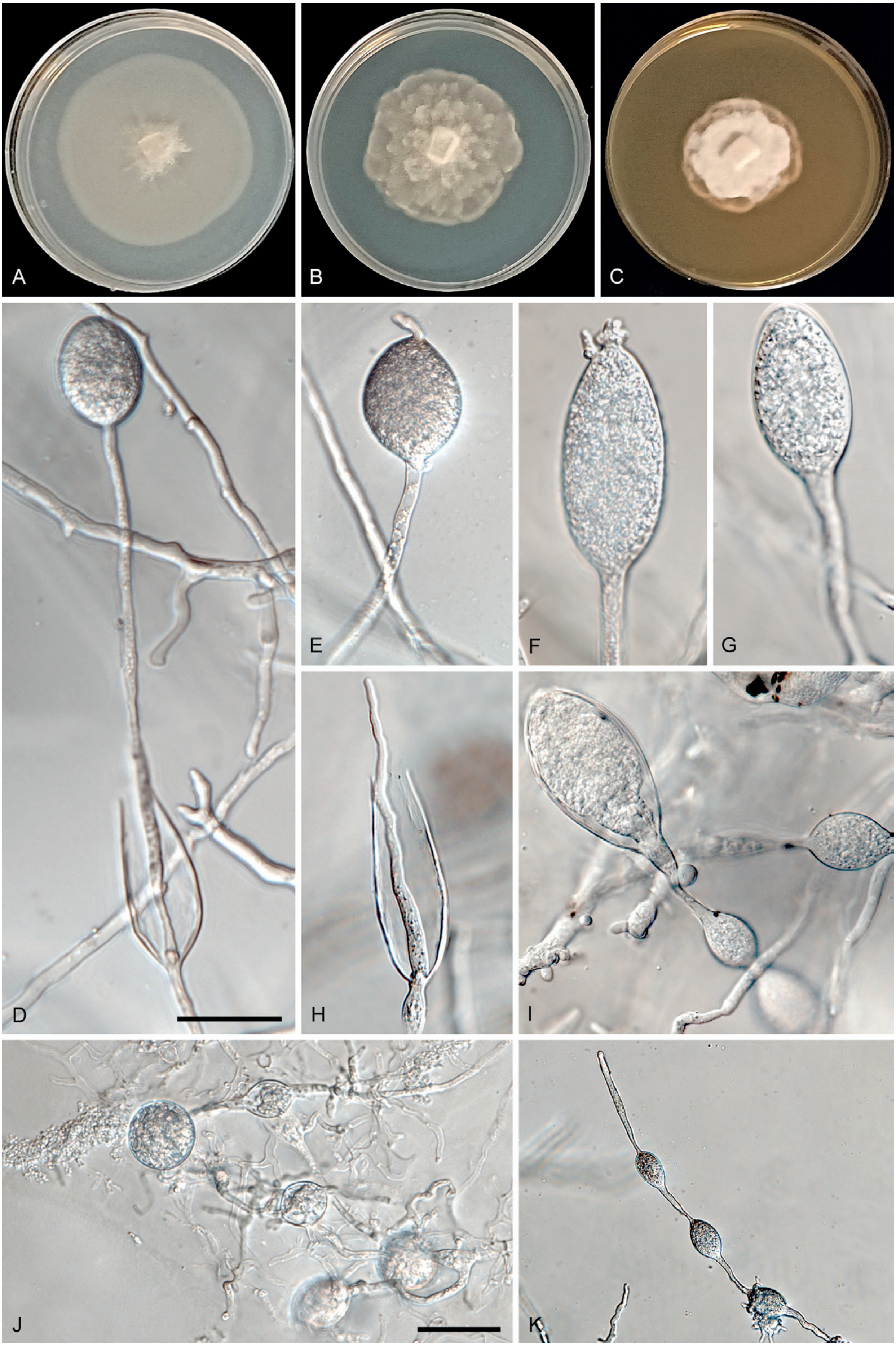

Fig. 15. *Phytophthora gonapodyides* ex-epitype culture CBS 554.67. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D–H.** Ellipsoid to elongated sporangia, nonpapillate, persistent originated in unbranched sporangiophores. **D, H.** Internal extended sporangial proliferation. **E.** Sporangium germinating directly with hyphae. **I.** Sporangium on a sporangiophore with hyphal swellings. **J, K.** Globose and irregular hyphal swellings. Scale bars = 20 µm; D applies to D–I; J applies to J, K.

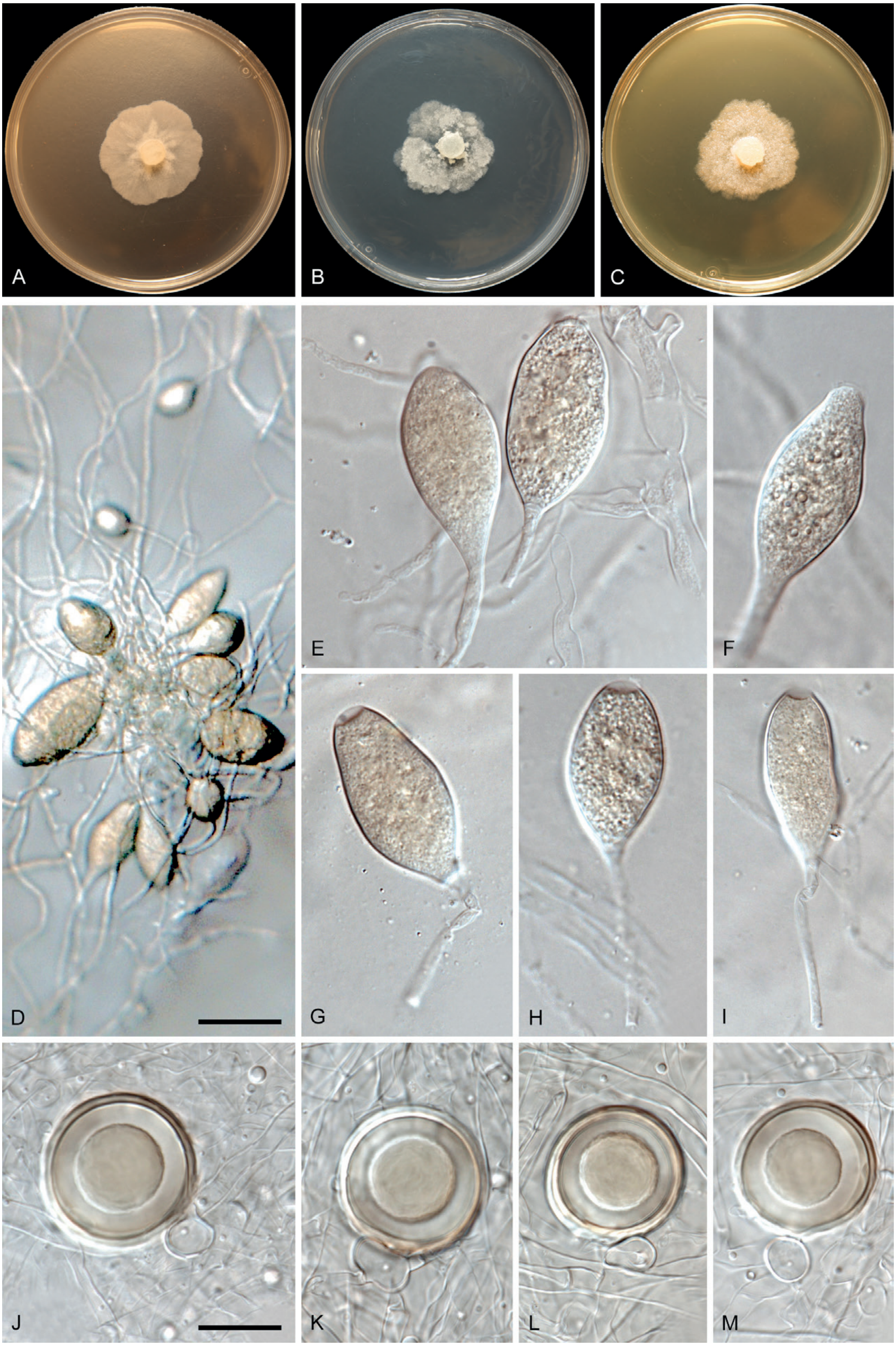

Fig. 16. *Phytophthora hibernalis* ex-epitype culture CBS 114104 (IMI 134760). **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D.** Sporangia originated in lax sympodial branching sporangiophores. **E–I.** Semipapillate caducous sporangia with medium to long pedicels. **J–M.** Oogonia with thick-walled, plerotic oospores and paragynous antheridia. Scale bars = 20 µm; E applies to E–I; J applies to J–M.

Culture characteristics: Colony morphology on V8-A, PDA, and MEA with no distinct pattern. Minimum growth temperature 6 °C, optimum 15–21 °C, and maximum 25 °C.

Notes: Type material of *P. hibernalis*, described on *Citrus sinensis* from Western Australia is not preserved in any of the Australian fungaria. One of the original illustrations is therefore chosen here as lectotype. In addition, a specimen from the same substrate and geographical origin is designated as epitype to fix the application of this name.

Carne (1926) described that *P. hibernalis* produces amphigynous antheridia, rarely paragynous (p. 36). However, figures in plate III show antheridia predominantly paragynous. The production of paragynous antheridia is one of the characteristics of the ex-epitype culture CBS 114104 (Fig. 16J–M).

Phytophthora ilicis Buddenh. & Roy A. Young, Phytopathology 47: 100. 1957. MycoBank MB 303620. Fig. 17.

Lectotype (designated here, MBT 10008016): **USA**, Oregon and Washington, from leaves and stems of *Ilex aquifolium*, fig. 3B (sporangium in the middle) and fig. 3C in Buddenhagen & Young (1957: 99, https://archive.org/details/sim_phytopathology_1957-02_47_2/page/98/mode/2up).
Epitype (designated here, MBT 10008017): **Canada**, British Columbia, from leaves and stems of holly (*Ilex* sp.), 1954, unknown collector (CBS H-25072).
Ex-epitype cultures: CBS 149896 = NRRL 64374. Other strain S&T BL 39. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: MG865511 (ITS), MH136905 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* semi-papillate; caducous with medium to long pedicels (5–25 µm); ovoid, obpyriform (25–45 × 15–28 µm); originated in unbranched or in simple sympodial *sporangiophores*. *Hyphal swellings* globose, subglobose produced individually or catenulated, also occasionally produced in sporangiophores. *Chlamydospores* rare. *Sexual morph*: *Homothallic. Oogonia* smooth-walled (25–35 µm diam), sometimes presenting tapered bases; *antheridia* amphigynous showing different shapes from short round to elongate; *oospores* plerotic and slightly aplerotic.

Culture characteristics: Colony morphology in V8-A and PDA with light stellate pattern, in MEA with slow growth. The minimum temperature for growth is 5 °C, optimum 20 °C, and maximum 25 °C. Conditions for growth and sporulation: Sporangia produced after mats growing in pea broth are transferred to water cultures and incubated for 5 d at 20 °C.

Notes: *Phytophthora ilicis* was introduced by Buddenhagen & Young (1957) for a serious leaf and twig disease of English holly in Oregon and Washington, USA. Original specimens could not be located. Therefore, the original illustrations are selected as lectotype here. A collection from the same host genus and continent for which a living culture and sequence data are available is designated as epitype. In contrast with the original description, *P. ilicis* produces hyphal swellings.

Phytophthora inundata Brasier, Sánch. Hern. & S.A. Kirk, Mycol. Res. 107(4): 481. 2003. MycoBank MB 373599. Fig. 18.

Holotype: A slide of oogonia and antheridia derived from paired isolates (IMI 389751 and IMI 390121) from roots of *Olea* sp. and *Salix matsudana* originating from Spain and UK (IMI 390141).
Epitype (designated here, MBT 10008018): UK, Kent, Bexley, from roots of *Salix matsudana*, 1976, C.M. Brasier & R.G. Strouts (IMI 389751, an A2 sexual compatibility type).
Ex-epitype cultures: CBS 216.85 = NRRL 64162 = CABI IMI 389751. Other strain S&T BL 20. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: MG865516 (ITS); MH136910 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* non-papillate, persistent, ovoid, obpyriform (30–68 × 20–52 µm) sometimes with tapered bases, showing internal extended and nested proliferations, originated in unbranched or simple sympodial *sporangiophores*, sometimes with swellings in sporangiophore. *Hyphal swellings* globose, subglobose, irregular, individual or catenulated and many times with radiating hyphae. *Chlamydospores* absent. *Sexual morph*: *Heterothallic/Sterile. Oogonia* smooth-walled, subspherical (35–43 µm), antheridia predominantly amphigynous, *oospores* aplerotic thick-walled, often yellowish. [Sexual morph in Brasier *et al.* (2003), pages 480–481, figs 9–12 on page 481].

Culture characteristics: Colony morphology on V8-A with no distinctive pattern, on PDA and MEA with light chrysanthemum pattern. Minimum growth temperature 3 °C, maximum 36 °C, and optimum 27–30 °C.

