The Biology and Distribution of Morels in Southern Chile

Giuliana Furci[1] Katherine LoBuglio[2] and Donald Pfister[2]

[1]Fundacion Fungi, Santiago Chile, [2]Harvard University Herbaria, Farlow Herbarium, Cambridge MA, USA

INTRODUCTION

The harvesting of morels is a vital economic activity for local communities in Chile because they are a significant commercial export for the country. Although many species of morels produce ascomata in the absence of fire, abundant ascomata production occurs among some *Morchella* species when triggered by fire. The intentional burning of *Nothofagus* forests in Southern Chile, as a means to increase morel production, has become a problem and has negatively impacted ecosystems. Information on the distribution of morels in South America is limited. Spegazzini (1909) described *M. patagonica* from Argentina and Gamundi et al. (2004) listed five *Morchella* species from Patagonia and surrounding areas including Spegazzini's species. Recently Pildain et al. (2014) and Baroni et al. (2018) have examined diversity of *Morchella* species in South America and the Caribbean using molecular methods. To better understand which *Morchella* species are being commercially harvested in Southern Chile, molecular markers were used to identify collections of morels being harvested and/or sold commercially and determine their phylogenetic relationships. Morels were sampled from collections in the Fungarium of the Fundación Fungi, Chile (FFCL) and batches purchased from commercial harvesters and bulk gatherers in 2015 and 2016. DNA sequence from the EF1a, RPB1, ITS and RPB2 were obtained and used for phylogenetic analyses. This study will contribute to the knowledge of morels in South America and help to understand their phylogenetic relationships with other *Morchella* species found worldwide.

Diversity of morel ascomata collected by commercial harvesters Chile.

RESULTS

Phylogenetic analyses of EF1a, RPB1, ITS and RPB2 DNA sequences determined that the 14 Morel specimens collected in Chile grouped into 4 clades:

M2, M4, M6, G1, G3, G4, G6 were part of the *Morchella frustrata* "Mountain blond Morel" clade.

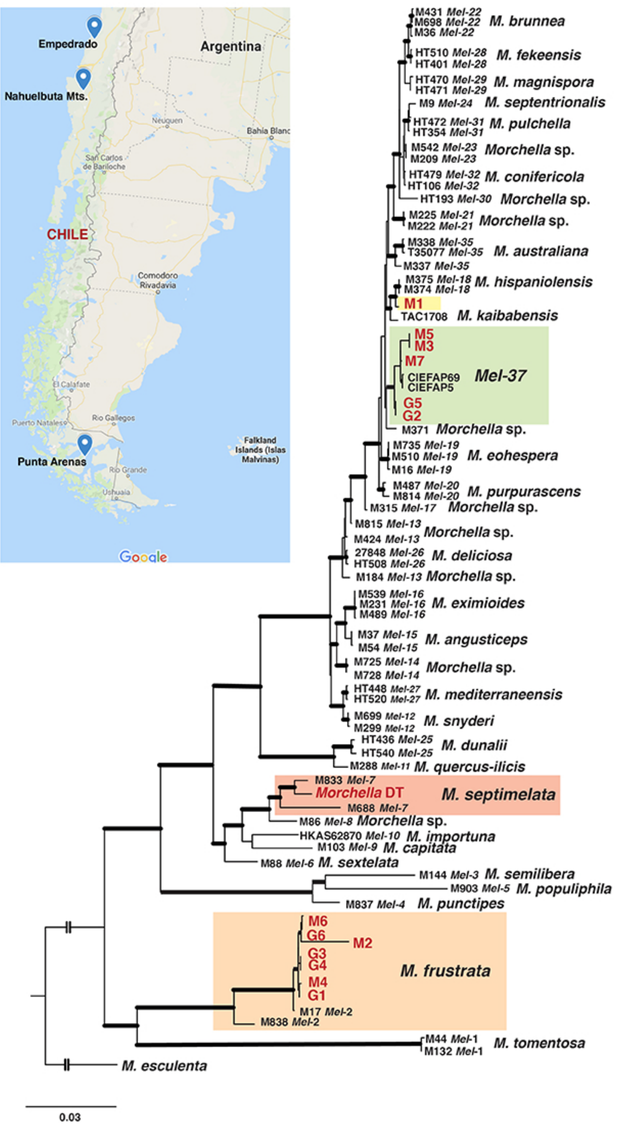
G2, G5, M3, M5, M7 were part of the Mel-37 clade determined to be a putatively new phylogenetic species by Pildain et al. 2014.

