

Phytophthora aquae-cooljarloo

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Phytophthora aquae-cooljarloo R. Mostowfizadeh-Ghalamfarsa & T.I. Burgess, *sp. nov.*

Etymology. Named for the association of this species with water at the place Cooljarloo.

Classification — *Peronosporaceae*, *Peronosporidae*, *Oomycota*.

Sporangia produced on V8 agar (V8A) and carrot agar (CA) flooded with both distilled water and non-sterile soil extract; terminal, non-papillate, mostly ellipsoid to ovoid and limoniform, sometime obovoid; $66 \pm 11.2 \times 37 \pm 4.5 \mu\text{m}$ (overall range $38\text{--}101 \times 29\text{--}54 \mu\text{m}$), length/breadth ratio of 1.9 ± 0.2 . *Sporangial proliferation* in chains of internally proliferating sporangia, both nested and extended. *Hyphal swellings* absent. *Chlamydospores* common, globose, thin-walled, $9\text{--}(20 \pm 5)\text{--}33 \mu\text{m}$. *Gametangia* were produced in single cultures (homothallic). *Oogonia*, smooth-walled, globose, golden to brown $34 \pm 4.5 \mu\text{m}$ (isolates ranged from $23\text{--}47 \mu\text{m}$). *Oospores* were aplerotic, with an average of $30 \pm 4 \mu\text{m}$ (isolate means 19 to $41 \mu\text{m}$). *Oospore walls* were av. $3.2 \pm 0.9 \mu\text{m}$, oospore wall index 0.5. *Antheridia* were parangynous, monoclinal, spherical to ellipsoidal, ranged from 5 to $17 \mu\text{m}$ in length (av. $12 \pm 1.7 \mu\text{m}$) and 5 to $14 \mu\text{m}$ in breadth (av. $9 \pm 1.7 \mu\text{m}$). *Hyphae* were hyaline, normally not septate, $4\text{--}5 \mu\text{m}$ wide. Minimum, optimum and maximum temperatures for growth were $4 \text{ }^\circ\text{C}$, $30 \text{ }^\circ\text{C}$ and $35 \text{ }^\circ\text{C}$, respectively. Radial growth rate on CA in the dark at $30 \text{ }^\circ\text{C}$ was $3.9 \pm 1.3 \text{ mm/d}$.

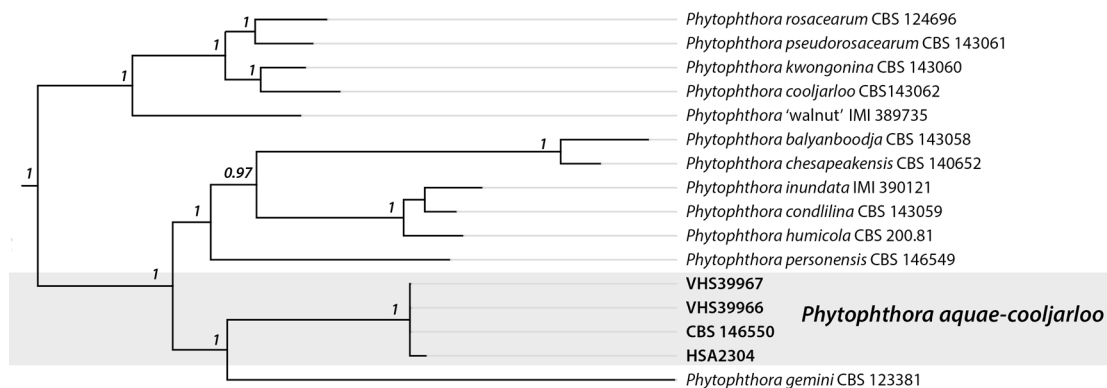
Culture characteristics — The colony patterns on all media were uniform with the exception of potato dextrose agar (PDA) which produced rose-shaped pattern in some isolates. Aerial mycelia were observed on some colonies specially on PDA.

Typus. AUSTRALIA, Western Australia, Cooljarloo, baited from pond water, collected by Department of Biosecurity, Conservation and Attractions, 20 Sept. 2017 (holotype MURU484, culture ex-type CBS 146550 = VHS36940, ITS, *Btub*, *hsp90*, *cox1*, *nadh1* and LSU sequences GenBank MT210484, MT210475, MT210480, MT210466, MT210470 and MT210485, MycoBank MB835165).

Additional materials examined. AUSTRALIA, Western Australia, Cooljarloo baited from pond water, collected by Department of Biosecurity, Conservation and Attractions, 18 Sept. 2019, cultures VHS39966, VHS39967; 1996, culture HSA2304.

Colour illustrations. Typical kwongan vegetation, north of Perth, Western Australia (Photo: Giles Hardy). Typical ellipsoid and limoniform sporangia; aplerotic oogonia with parangynous antheridia; small chlamydospore; uniform colony on V8 agar. Scale bar = $20 \mu\text{m}$.

Notes — Isolates of *Phytophthora aquae-cooljarloo* constitute a well-supported monophyletic group sharing a common ancestor with *P. gemini* (Man in 't Veld et al. 2011). These species together with *P. humicola* (Ko & Ann 1985), *P. inundata* (Brasier et al. 2003), *P. condilina* (Burgess et al. 2018), *P. balyanboodja* (Burgess et al. 2018), *P. chesapeakeensis* (Man in 't Veld et al. 2019), and *P. personensis* (Crous et al. 2020a) cluster within clade 6a of the *Phytophthora* phylogeny (Burgess et al. 2018). In a multigene phylogeny of the ITS, *Btub*, *hsp90*, *cox1* and *nadh1* gene regions, *P. aquae-cooljarloo* differs from its sister taxon, *P. gemini*, by 8.8 %. Morphologically, *P. aquae-cooljarloo* is similar to other species in clade 6a, producing terminal, ellipsoid to ovoid, persistent, non-papillate sporangia, and it is also a high-temperature tolerant *Phytophthora* species. Isolates of *P. aquae-cooljarloo* are homothallic and produce abundant oospores in culture similarly to *P. humicola*, *P. inundata*, and *P. condilina*. Unlike *P. balyanboodja*, *P. chesapeakeensis* and *P. gemini*, *P. aquae-cooljarloo* produces chlamydospores, but does not form any hyphal swellings which differs from all other species in the clade except *P. balyanboodja*. *Phytophthora aquae-cooljarloo* has been isolated over a 25-yr-period from seasonal ponds in the dry *Banksia* shrublands (the kwongan) in the sandplains north of Perth, Western Australia at a single location, Cooljarloo.



Bayesian inference tree based on a concatenated ITS, *Btub*, *hsp90*, *cox1* and *nadh1* sequence alignment showing the placement of *Phytophthora aquae-cooljarloo* in *Phytophthora* Clade 6a. The tree was generated in MrBayes v. 3.2.6 (Huelsenbeck & Ronquist 2001) as a plugin in Geneious Prime® 2019.2.3 (www.geneious.com) using the GTR substitution model. The posterior probability values are shown at the nodes. The tree was rooted to *P. thermophila* (not shown) and the novel species is shown in bold font.

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