Notes: Brasier *et al.* (2003) designated a single specimen as the holotype, namely, a single slide (with its own unique IMI number) with material taken from a culture from two crossed strains of the species (parent strains). One of the parent strains is here designated as epitype.

Phytophthora meadii McRae, J. Bombay Nat. Hist. Soc. 25: 760. 1918. MycoBank MB 120866. Fig. 19.

Neotype (designated here, MBT 10008019): **India**, Kerala State, Palapilly Region, Trichur District, Vaniampara rubber estate, Travancore, collected from rubber (*Hevea brasiliensis*), 2001, unknown collector (CBS H-25073).
Ex-neotype cultures: CBS 148927 = NRRL 64146. Other strain S&T BL 81. Other duplicates of the ex-neotype in Table 2. Barcode sequences for ex-neotype GenBank: MG865529 (ITS), MH136924 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* papillate to semi-papillate, sometimes bipapillate; caducous with medium to long pedicels (6–20 µm long); ovoid, ellipsoid, elongate, obpyriform, globose, irregular forms (17–44 × 15–29 µm); originated in sympodial branched *sporangiophores. Hyphal swellings* small, globose to elongate, irregular, produced also in sporangiophores. *Chlamydospores* intercalar and terminal rarely produced. *Sexual morph*: *Heterothallic. Oogonia* smooth-walled; *antheridia* amphigynous, some with cylindrical shapes; *oospores* slightly aplerotic to plerotic.

Culture characteristics: Colony morphology after 7 d of growth on PDA and V8-A with stellate pattern, on MEA with light stellate pattern. Minimum temperature for growth is 6 °C, optimum 25–30 °C, and maximum 32 °C. *Phytophthora meadii* produces abundant sporangia and zoospores in V8-A flooded with 10 % soil solution.

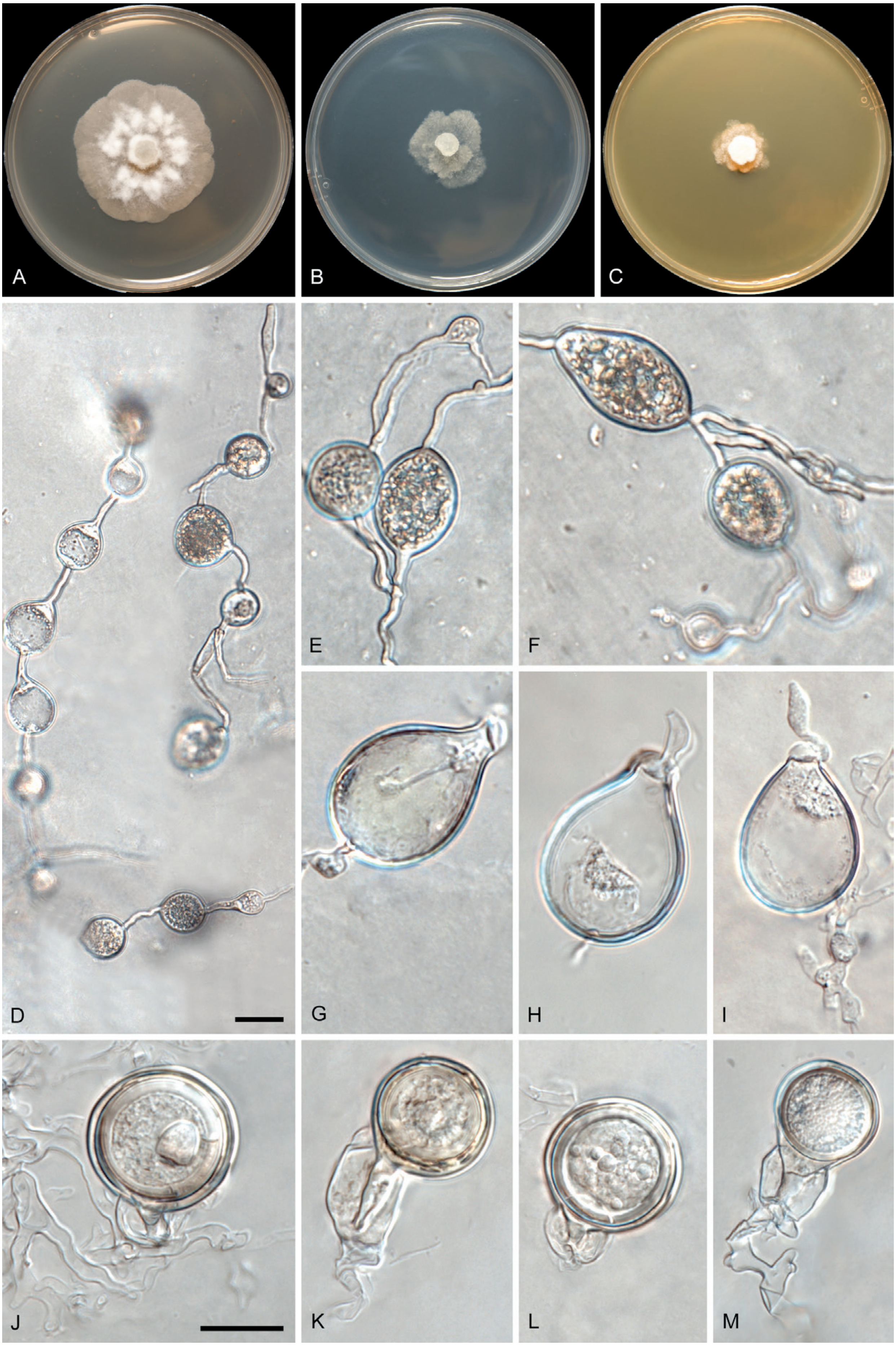

Fig. 17. *Phytophthora ilicis* ex-epitype culture NRRL 64374. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D–F.** Globose to sub-globose hyphal swellings. **G–I.** Semipapillate ovoid empty sporangia with short pedicels. **J–M.** Oogonia with amphigynous antheridia. **J.** Thick-walled plerotic oospore with a lipid globule. **K.** Smooth-walled oogonium with a plerotic oospore and a long unicellular amphigynous antheridium. Scale bars = 20 µm; J applies to E–M.

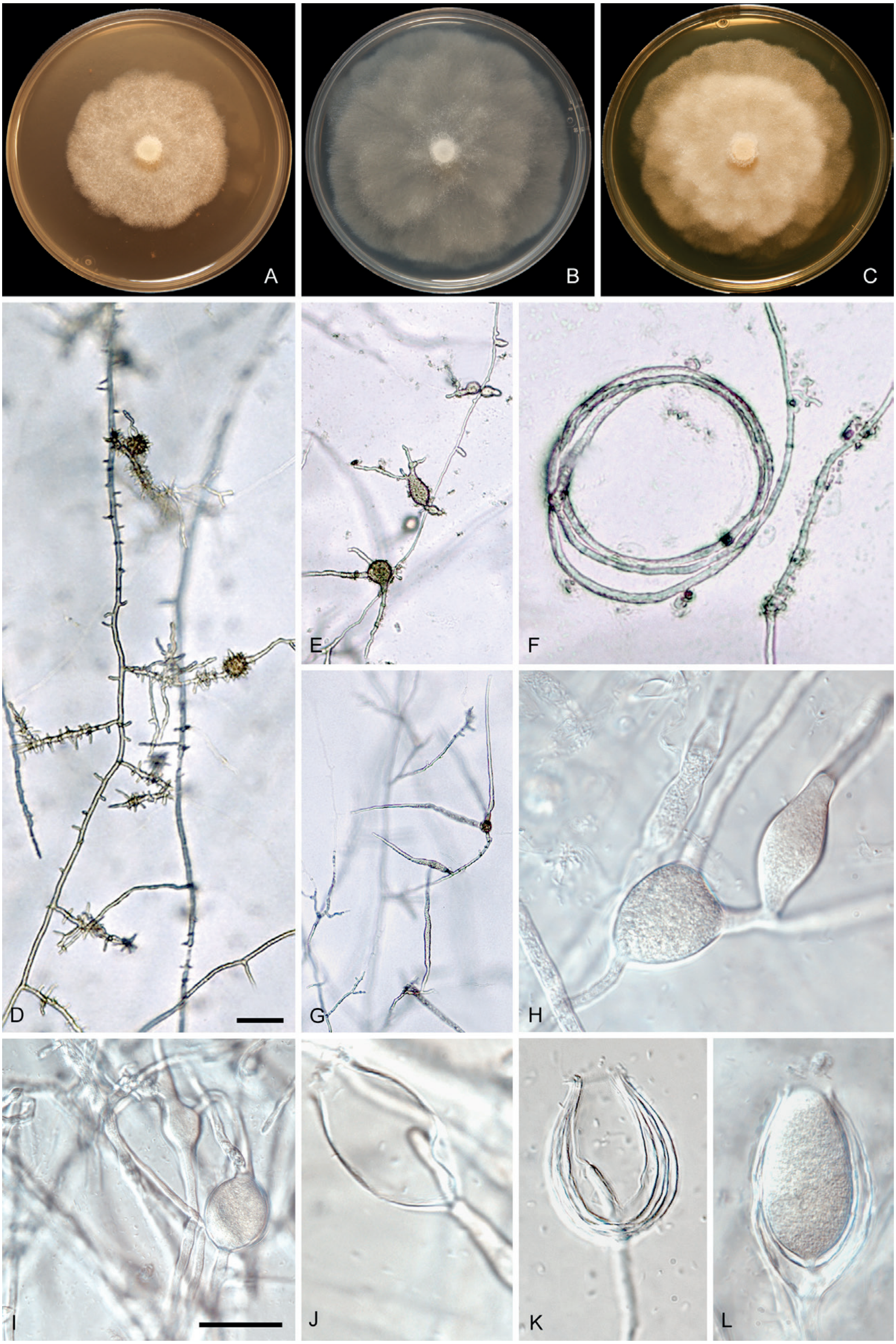

Fig 18. *Phytophthora inundata* ex-epitype culture CBS 216.85 (IMI 389751). **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D, E, G–I.** Globose to subglobose and irregular hyphal swellings. **F.** Typical coiled hyphae. **J–L.** Sporangia originated in unbranched sporangiophores. **H, I.** Internal nested sporangial proliferation. Scale bars = 20 µm; D applies to D, E, G; I applies to F, H–L.

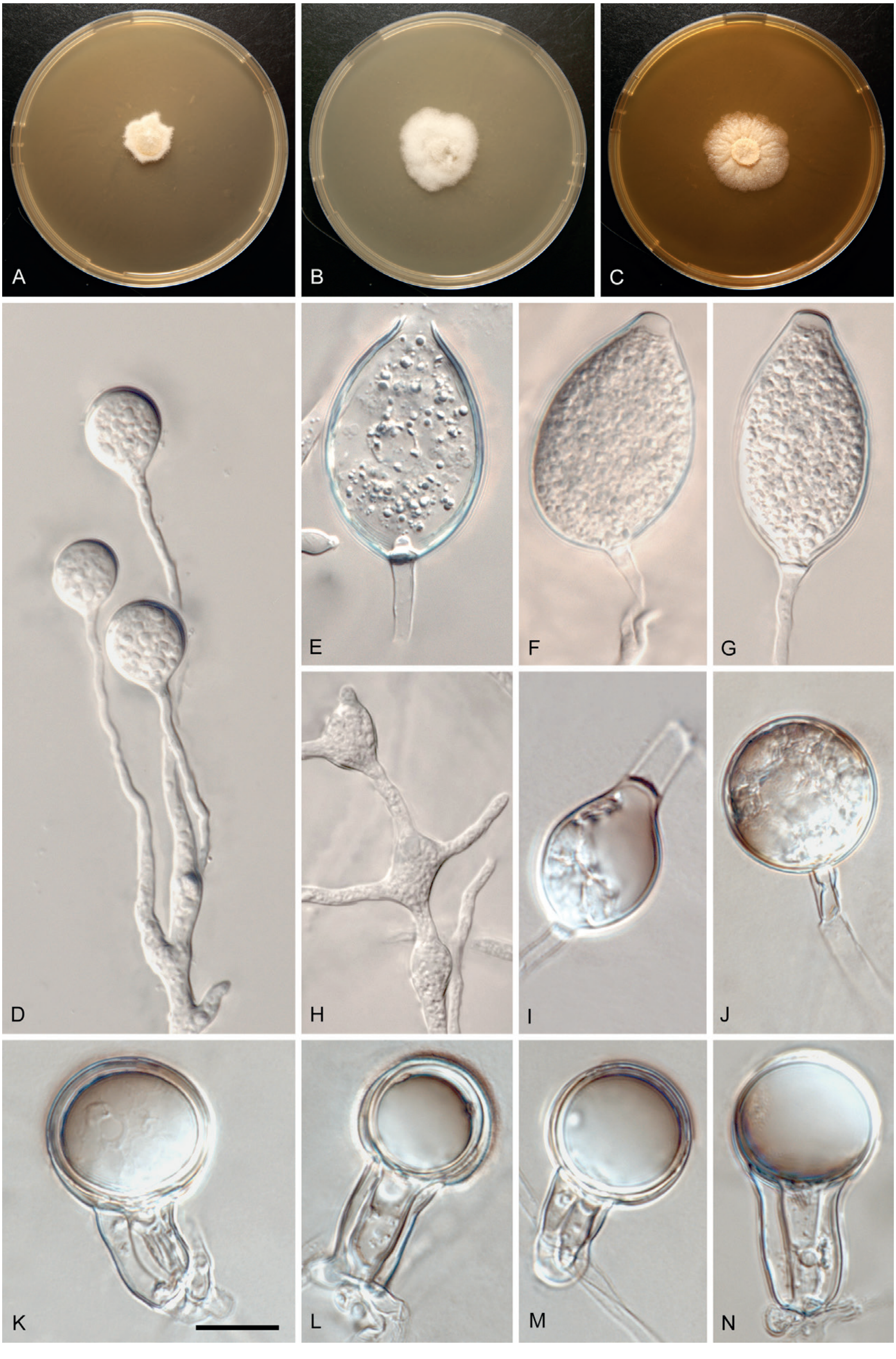

Fig. 19. *Phytophthora meadii* ex-neotype culture CBS 148927. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D.** New forming sporangia in a sympodium sporangiophore. **E–G.** Ovoid to limoniform papillate sporangia. **E.** Caducous sporangium with medium pedicel. **H.** Irregular hyphal swellings. **I.** Intercalar hyphal swelling. **J.** Terminal chlamydospore. **K–N.** Smooth-walled oogonia with plerotic oospores and elongated amphigynous antheridia. Scale bar = 20 μm; K applies to K–N.