M1 was sister to the Mel-18 clade which includes *M. hispaniolensis*. This specimen was collected in Punta Arenas, Chile as part of a general collection of fungi.

Morchella sp. DT (collected from a post-burn forest) was part of the "Fire adapted lineage" (Mel-6 to Mel-10) and was closest to *M. septimelata* (Mel-7).

Nothofagus forest in Chile.

Results of a forest burn and emerging morel.



Phylogenetic relationships of *Morchella* specimens collected in Chile to species in the Elata Clade. The tree was determined from Maximum Likelihood (ML) analysis of combined EF1-a, RPB1, ITS and RPB2 DNA sequence data. The morel specimens from Chile are in red. Branches in bold indicate parsimony and ML bootstrap support > 70% and Bayesian posterior probabilities > 95%. The tree was rooted with *Morchella esculenta*.

SUMMARY

The 14 specimens included in this study belong to the highly diverse Elata Clade. As found in the studies of Taskin et al. (2012) for Turkey and Pildain et al. (2014) for Argentina, *M. frustrata* represents the most widely collected morel among our Chilean specimens. Interestingly 5 of our specimens were in the clade represented by the new phylogenetic species suggested but not named by Pildain et al. (2014), *Mel-37*, which is only known from South America. We will honor Irma Gamundí, Argentine mycologist, by naming this new species *M. gamundiae*.

The genetic diversity observed among the Chile specimens examined support the idea that harvesting morels in the absence of destructive burning practices can be successful. Such information will be useful in outreach programs to local communities to help promote and develop sustainable practices for commercial morel harvesting and discourage destructive burning practices.

Table 1. Morchella species included in study. Morchella strains where species names or "Mel" code not yet assigned listed as "NA".