Notes: McRae first described *Phytophthora meadii* in J. Bombay Nat. Hist. Soc. 25: 760 (1918a; https://www.biodiversitylibrary.org/item/28019#page/914/mode/1up). This publication is labelled to be published on the 2 Jan. 1918 and does not contain line drawings. Later that year, McRae (1918b) gave a more detailed description of the species including illustrations (Plate II figs 1–25, line drawings of asexual morph; Plate III figs 1–19, line drawings of sexual morph). The illustrations in the later paper are however not part of the original material and can therefore not serve as lectotype. Original specimens of *P. meadii* could not be traced. Therefore, a neotype is designated here from the same substrate and origin.

Phytophthora megasperma Drechsler, J. Wash. Acad. Sci. 21: 524. 1931. MycoBank MB 270758. Fig. 20.

Lectotype (designated here, MBT 10008020): **USA**, isolated from *Althaea rosea*, figs. 4 (https://www.biodiversitylibrary.org/page/39914915#page/615/mode/1up) & 5 (https://www.biodiversitylibrary.org/page/39914915#page/617/mode/1up) in Drechsler (1931: 521, 523).
Epitype (designated here, MBT 10008021): **USA**, isolated from *Althaea rosea* by Drechsler in 1949, unknown collection date and collector (IMI 032035).
Ex-epitype cultures: CBS 402.72 = ATCC 58817 (MCI). Other strain S&T BL 43. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: MG865535 (ITS), MH136930 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* non-papillate, persistent, elongated, ellipsoid, obpyriform, or distorted shapes (48–99 × 29–46 μm), some with tapered base; with external and internal in extended and nested proliferation, originated in unbranched *sporangiophores. Hyphal swellings* globose, subglobose to elongated with radiating hyphae. *Chlamydospores* absent. *Sexual morph*: *Homothallic. Oogonia* spherical (16–61 μm diam); *antheridia* spherical or ellipsoid (14–20 × 10–18 μm), predominantly paragynous; *oospores* aplerotic (11–54 μm).

Culture characteristics: Colony morphology after 7 d of growth on PDA, V8-A, and MEA with no distinct pattern. Minimum growth temperature 3 °C; optimum 18 °C, and maximum 27 °C.

Notes: *Phytophthora megasperma* was described by Drechsler (1931) as causing a destructive decay of stems and roots of *Althea rosea* in Washington D.C. and at Rosslyn, Virginia, USA. Original specimens could not be located. Therefore, two of the original illustrations are selected as lectotype here. In addition, a specimen from the same host and country for which living cultures and sequences data are available is designated as epitype.

Phytophthora mexicana Hotson & Hartge, Phytopathology 13: 520. 1923. MycoBank MB 253321. Fig. 21.
Synonym: *Phytophthora hydrophila* Curzi, Riv. Patol. Veg. 17: 11. 1927. MycoBank MB 267501.

Lectotype (designated here, MBT 10008022): **Mexico**, on fruit of *Lycopersicon esculentum*, plates XXII & XXIII in Hotson & Hartge (1923).
Epitype (designated here, MBT 10008023): **USA**, Texas High Plains (NW Texas), from Chile Pepper 'latigo' (*Capsicum annuum* var. 'latigo'), A2, 2007, R. French (CBS H-25074).
Ex-epitype culture: CBS 149405. Other strain S&T BL 199. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: OP020178 (ITS), OP728146 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* semi-papillate and papillate; ellipsoid, ovoid, globose, irregular shape (16–33 × 16–77 μm), some with tapered bases, caducous with long, medium, and short pedicels; originated individual, two, three, and simple sympodial *sporangiophores. Hyphal swellings* knobby and irregular. *Chlamydospores* globose, terminal, intercalar. *Sexual morph*: *Homothallic/Heterothallic*. *Oogonia* terminal, smooth-walled (24–37 μm) or with slight wavy wall; *antheridia* amphigynous short; *oospores* aplerotic some showing big ooplast.

Culture characteristics: Colony morphology after 7 d of growth on V8-A and MEA with no distinct pattern and in PDA with radiate pattern. Optimum growth temperature 24–27 °C, and maximum 32 °C.

Notes: Original material of *Phytophthora mexicana* described by Hotson & Hartge (1923) on *Lycopersicon esculentum* from Mexico could not be traced. The plates provided in the protologue are therefore designated as lectotype here with a specimen from Texas, USA, as supporting epitype. The epitype fits the morphology of the asexual morph well. Although Hotson & Hartge (1923) did not indicate the production of caducous sporangiophores, this condition for the species is clearly shown in plate XXII fig. 7 and plate XXIII fig. 17 where sporangia with medium pedicel are observed.

Phytophthora nicotianae Breda de Haan, Meded. Lands Plantentuin, Batavia 15: 57. 1896. MycoBank MB 194443. Fig. 22
Synonyms: *Phytophthora parasitica* var. *nicotianae* (Breda de Haan) Tucker, Res. Bull. Missouri Agric. Exp. Sta. 153: 173. 1931. MycoBank MB 253828.
Phloeophthora nicotianae (Breda de Haan) G.W. Wilson, Mycologia 6 (2): 80. 1914. MycoBank MB 246601.
Nozemia nicotianae (Breda de Haan) Pethybr., Sci. Proc. Roy. Dublin Soc. 13: 557. 1913. MycoBank MB 627064.
Phytophthora melongenae Sawada, Special Rep. Agric. Exp. Stat. (Taiwan) 11: 77. 1915. MycoBank MB 232247.
Phytophthora parasitica Dastur, Mem. Dept. Agric. India 5 (4): 177. 1913. MycoBank MB 194284.
Phytophthora nicotianae var. *parasitica* (Dastur) G.M. Waterh., Mycolog. Pap. 92: 14. 1963. MycoBank MB 353741.
Phytophthora parasitica var. *rhei* G.H. Godfrey, J. Agric. Res. 23: 21. 1923. MycoBank MB 273614.
Phytophthora tabaci Sawada, Rep. Dept. Agric. Gov. Res. Inst. Formosa 27: 35. 1927. MycoBank MB 279692.
Phytophthora terrestris Sherb., Phytopathology 7: 127. 1917. MycoBank MB 194200.
Blepharospora terrestris (Sherb.) Peyronel, Atti Accad. Naz. Lincei 29: 194. 1920. MycoBank MB 280038.

Lectotype (designated here, MBT 10008024): **Indonesia**, Sumatra, Java, Pl. 1, fig. 6 in Breda de Haan (1896).
Epitype (designated here, MBT 10008025): Indonesia, Sulawesi Utara, Tinoor, from stem lesion of orchid *Gramatophyllum* sp., 1989, M.D. Coffey (CBS H-25075, dried culture).
Ex-epitype cultures: CBS 149823 = NRRL 64371. Other strain S&T BL 162. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: JN699566 (ITS), MH477752(*COI*). Other sequences provided in Table 2.

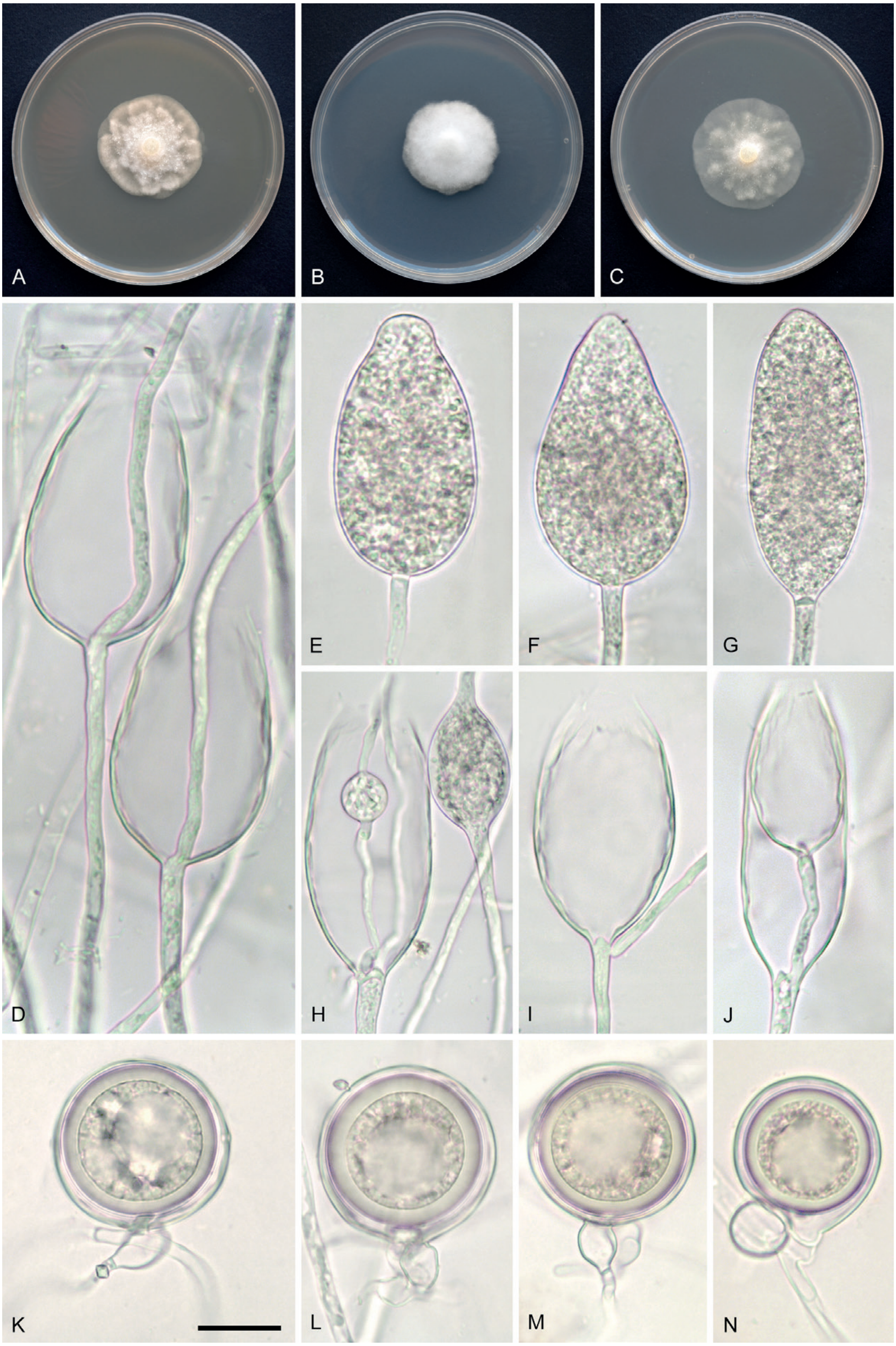

Fig. 20. *Phytophthora megasperma* ex-epitype culture CBS 402.72 (IMI 32035). **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D.** Empty sporangia with internal extended proliferations. **E–G.** Ovoid to elongated persistent sporangia. **H.** Sporangium with internal extended proliferations and, on the right side, an intercalary hyphal swelling. **I.** External proliferation from the sporangium base. **J.** Internal nested sporangial proliferation. **K–N**. Oogonia with slightly aplerotic and thick-walled oospores and paragynous antheridia. Scale bar = 20 µm; K applies to D–N.

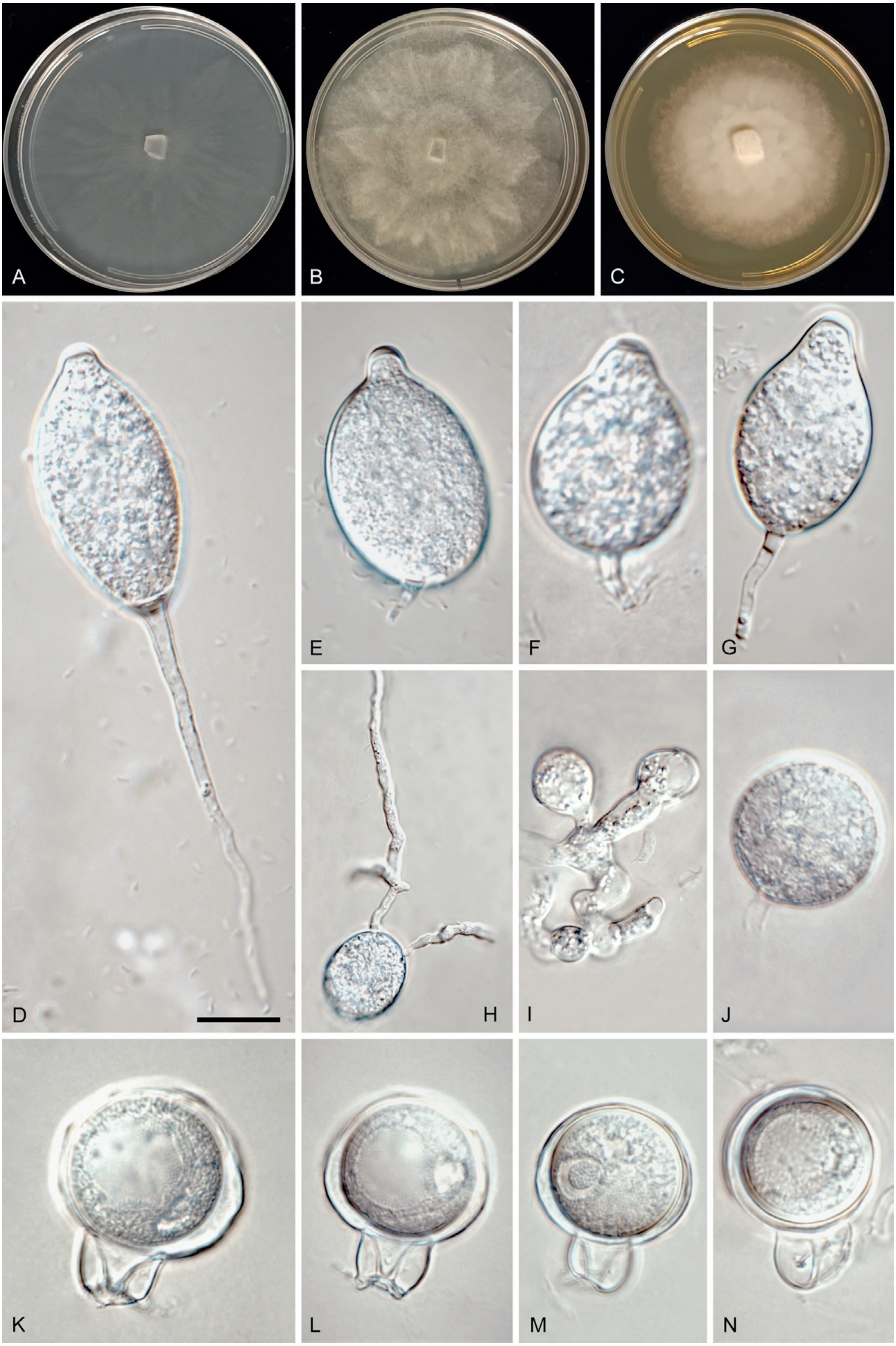

Fig. 21. *Phytophthora mexicana* ex-epitype culture CBS 149405. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D–G.** Ovoid to limoniform papillate and caducous sporangia. **D.** Long pedicel. **E, F.** Short pedicels. **G.** Medium pedicel. **H, I.** Knobby irregular hyphal swellings. **J.** Terminal globose chlamydospore. **K–N.** Globose to slightly wavy oogonia with aplerotic oospores and short amphigynous antheridia. Scale bar = 20 µm; D applies to D–N.

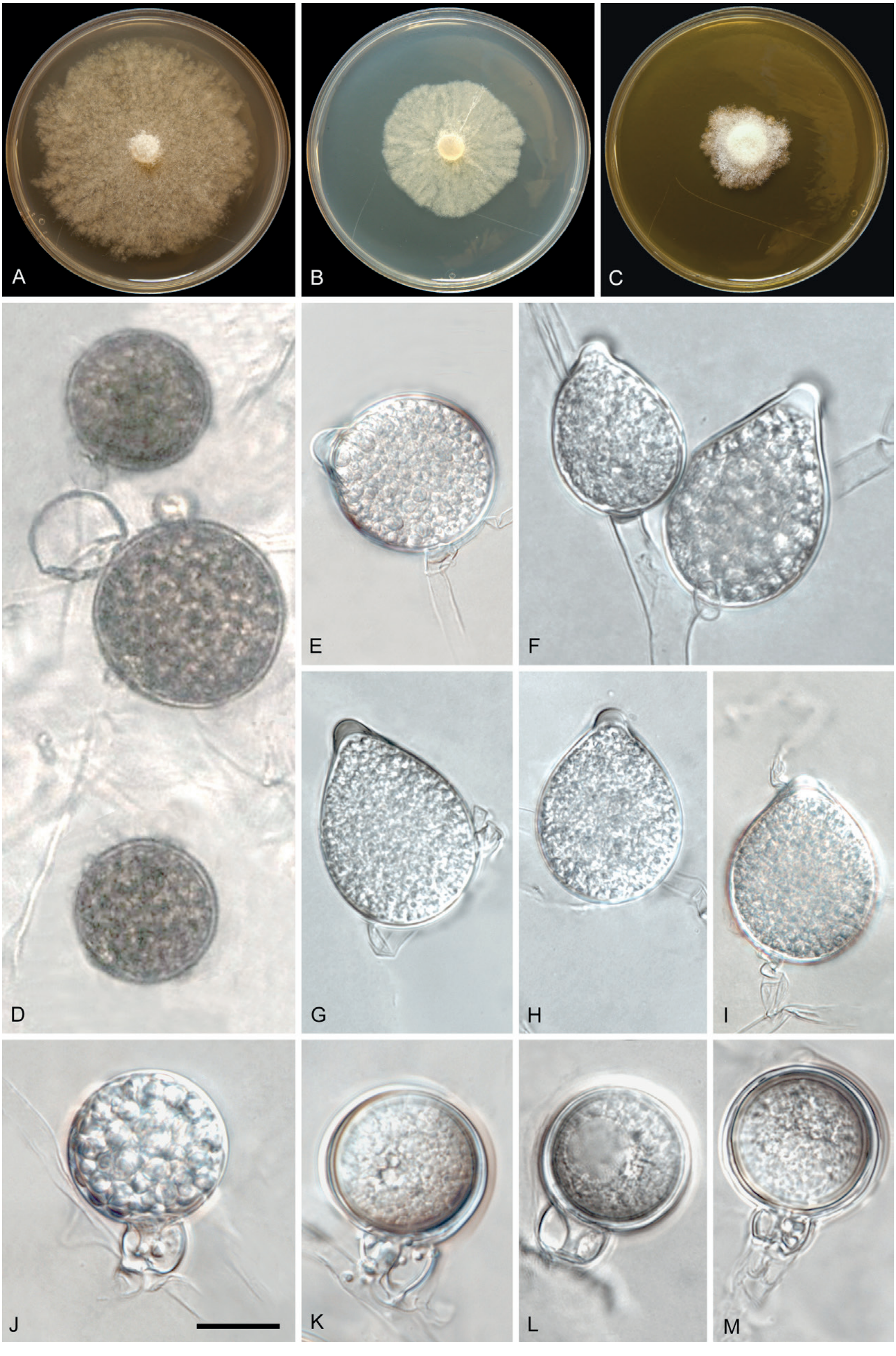

Fig. 22. *Phytophthora nicotianae* ex-epitype culture NRRL 64371. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D.** Globose chlamydospores. **E–I.** Globose to ovoid papillate sporangia. **E.** Lateral attached sporangium. **H.** Intercalary sporangium. **J–M.** Smooth-walled oogonia with oospores and amphigynous antheridia. **J.** Aborted oogonium. **L.** A slightly aplerotic oospore containing a lipid globule. Scale bar = 20 µm; J applies to D–M.

Ex-epitype genome sequenced strain: *Phytophthora nicotianae* CBS 149823. This Whole Genome Shutgun project has been deposited at GenBank under the accession Genome (genome size 106.7 Mbp; BioProjec PRJNA605765; BioSample SAMN14078572; Srivastava *et al.* 2022). Additonal information for the ex-neotype genome in Table 3.

Description: *Asexual morph*: *Sporangia* papillate, persistent and caducous with short pedicels (1–4 µm), ovoid, globose, obovoid, obpyriform, and with irregular shapes (15–64 × 11–47 µm), some sporangia with elongated necks and tapered bases; sporangia originated in simple sympodial *sporangiophores*. *Hyphal swellings* globose, subglobose, intercalary, many times with radiating hyphae. *Chlamydospores* globose (15–43 µm), lateral, terminal, intercalary. *Sexual morph*: *Heterothallic. Oogonia* smooth-walled (24–32 µm diam); antheridia amphyginous (9–21 × 10–15 µm); *oospores* predominantly aplerotic or slightly aplerotic (19–27 µm diam).

Culture characteristics: Colony morphology on V8-A and PDA with no distinct pattern with coralloid edges, and MEA with slow growth. Minimum growth temperature 9 °C, optimum 24 °C, maximum 33 °C.

Notes: Breda de Haan (1896) only provided a very brief description of P. nicotianae without clearly indicating a holotype or mentioning a living culture. Ho & Jong (1989) gave an overview on the taxonomic and nomenclatural history of this species and stated that no holotype is preserved. They further discussed that only one of the original illustrations clearly belongs to *P. nicotianae* ("The paragynous antheridia as described and figured by him [= Breda de Haan] indeed pertain to *P. nicotianae*".) while the other illustration showing the oospores represents probably a species of *Pythium*. Hall (1993) incorrectly designated a specimen from IMI (IMI 335174) as neotype of *P. nicotianae*. However, since an illustration is available as part of the original material, it must be selected as lectotype, which is done here. In addition, a representative strain is chosen of which a dried culture is designated as epitype to fix the application of this name.

Phytophthora palmivora (E.J. Butler) E.J. Butler, Sci. Rep. Agric. Res. Inst. Pusa 1918–1919: 82. 1919. MycoBank MB 194605. Fig. 23.
Basionym: *Pythium palmivorum* E.J. Butler, Mem. Dept. Agric. India 1 (5): 82. 1907. MycoBank MB 170467.

Representative strain: *India*, from fruit of areca (*Areca catechu*) isolated by S. Kanara, in 1956, no. N 90, collection date and collector unknown, (A2) IMI 348384. Living cultures: CBS 305.62 (A2) = NRRL 64372. Other strain S&T BL 105. Other duplicates of the representative strain in Table 2. Barcode sequences for representative strain GenBank: MG865559 (ITS), MH136949 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* papillate; caducous with short pedicel; globose, ovoid, obpyriform, ellipsoid, and irregular shapes (27–70 × 21–46 µm) originated in simple sympodial *sporangiophores*. *Hyphal swellings* globose, subglobose, elongate, and irregular shapes. *Chlamydospores* globose or subglobose (16–50 × 16–45 µm), terminal or intercalary. *Sexual morph*: *Heterothallic. Oogonia* smooth-walled (28–42 µm diam); *antheridia* spherical, short cylindrical or ellipsoid (12–21 × 13–17 µm), sometimes with spine or digitate projections; *oospores* plerotic to slightly aplerotic (27–40 µm diam).

Culture characteristics: Colonies on V8-A agar, PDA, and MEA with no distinctive pattern. Some colonies with slight chrysanthemum pattern (*i.e.*, isolate CPHST-BL 46). Minimum growth temperature 9 °C, optimum 24–30 °C, maximum 33 °C. Chlamydospores are abundantly produced in agar and water cultures.

Notes: Butler (1906) reported the disease in Madras, Southeast India, affecting three species of palms, palmyra (*Borassus flabellifer*), coconut (*Cocos nucifera*) and areca (*Areca catechu*). In 1907, Butler illustrated (https://www.byterfly.eu/islandora/object/librib:612756#page/174/mode/2up) and named the fungus *Pythium palmivora* reporting it also from date (*Phoenix sylvestris*). Later he renamed it to *Phytophthora palmivora*. According to TL-2 (https://www.sil.si.edu/DigitalCollections/tl-2/browse.cfm?vol=10#page/295), type material of Butler could be preserved in B, IMI, and PUR. However, no material could be traced in these three fungaria (pers. comm. with the curators), but some specimens collected by Butler in Godavari, India, on leaves of *Borassus flabellifer* are preserved in S (https://herbarium.nrm.se/specimens/F39482; https://herbarium.nrm.se/specimens/F39486). Unfortunately, these specimens are not available for loan at the moment due to the renovation of the building. Therefore, both lecto- and epitypification are pending. In the meantime, strain IMI 348384 is selected here as representative strain.