Morchella Species and Strain	Elata Clade "Mel" Code	Country of Origin	Species Reference
M. angusticeps M37	Mel-15	USA	O'Donnell et al. 2011
M. angusticeps M54	Mel-15	USA	O'Donnell et al. 2011
M. australiana M337	Mel-35	Australia	Elliott et al. 2014
M. australiana M338	Mel-35	Australia	Elliott et al. 2014
M. australiana T35077	Mel-35	Australia	Elliott et al. 2014
M. australiana M371	NA	Australia	Elliott et al. 2014
M. brunnea M36	Mel-22	Canada	Kuo et al. 2012
M. brunnea M431	Mel-22	USA	Kuo et al. 2012
M. brunnea M698	Mel-22	USA	Kuo et al. 2012
M. capitata M103	Mel-9	USA	Kuo et al. 2012
M. conifericola HT106	Mel-32	Turkey	Taskin et al. 2016
M. conifericola HT479	Mel-32	Turkey	Taskin et al. 2016
M. deliciosa 27848	Mel-26	Sweden	Richard et al. 2015
M. deliciosa HT508	Mel-26	Turkey	Richard et al. 2015
M. dunalii HT436	Mel-25	Turkey	Richard et al. 2015
M. dunalii HT540	Mel-25	Turkey	Richard et al. 2015
M. eohespera M16	Mel-19	Netherlands	Petrzelova et al. 2019
M. eohespera M510	Mel-19	Switzerland	Petrzelova et al. 2019
M. eohespera M735	Mel-19	China	Petrzelova et al. 2019
M. eximioides M231	Mel-16	Sweden	O'Donnell et al. 2011
M. eximioides M489	Mel-16	Norway	O'Donnell et al. 2011
M. eximioides M539	Mel-16	Denmark	O'Donnell et al. 2011
M. fekeensis HT401	Mel-28	Turkey	Taskin et al. 2016
M. fekeensis HT510	Mel-28	Turkey	Taskin et al. 2016
M. frustrata M17	Mel-2	Canada	Kuo et al. 2012
M. frustrata M838	Mel-2	USA	Kuo et al. 2012
M. hispaniolensis M374	Mel-18	Dominican Republic	Baroni et al. 2018
M. hispaniolensis M375	Mel-18	Dominican Republic	Baroni et al. 2018
M. importuna HKAS62870	Mel-10	Germany	Kuo et al. 2012
M. kaibabensis TAC1708	NA	USA	Baroni et al. 2018
M. magnispora HT470	Mel-29	Turkey	Taskin et al. 2016
M. magnispora HT471	Mel-29	Turkey	Taskin et al. 2016
M. mediterraneensis HT448	Mel-27	Turkey	Taskin et al. 2016
M. mediterraneensis HT520	Mel-27	Turkey	Taskin et al. 2016
M. populiphila M903	Mel-5	USA	Kuo et al. 2012
M. pulchella HT354	Mel-31	Turkey	Richard et al. 2015
M. pulchella HT472	Mel-31	Turkey	Richard et al. 2015
M. punctipes M837	Mel-4	USA	Clowez et al. 2012
M. purpurascens M487	Mel-20	Norway	Petrzelova et al. 2019
M. purpurascens M814	Mel-20	China	Petrzelova et al. 2019
M. quercus-ilicis M288	Mel-11	Canary Islands	Clowez et al. 2012
M. semilibera M144	Mel-3	Netherlands	Kuo et al. 2012
M. septentrionalis M9	Mel-24	USA	Kuo et al. 2012
M. septimelata M688	Mel-7	USA	Kuo et al. 2012
M. septimelata M833	Mel-7	USA	Kuo et al. 2012
M. sextelata M88	Mel-6	USA	Kuo et al. 2012
M. snyderi M299	Mel-12	USA	Kuo et al. 2012
M. snyderi M699	Mel-12	USA	Kuo et al. 2012
M. tomentosa M132	Mel-1	USA	Kuo et al. 2008
M. tomentosa M44	Mel-1	USA	Kuo et al. 2008
Morchella sp. CIEFAP 5	Mel-37	Argentina	Pildain et al. 2014
Morchella sp. CIEFAP 69	Mel-37	Argentina	Pildain et al. 2014
Morchella sp. M36	Mel-8	USA	NA
Morchella sp. M184	Mel-13	India	NA
Morchella sp. M424	Mel-13	India	NA
Morchella sp. M815	Mel-13	China	NA
Morchella sp. M725	Mel-14	China	NA
Morchella sp. M728	Mel-14	China	NA
Morchella sp. M209	Mel-23	Finland	NA
Morchella sp. M542	Mel-23	Denmark	NA
Morchella sp. M222	Mel-21	Japan	NA
Morchella sp. M225	Mel-21	Japan	NA
Morchella sp. HT193	Mel-30	Turkey	NA
Morchella sp. M315	Mel-17	China	NA
Morchella sp. M1	NA	Chile	This Study *
Morchella sp. M2	Mel-2	Chile	This Study
Morchella sp. M3	Mel-37	Chile	This Study
Morchella sp. M4	Mel-2	Chile	This Study
Morchella sp. M5	Mel-37	Chile	This Study
Morchella sp. M6	Mel-2	Chile	This Study
Morchella sp. M7	Mel-37	Chile	This Study
Morchella sp. G1	Mel-2	Chile	This Study
Morchella sp. G2	Mel-37	Chile	This Study
Morchella sp. G3	Mel-2	Chile	This Study
Morchella sp. G4	Mel-2	Chile	This Study
Morchella sp. G5	Mel-37	Chile	This Study
Morchella sp. G6	Mel-2	Chile	This Study
Morchella sp. DT	Mel-7	Chile	This Study

CHILE SPECIMENS INCLUDED IN THIS STUDY*

The isolates included in this study were from several sources. Those collected by commercial harvesters in Chile are M1-M7 and those collected by Giuliana Furci are G1-G6. These specimens were harvested in the Nahuelbuta Mountain Range (exact locations unknown) except for M1 which was collected by a commercial hunter in Punta Arenas.

Morchella sp. DT was collected by Daniela Torres of the Fungi Foundation of Chile in 2017 from a Pine Plantation (Empedrado, Maule Region, northwest of the Nahuelbuta Mountain Range) where a devastating wildfire occurred the previous year.

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Corresponding Author: klobuglio@oeb.harvard.edu