Phytophthora phaseoli Thaxt., Bot. Gaz. 14: 274. 1889. MycoBank MB 194478. Figs. 24, 25.

Lectotype (designated here, MBT 10008026): **USA**, Connecticut, New Haven, on pods, stems and leaves of Lima beans (*Phaseolus lunatus*), Sept. 1889, R. Thaxter (FH00965504).
Epitype (designated here, MBT 10008027): **USA**, Delaware, collected in 1937 from Lima beans (*Phaseolus lunatus*), collection date and collector unknown (CBS 114105, preserved in a metabolically inactive state).
Ex-epitype cultures: CBS 114105 = NRRL 64338. Other strain S&T BL 28. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: MG865564 (ITS), MH136956 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* semi-papillate and papillate, caducous with short to medium pedicels (4–20 µm long, mostly short, limoniform, ovoid, ellipsoid, obovoid, or irregular and some with tapered bases (18–54 × 11–27 µm), non-proliferating, originated in simple/simple sympodial *sporangiophores* which are slightly swollen at the base of sporangium. *Hyphal swellings* absent. *Chlamydospores* absent. *Sexual morph*: *Sterile/Homothallic*.

Culture characteristics: Colonies after 7 d of growth on V8-A, PDA, and MEA with slow growth and no special pattern. Minimum growth temperature is 9 °C, optimum 15–20 °C, and maximum 27 °C.

Notes: Thaxter collected this species in New Haven, Connecticut, USA, in September and October 1889 on pods, stems and leaves of Lima bean. Numerous specimens are available in several fungaria, including FH, BPI, and NY. One of the specimens preserved in Thaxter's herbarium in FH is chosen as lectotype herein (Fig. 24). In addition, a specimen collected from the same host and country is designated as epitype to fix the application of this name.

Our different attempts to produce oospores for the selected ex-epitype culture CBS 114105 failed in single growth and in pairings with A1 and A2 types of different species, showing the character

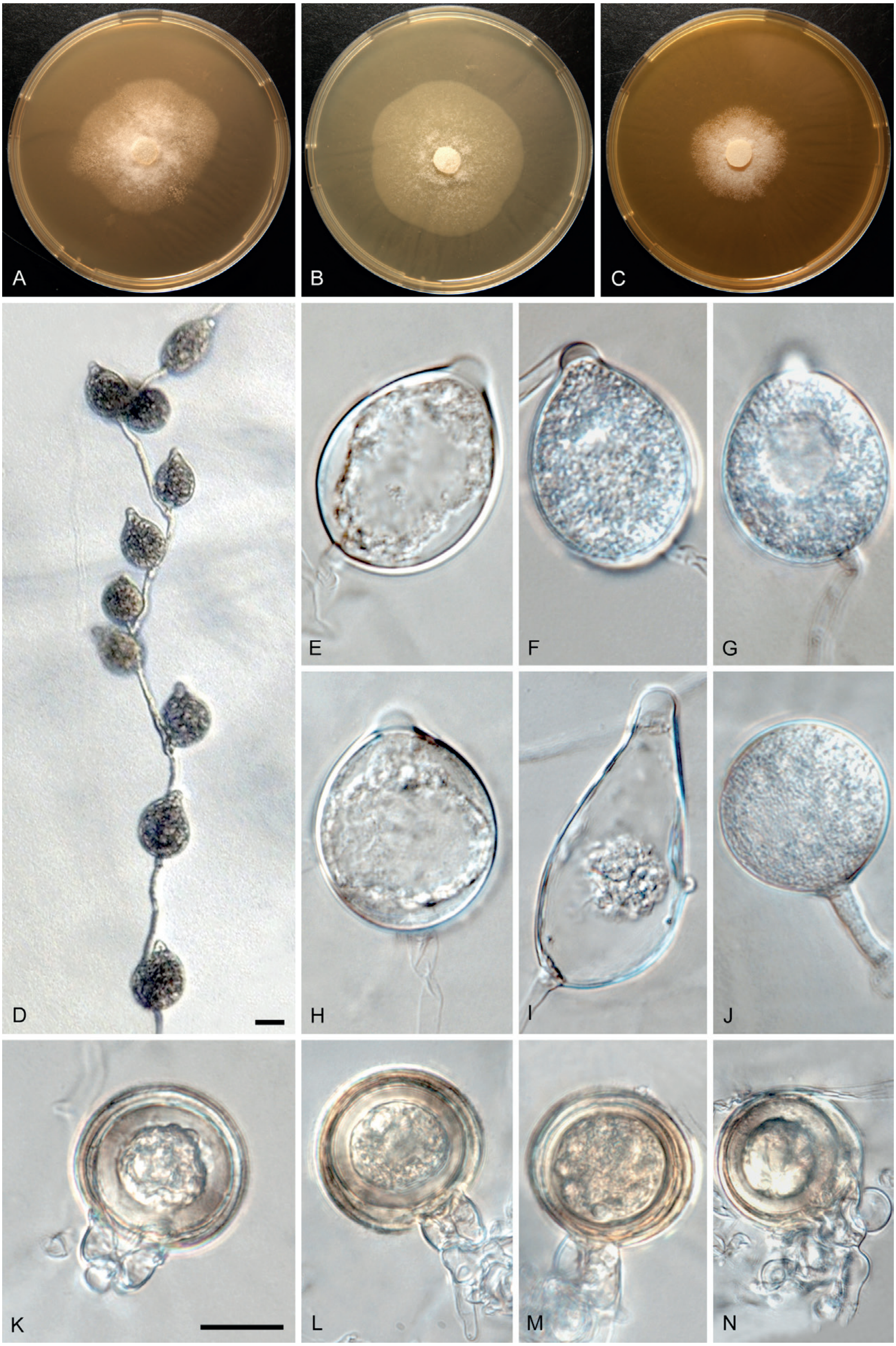

Fig. 23. *Phytophthora palmivora* representative strain culture CBS 305.62 (IMI 348384). **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D.** Sporangia originated in simple sympodial sporangiophore. **E–I.** Ovoid to obpyriform papillate sporangia. **E, F, I.** Sporangia showing a short, preformed pedicel. **J.** Terminal globose chlamydospore. **K–M.** Oogonia with golden-brown wall and unicellular amphigynous antheridia. **L.** Aplerotic oospore. **N.** Oogonium with two antheridia. Scale bars = 20 µm; K applies to E–N.

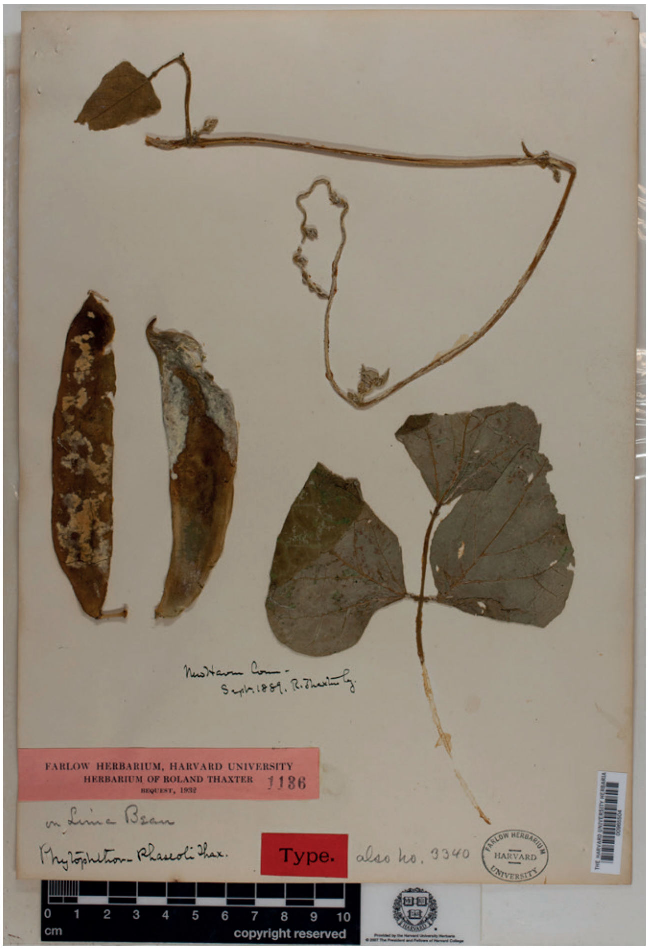

Fig. 24. Lectotype of *Phytophthora phaseoli* preserved in FH.

to be sterile. According to Evans *et. al.* (2007), *P. phaseoli* is homothallic with amphigynous antheridia and rarely produce oospores in old cultures and on plant tissue.

Phytophthora porri Foister, Trans. Bot. Soc. Edinb. 30(4): 277. 1931. MycoBank MB 275104. Fig. 26.

Lectotype (designated here, MBT 10008028): UK, on leaves of *Allium porrum*, fig. 1 (amphigynous antheridia), fig. 2 (paragynous antheridia), and fig. 3 (sporangia) in Foister (1931: 264–266).
Epitype (designated here, MBT 10008029): UK, from leek (*Allium porrum*), 1994, unknown collector (CBS H-25076).
Ex-epitype cultures: CBS 116662 = NRRL 64316. Other strain S&T BL 147. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: MG865569 (ITS), MH136961 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* semi-papillate and non-papillate; persistent and caducous with short and medium pedicels; obpyriform, ovoid, ellipsoid, or with irregular shapes (16–67 × 13–39 µm) sometimes with tapered bases, sometimes caducous with medium pedicels; not proliferating; originated on simple sympodial *sporangiophores*, often with intercalary swellings. *Hyphal swellings* globose, ellipsoid, single or in chains. *Chlamydospores* absent. *Sexual morph*: *Homothallic. Oogonia* smooth-walled and with slight wavy walled; spherical to subglobose (17–40 µm diam); *antheridia* predominantly paragynous and sometimes amphigynous, globose, short cylindrical or irregular shape; *oospores* predominantly aplerotic (16–34 µm diam). A high proportion of aborted oogonia are observed. Oogonia and oospores turning gold on maturity.

Culture characteristics: Colony morphology on PDA, V8A, MEA with rosette pattern. Minimum growth temperature 3 °C, optimum 15 °C, and maximum 18 °C. Hyphal swellings formed in agar or in soil water extract.

Notes: Type material of this species could not be traced. Attempts to find it in E failed (pers. comm. Heleen Plaisier, herbarium RBGE). Original illustrations provided in Foister (1931) are therefore chosen as lectotype. A supporting epitype is designated here from the same substrate and country. Although the manuscript of Foister (1931) does not refer to caducous sporangia, fig. 3A clearly shows a sporangium with a short pedicel.

Phytophthora primulae J.A. Toml., Trans. Brit. Mycol. Soc. 35(3): 233. 1952. MycoBank MB 303623. Fig. 27.

Lectotype (designated here, MBT 10008030): *UK*, England, from roots of *Primula polyantha*, figs. 2–4 (sporangia) and fig. 5 (sexual morph) in Tomlinson (1952: 226, 230).
Epitype (designated here, MBT 10008031): Germany, from *Primula acaulis*, 1997, W. Veenbaas, isol. A.W.A.M. de Cock (CBS H-25077).
Ex-epitype cultures: CBS 620.97 = NRRL 64336. Other strain S&T BL 50. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: MG865571 (ITS), MH136963 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* non-papillate and semi-papillate, persistent; ellipsoid, obpyriform, ovoid, or with irregular shapes (33–109 × 13–39 µm), many times showing typical constrictions, and sometimes with tapered bases, no internal proliferation is observed but external proliferation originating secondary sporangia is occasionally observed; sporangia mostly originated on unbranched *sporangiophores* which often present basal and intercalary swellings. *Hyphal swellings* globose, elongate, or irregular; solitary, catenulated or toruloid kind and clustered; many times, with radiating hyphae. *Chlamydospores* absent. *Sexual morph*: *Homothallic. Oogonia* smooth-walled and with slight wavy walls; spherical to subglobose (20–50 µm diam); *antheridia* predominantly paragynous and sometimes amphigynous, spherical, ovoid, club-shaped or irregular shape, sometimes with wide antheridial hyphae, and with two or three antheridia in a single oogonium; *oospores* aplerotic to slightly aplerotic (17–40 µm diam). Many aborted oospores are observed.

Culture characteristics: Colony morphology on PDA, V8-A, MEA with non-distinct pattern. Minimum growth temperature 3 °C, optimum 15–21 °C, and maximum 27 °C. Hyphal swellings formed in agar or in soil water extract.

Notes: Type material of *Phytophthora primulae* was indicated to be preserved in the Plant Pathology Laboratory in Harpenden (Tomlinson 1952). According to Index Herbariorum this no longer exists (http://sweetgum.nybg.org/science/ih/herbarium-details/?irn=123903). As no type of material could be located elsewhere, four of the original illustrations are therefore selected as lectotype here. A collection from the same host and continent is designated as supporting epitype.

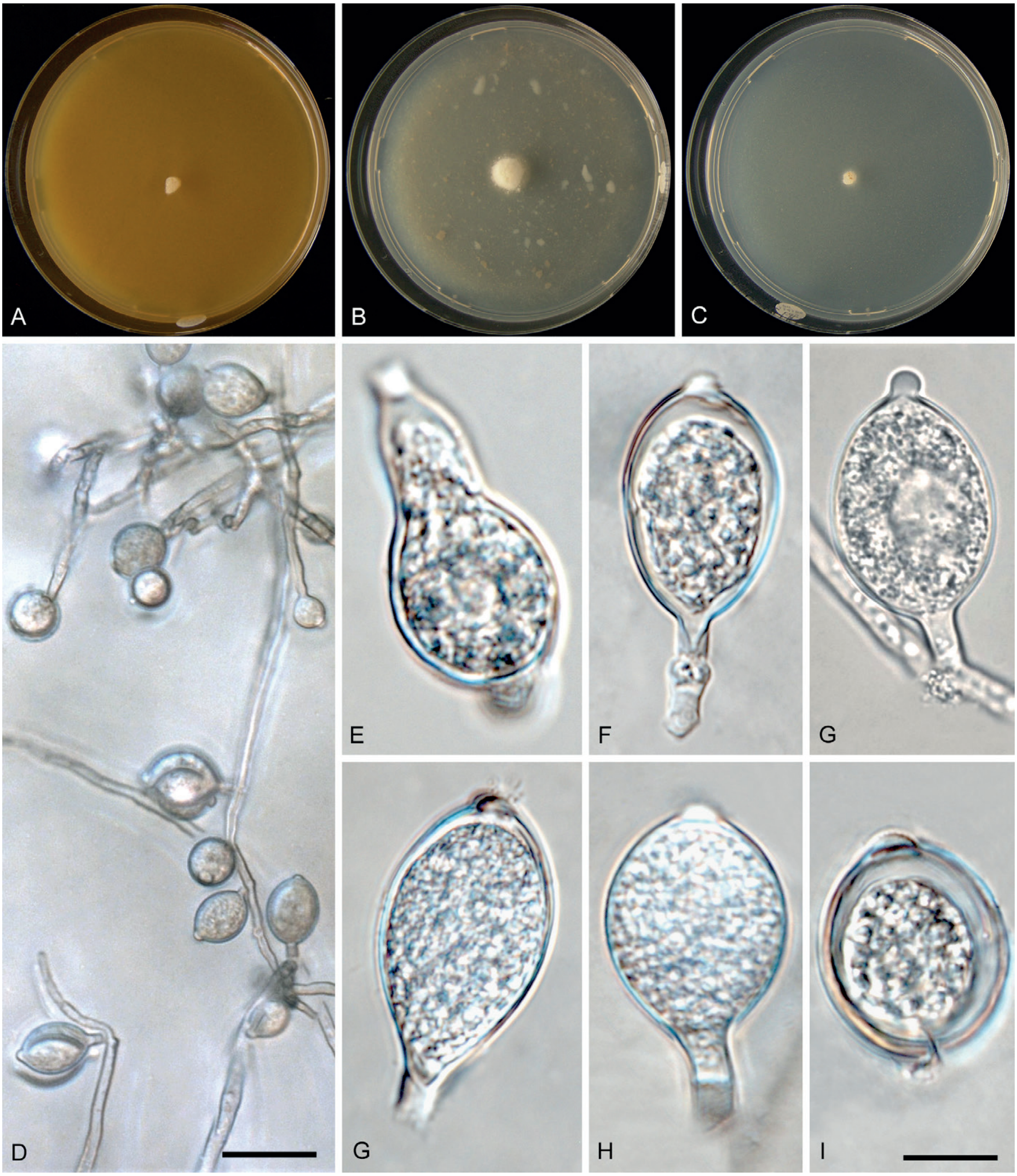

Fig. 25. *Phytophthora phaseoli* ex-epitype culture CBS 114105. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Corn Meal Agar. **D.** Sporangia originated in simple and simple sympodial sporangiophores. **E–I.** Obpyriform, limoniform, ovoid and globose semi-papillate and papillate (**G**) sporangia. **F–I.** Caducous sporangia with short to medium pedicels. Scale bars = 20 μm; I applies to E–I.

Phytophthora sojae Kaufm. & Gerd., Phytopathology 48: 207. 1958. MycoBank MB 303624. Fig. 28.

Lectotype (designated here, MBT 10008032): **USA**, Illinois, from a field near Blackstone, isolated from a diseased soybean stem (*Glycine max*), fig. 1D–J in Kaufmann & Gerdemann (1958: 203, https://archive.org/details/sim_phytopathology_1958-04_48_4/page/202/mode/2up).

Epitype (designated here, MBT 10008033): **USA**, Wisconsin, from soybean (*Glycine max*), collection date and collector unknown (CBS H-25079).
Ex-epitype cultures: CBS 149406 = NRRL 64266 (Race 1). Other strain S&T BL 56G. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: MG865588 (ITS), MH136980 (*COI*). Other sequences provided in Table 2.

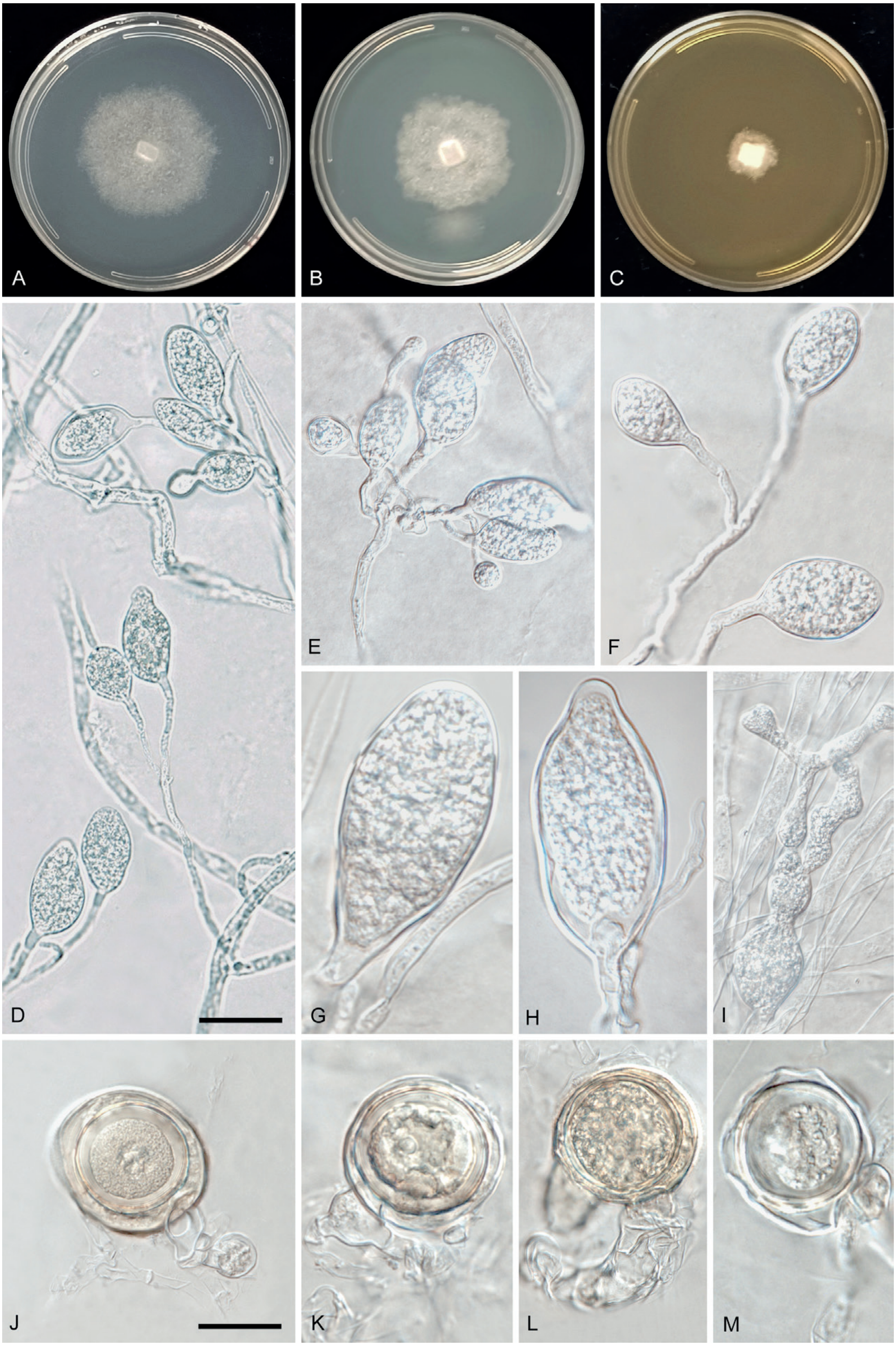

Fig. 26. *Phytophthora porri* ex-epitype culture CBS 116662. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D–F.** Sporangia originated in simple sympodial sporangiophores. **G, H.** Limoniform to elongated, semipapillate, persistent sporangia. **I.** Irregular hyphal swellings. **J–M.** Oogonia with golden-brown and slight wavy wall, and paragynous antheridia. **J, K.** Thick-walled and aplerotic oospores. Scale bars = 20 µm; D applies to D–I; J applies to J–M.

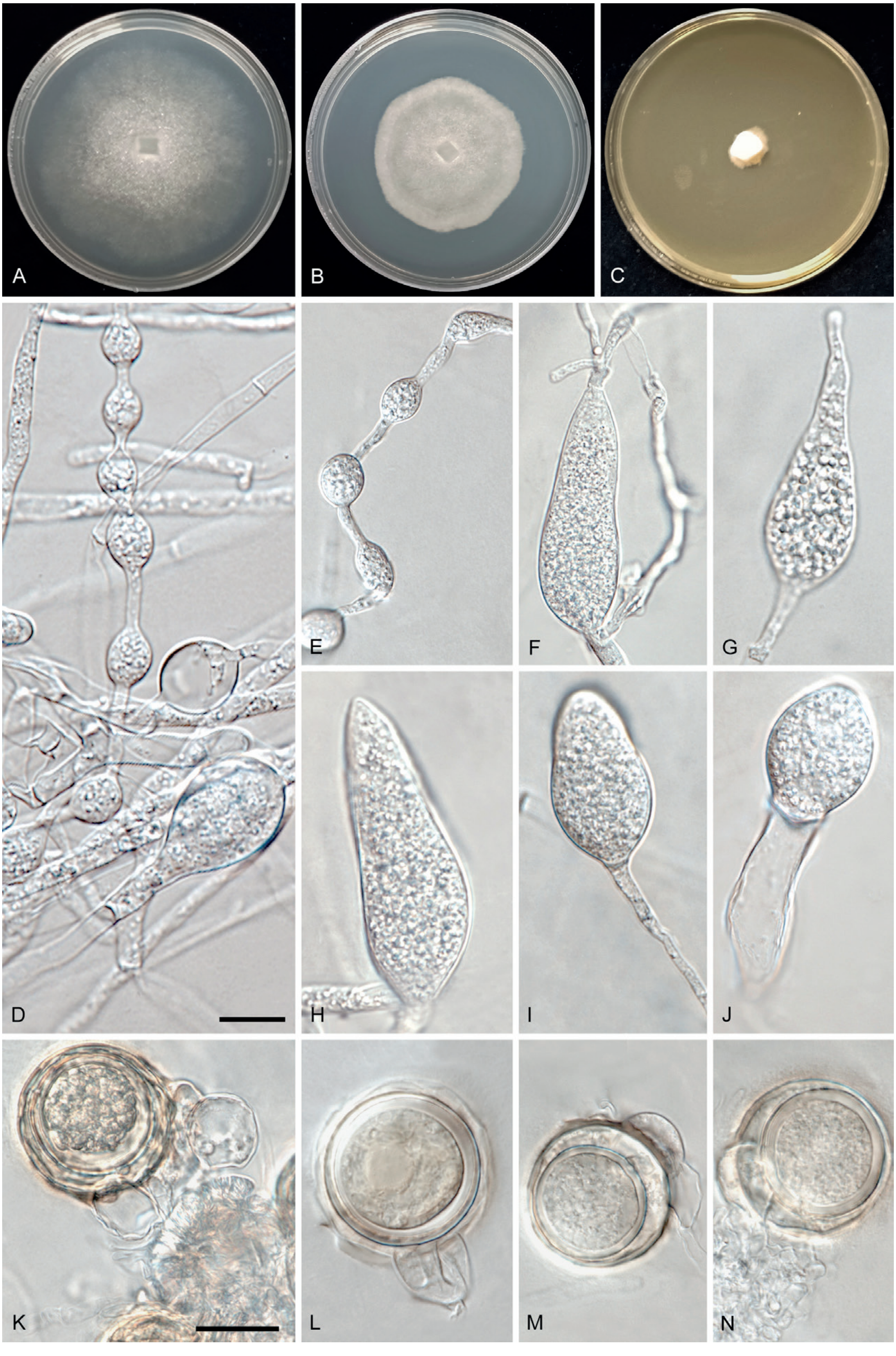

Fig. 27. *Phytophthora primulae* ex-epitype culture CBS 620.97. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D, E.** Catenulate, globose to subglobose and irregular hyphal swellings. **F–J.** Ovoid, obpyriform and elongated persistent sporangia. **F, G.** Sporangia showing direct germination from the apex and close to the base. **K–N.** Slight wavy walled oogonia with aplerotic oospores. **K, M, N.** Oogonia with paragynous antheridia. **L.** Oogonium with thick-walled oospore and amphigynous antheridium. Scale bars = 20 µm; D applies to D–J; K applies to K–N.

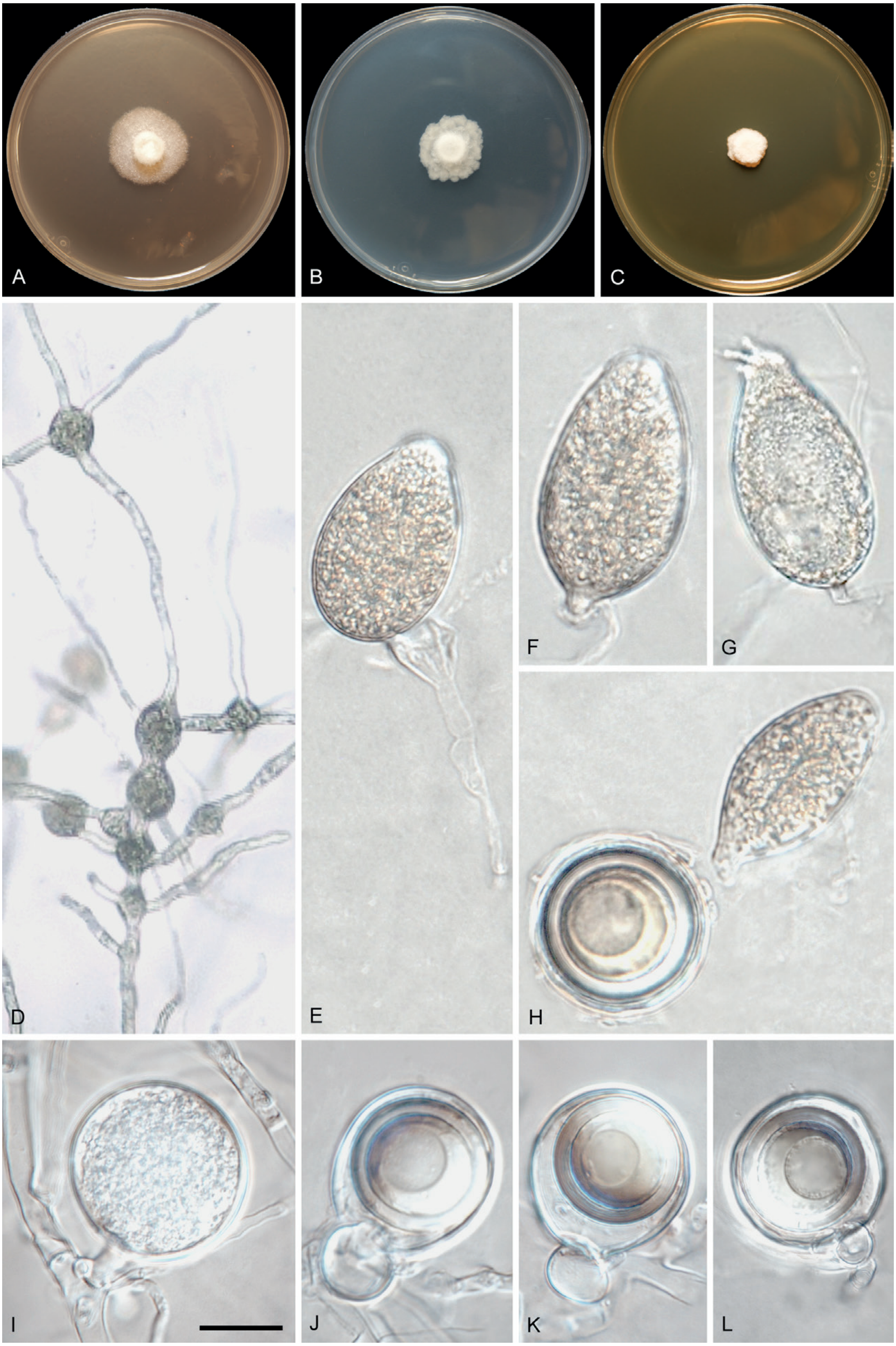

Fig. 28. *Phytophthora sojae* ex-epitype culture CBS 149406. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D.** Catenulate, globose to subglobose and irregular hyphal swellings. **E–G.** Nonpapillate and permanent sporangia. **H.** Oogonium and sporangium produced at the same time on solid medium. **I.** Terminal globose chlamydospore. **J–L.** Smooth-walled oogonia with paragynous antheridia nearly spherical to club-shaped and aplerotic oospores with big ooplasts. Scale bar = 20 µm; I applies to D–L.

Description: *Asexual morph*: *Sporangia* non-papillate; ovoid, ellipsoid, obpyriform, obovoid (43–101 × 24–55 µm), some with tapered bases, originated in simple sympodial and undifferentiated *sporangiophores*, sometimes showing internal and external proliferation. *Hyphal swellings* intercalary, spherical to irregular in shape. *Chlamydospores* globose rarely produced. *Sexual morph*: *Homothallic. Oogonia* spherical to subspherical (24–45 × 23–41 µm), some with distorted shapes, some with tapered base, some with tangled or knotted hyphae around the antheridium; *antheridia* predominantly paragynous (9–18 × 8–16 µm), frequently with a single long spine or digitate projection; *oospores* plerotic, aplerotic, and slightly aplerotic (18–39 µm diam).

Culture characteristics: Colony after 7 d of growth on PDA and MEA is very small, and on V8-A grows well and with no defined pattern. Minimum growth temperature 10 °C, optimum 22–30 °C, and maximum 33 °C.

Notes: Although stated in the original paper, a dried specimen was never deposited at ILL (pers. comm. with Andy Miller). Illustrations from the protologue are therefore chosen as lectotype here. In addition, an epitype is designated from the same geographical origin and substrate to fix the application of this name.

Phytophthora syringae (Kleb.) Kleb., Krankheiten des Flieders: 74. 1909. MycoBank MB 194524. Fig. 29.
Basionym: *Phloeophthora syringae* Kleb., Centralbl. Bakteriol. Parasitenk. 2. Abth. 15: 336. 1905. MycoBank MB 146927.
Synonym: *Nozemia syringae* (Kleb.) Pethybr., Sci. Proc. Roy. Dublin Soc. 13: 557. 1913. MycoBank MB 416474.

Neotype: (designated here, MBT 10008034): Germany, on *Syringa vulgaris*, collection date and collector unknown, isol. Oct. 1995 by J. Dalchow, Hessisches Landesamt f. Ernährung, Pflanzenschutzdienst, Frankfurt/M. (CBS H-25080).
Ex-neotype cultures: CBS 110161 = NRRL 64329. Other strain S&T BL 57G. Other duplicates of the ex-neotype in Table 2. Barcode sequences for ex-neotype GenBank: MG865590 (ITS), MH136982 (*COI*). Other sequences provided in Table 2.
Ex-neotype genome sequenced strain: *Phytophthora syringae* CBS 110161. This Whole Genome Shotgun project has been deposited at GenBank under the accession Genome USDA_Psyr_BL57G_1.0 reference (genome size 74.93 Mbp; BioProject PRJNA605765; BioSample SAMN14078573; Srivastava *et al.* 2022). Additional information for the ex-neotype genome in Table 3.

Description: *Asexual morph*: *Sporangia* semi-papillate, persistent, broad ovoid, ellipsoid, obpyriform, or distorted shapes (20–65 × 18–40 µm) sometimes with tapered base; originated in close simple sympodial *sporangiophores* with intercalary swellings. *Hyphal swellings* often catenulated, and spherical or irregular shape. *Chlamydospores* rarely produced. *Sexual morph*: *Homothallic. Oogonium* smooth-walled, globose (25–47 µm diam), sometimes with tapered base; *antheridia* spherical, ovoid, or club-shaped and are predominately paragynous and rarely amphigynous, sometimes with digitate projections; and *oospores* plerotic, aplerotic, or slightly aplerotic (20–39 µm diam).

Culture characteristics: Colony on CMA with no special pattern, on PDA and V8 with chrysanthemum/rosette pattern. The minimum growth temperature is 5 °C, the optimum is 18–20 °C, and the maximum is 23–25 °C. Oogonia formed abundantly in culture and host tissues.

Notes: *Phytophthora syringae* was originally described as *Phloeophthora syringae* by Klebahn (1905) in a very short note written in German without any illustration. Original material of that species could not be located in B. All material preserved in HBG postdates the protologue (Klebahn 1905) and can only be regarded as subsequent material. One of the specimens in HBG served as source for a drawing published in Klebahn (1909) where he recombined the species in *Phytophthora*, however, this is also subsequent material.

As no original material is available for lectotypification we designate a neotype here to fix the application of this name.

Phytophthora vignae Purss, Queensland J. Agric. Anim. Sci. 14: 141. 1957. MycoBank MB 303625. Fig. 30.

Lectotype (designated here, MBT 10008035): **Australia**, Queensland, Stuart Valley, collected from stem and root tissue of cowpea (*Vigna sinensis*), figs. 6, 7 (sporangia) and figs. 8, 9 (sexual morph) in Purss (1957: 132–135).
Epitype (designated here, MBT 10008036): ***Australia***, *Vigna unguiculata* (race 1), collection date and collector unknown (World Phytophthora Collection P3019, preserved in a metabolically inactive state).
Ex-epitype culture: WPC P3019. Other strain S&T BL 30. Other duplicates of the ex-epitype in Table 2. Barcode sequences for ex-epitype GenBank: MG865598 (ITS), MH136989 (*COI*). Other sequences provided in Table 2.

Description: *Asexual morph*: *Sporangia* non-papillate; persistent; ovoid to obpyriform (27–72 × 15–54 µm) sometimes with tapered base and showing nested and extended proliferation; produced in unbranched and sometimes in simple sympodial *sporangiophores*. *Hyphal swellings* irregular, terminal, and intercalary; occasionally in sporangiophores. *Chlamydospores* terminal and intercalary, globose (12–21 µm). *Sexual morph*: *Homothallic*. *Oogonia* smooth-walled (27–42 µm diam); *antheridia* amphigynous, spherical to ovate; *oospores* aplerotic (24–32 µm diam) [Sexual morph described in Purss (1957) pages 132–135, figs. 6–9]. CABI presents information for the typical oospores of this species (https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.40998).

Culture characteristics: Colony morphology on CMA, PDA, V8 with no distinct pattern. Minimum growth temperature 10 °C, optimum 24 °C, and maximum 32 °C. Sporangia produced in distilled water following growth in pea broth. Chlamydospores and hyphal swellings produced in CMA and oatmeal agar. Sexual stage produced abundantly in host tissue, OA, and CMA.

Notes: Type material of *P. vignae* could not be traced in any Australian fungarium. Illustrations provided in the original paper by Purss (1957) are therefore selected as lectotype and an epitype is designated from the same country and host genus.

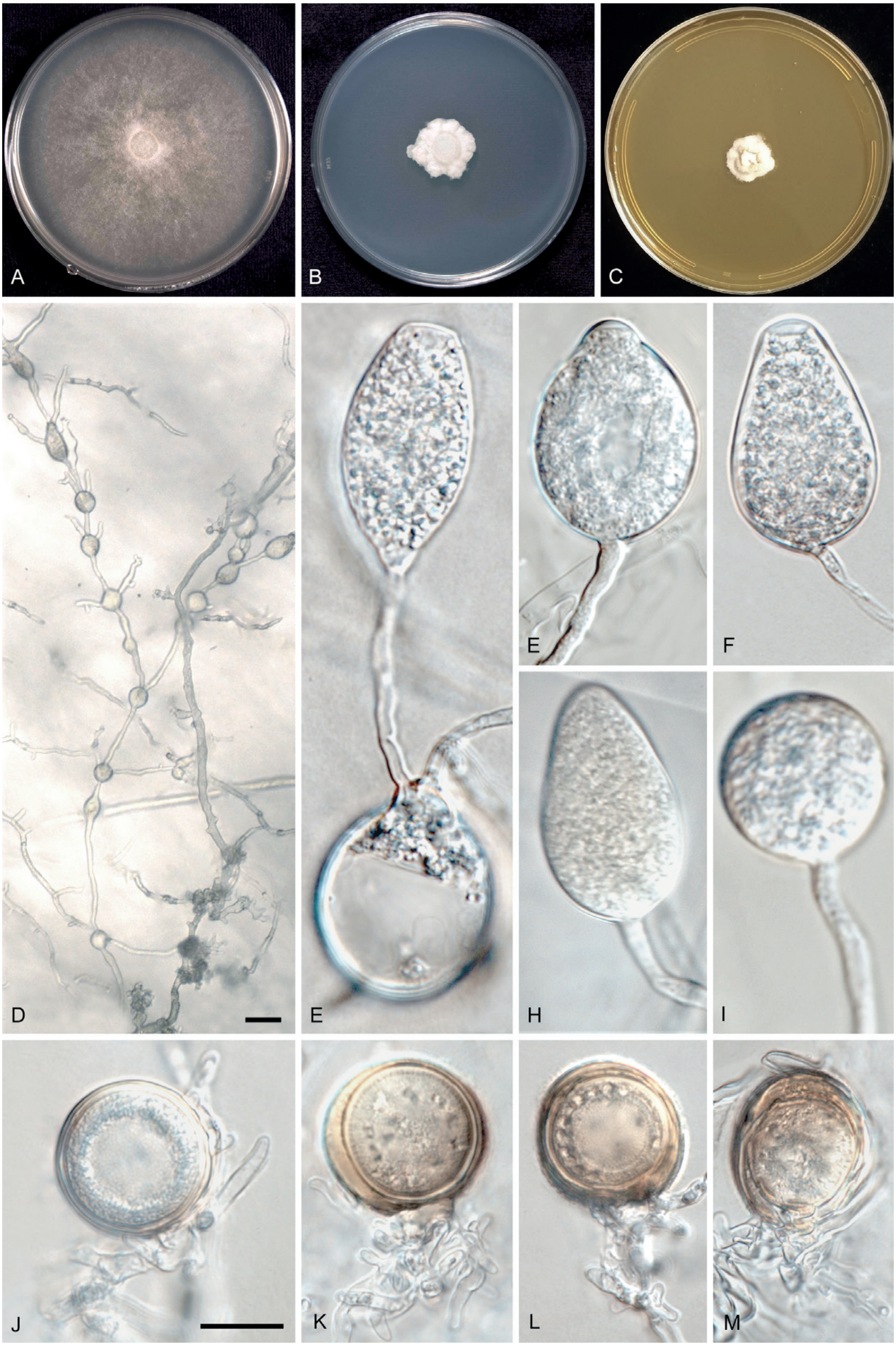

Fig. 29. *Phytophthora syringae* ex-epitype culture CBS 110161. **A–C.** Colony morphology after 7 d growth at 20 °C. **A.** V8-Agar. **B.** Potato-Dextrose Agar. **C.** Malt Extract Agar. **D.** Catenulate, globose to subglobose and irregular hyphal swellings. **E–H.** Sporangia originated in simple sympodial sporangiophores. **E.** Empty, primary transitional sporangium with a secondary mature sporangium originated from through the apex. **E, F, H.** Nonpapillate and persistent sporangia. **I.** Terminal globose chlamydospore. **J–M.** Globose oogonia showing golden-brown wall, slightly aplerotic oospore and paragynous antheridia with digital projections. **M.** Elongated oogonium with a slightly aplerotic oospore. Scale bars = 20 µm; J applies to E–M.

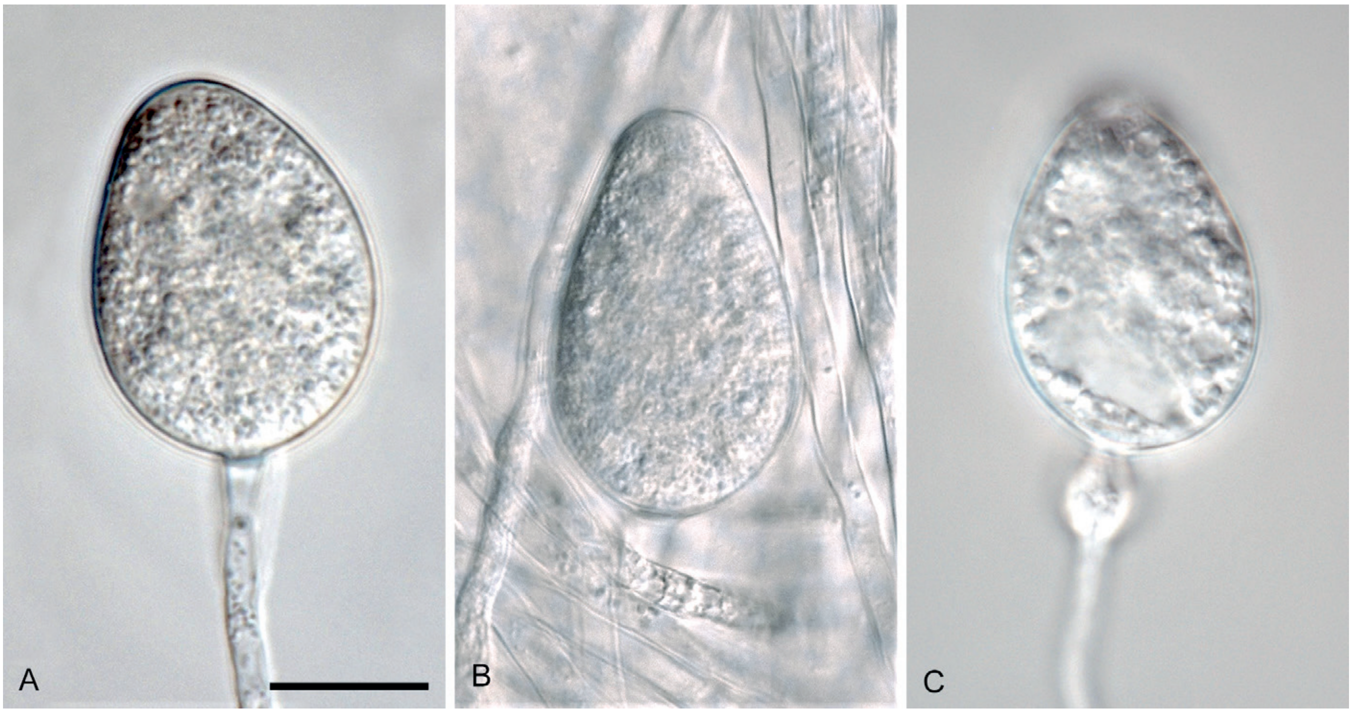

Fig. 30. *Phytophthora vignae* ex-epitype culture WPC P3019. **A–C.** Non-papillate persistent sporangia produced in unbranched sporangiophores. **C.** Ovoid sporangium with a hyphal swelling in the sporangiophore. Scale bar = 20 µm.

CONCLUSIONS AND RECOMMENDATIONS

1 This manuscript in association with *IDphy* online resource (https://idtools.org/tools/1056/index.cfm) is the first to provide an up-to-date morphological and phylogenetic overview of the 212 valid *Phytophthora* species described to the present. *IDphy* provides individual factsheets with information on the nomenclature, morphological and molecular information of the types and important links for the species and is a valuable resource for researchers working with *Phytophthora.*

2 For the convenience of identification of the 212 species described to the present, we are providing in the *IDphy* online resource a Lucid Key (https://idtools.org/tools/1056/index.cfm?pageID=3141), a Tabular Key, a Molecular Toolbox with seven genes for Sanger sequencing, and Databases with Molecular Operational Taxonomic Units (MOTU) for Second and Third Generation Metabarcoding High-throughput (HTS) sequencing, all based on information of the ex-types.

3 In this manuscript we have rectified past taxonomic and phylogenetic inconsistencies and defined the correct position and boundaries of the 212 species.

4 Through the designation of new types and ex-type cultures and assuring that these are available from the most important herbaria and culture collections globally, we have rectified past taxonomic and phylogenetic inconsistencies and provided a solid baseline for moving forward.

5 We highly encourage researchers working with new species of *Phytophthora* to make deposits of the type in recognized herbaria and at least two or three ex-types in international culture collections registered at the World Federation of Culture Collections (WFCC) with preference for the collections of CBS, NRRL and ATCC as recommended in Abad *et al.* (2023). Most recent species descriptions have correctly assigned types and make living cultures (ex-types) available for international researchers.

6 Types are important because they represent a materialization of the abstract concept of species, are objective references to compare newly discovered species, and if conserved make retrospective systematic revisions possible; thus, providing a sound backbone for a robust and long-lasting taxonomic system. However, species descriptions should include several isolates to ensure that intraspecific variability is captured. In cases where a single isolate is recovered it should be considered a “provisional” species until at least another specimen is obtained and then validated as a new species by morphological characterization of the type specimen. In cases where suspected new species is obtained in HTS analysis this can be reported as new “phylotype” and validated as a new species by morphological characterization of the type specimen.

7 Considering the high importance of the genus *Phytophthora*, we recommend whole genome sequencing (WGS) for the ex-types whenever possible. Currently there are only 23 WGS for ex-types from the 212 described species. The WGS of well authenticated species can reveal insights into studies of gene functions and empowering the area of comparative genomics with a number of applications including the development of robust primers for specific detection of species, as well as for metagenomic and metabarcoding studies.

8 *IDphy* has been updated to include all new species described up to the end of 2022. Authors of species descriptions are encouraged to communicate with curators to ensure new fact sheets are correct. Moving forward, *IDphy* will be updated annually with new fact sheets, a new phylogeny, and new sequences.

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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: https://studiesinmycology.org/

Supplementary File S1. Methods for isolation, maintenance, sporulation, and storage of *Phytophthora* species.

Supplementary File S2. *IDphy2* Molecular Protocols for Sanger Sequencing with seven genes.

Supplementary File S3. ITS rDNA, *COI*, MOTUs, 3G HTS and 2G HTS local databases.

Supplementary Fig. S1. Order *Peronosporales*. Maximum likelihood tree inferred with IQ-TREE v. 2 from a three-locus (ITS, *COI* and *β-tub*) alignment (Supplementary Table S1). Ultrafast bootstrap support values ≥ 50 % are shown above and posterior probabilities ≥ 0.90 from a Bayesian analysis are below branches.

Supplementary Fig. S2. *Phytophthora* and related obligate biotrophic taxa. Maximum likelihood tree inferred with IQ-TREE v. 2 from a five-locus

(*COI*, *β-tub*, *EF1α*, *L10* and *HSP90*) alignment (Supplementary Table S1). Ultrafast bootstrap support values ≥ 50 % are shown above and posterior probabilities ≥ 0.90 from a Bayesian analysis are below branches.

Supplementary Fig. S3. Seven-locus *Phytophthora* phylogeny featuring 213 described species. Bayesian tree inferred with MrBayes v. 3.2.7. Posterior probabilities ≥ 0.90 are shown. Sequence accessions are listed in Table 2.

Supplementary Fig. S4. ITS-only maximum likelihood tree. Tree inferred using IQ-TREE v. 2 from a 217 taxon alignment with 1 178 nucleotide positions and 404 binary gap positions. Ultrafast bootstrap support values ≥ 50 % are shown above and posterior probabilities ≥ 0.90 from a Bayesian analysis are below branches.

Supplementary Fig. S5. *COI*-only maximum likelihood tree. Tree inferred using IQ-TREE v. 2 from a 190 taxon alignment with 744 nucleotide positions. Ultrafast bootstrap support values ≥ 50 % are shown above and posterior probabilities ≥ 0.90 from a Bayesian analysis are below branches.

Supplementary Fig. S6. *YPT1*-only maximum likelihood tree. Tree inferred using IQ-TREE v. 2 from a 180 taxon alignment with 850 nucleotide positions and 322 binary gap positions. Ultrafast bootstrap support values ≥ 50 % are shown above and posterior probabilities ≥ 0.90 from a Bayesian analysis are below branches.

Supplementary Fig. S7. *β-tub*-only maximum likelihood tree. Tree inferred using IQ-TREE v. 2 from a 213 taxon alignment with 1 053 nucleotide positions. Ultrafast bootstrap support values ≥ 50 % are shown above and posterior probabilities ≥ 0.90 from a Bayesian analysis are below branches.

Supplementary Fig. S8. *EF1α*-only maximum likelihood tree. Tree inferred using IQ-TREE v. 2 from a 192 taxon alignment with 879 nucleotide positions. Ultrafast bootstrap support values ≥ 50 % are shown above and posterior probabilities ≥ 0.90 from a Bayesian analysis are below branches.

Supplementary Fig. S9. *L10*-only maximum likelihood tree. Tree inferred using IQ-TREE v. 2 from a 186 taxon alignment with 465 nucleotide positions. Ultrafast bootstrap support values ≥ 50 % are shown above and posterior probabilities ≥ 0.90 from a Bayesian analysis are below branches.

Supplementary Fig. S10. *HSP90*-only maximum likelihood tree. Tree inferred using IQ-TREE v. 2 from a 190 alignment with 933 nucleotide positions. Ultrafast bootstrap support values ≥ 50 % are shown above and posterior probabilities ≥ 0.90 from a Bayesian analysis are below branches.

Supplementary Table S1. Taxa added for Figs. 1, 2.

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