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SUPPLEMENTARY ONLINE MATERIAL FOR

Phylogenetic relationships and time-calibration of the South American fossil and extant species of southern beeches (*Nothofagus*)

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Supplementary Online Material

SOM 1. Characters and its corresponding states used in the phylogenetic analysis.

SOM 2. First and last appearance data for *Nothofagus*.

SOM 3. Support measures from time-calibrated tree.

SOM 4. Strict consensus trees.

SOM 1. Characters and its corresponding states used in the phylogenetic analysis

0. Leaf vernation: 0-plicate; 1-planar; 2-revolute; 3-conduplicate. Heenan and Smissen (2013) based on Philipson and Philipson 1979

1. Cupule valves and fruit: 0-valves 4, fruit 2 trimerous, 1 dimerous; 1-valves 2, fruit 3 dimerous; 2- valves 2, fruit 1 dimerous; 3-valves 2, fruit 1 trimerous; 4-valves 2–4, fruit 1 trimerous, 0–1 dimerous; 5-valves 4, fruit 4–7. Heenan and Smissen (2013) based on Hill and Read (1991).

2. Cupule appendage type: 0-glandular; 1-lamellate. Heenan and Smissen (2013) based on Hill and Read (1991).

3. Peduncle length: 0-sessile or short; 1-long. Heenan and Smissen (2013).

4. Cupule valves: 0-woody; 1-thin; 2-thin and shorter than the fruit. Heenan and Smissen (2013).

5. Staminate flowers: 0-perianth present; 1-perianth absent, pseudanthium present. From Heenan and Smissen (2013) based on Langdon (1947); Rozefelds and Drinnan (1998).

6. Pollen shape in polar view: 0-peritreme; 1-goniotreme. Heenan and Smissen (2013) based on Dettmann et al. (1990).

7. Pollen polar to equatorial lengths: (l/E). 0-l/E > 0.35; 1-l/E < 0.3. Dettmann et al. (1990).

8. Pollen aperture thickening: 0-annulate; 1-heavy thickening; 2-rimmed; 3-unthickened. Dettmann et al. (1990).

9. Stipule attachment: 0-not peltate; 1-peltate. Steenis (1953).

10. Phyllotaxy: 0-distichous; 1-spiral. Heenan and Smissen (2013)

11. Glandular trichomes on cuticle: 0-present; 1-absent. Hill and Read (1991).

12. Solitary unicellular trichome type A: 0-present; 1-absent. Hill and Read (1991).

13. Solitary unicellular trichome type C: 0-present; 1-absent. Hill and Read (1991).

14. Conical trichomes: 0-present; 1-absent; 2-broad-based form; 3-SUTTB or SUTTD. Jordan and Hill (1999).

15. T pieces at stomatal poles: 0-absent; 1-present. Hill and Read (1991).

16. Stomatal orientation: 0-random; 1-mostly parallel with the midrib. Hill and Read (1991).

17. Giant stomata on veins: 0-present; 1-absent. Hill and Read (1991); Jordan and Hill (1999).

18. Stomatal size excluding giant stomata: 0-more or less even; 1-variable. Heenan and Smissen (2013)

19. Upper epidermal cells over veins: 0-more elongate than areolar cells; 1-not distinguishable from areolar cells; 2-thinner than areolar cells. Heenan and Smissen (2013)

20. Fimbrial vein: 0-absent; 1-type 1; 2-type 2. Jordan and Hill (1999).

21. Anther ornamentation: 0-type a, non-ornamented; 1-type b, isomorphic; 2-type c1, heteromorphic; 3-type c2, heteromorphic; 4-type c3, heteromorphic; 5-type c4, heteromorphic. Rozefelds (1998).

22. Filaments: 0-free; 1-connate. Rozefelds (1998) and Rozefelds and Drinnan (2002).

23. Stamen number: 0-<20; 1-usually >20. Rozefelds (1998).

24. Pollen aperture ends: 0-U-shaped; 1-V-shaped. Manos (1997) and Dettmann et al. (1990).

25. Epidermal cell walls: 0-not granular; 1-granular. Hill and Read (1991)

26. Stamen development: 0-centripetal; 1-pseudocentrifugal. Rozefelds and Drinnan (1998).

27. Staminate perianth lobe number: 0-4; 1-6–14. Rozefelds and Drinnan (1998).

28. Staminate perianth shape: 0-narrowly campanulate; 1-broadly campanulate; 2-tubular. Rozefelds and Drinnan (1998).

29. Staminate perianth lobes: 0-prominent; 1-reduced. Rozefelds and Drinnan (1998).

30. Anther distal connective protrusion: 0-absent; 1-present, weakly or strongly developed. Rozefelds (1998); Rozefelds and Drinnan (1998).

31. Cupule vestiture: 0-simple trichomes; 1-densely covered with simple trichomes; 2-glabrous. Hill and Read (1991).

32. Pollen aperture length: 0-4–11 μm; 1->15 μm. Manos (1997).

33. *Cyttaria* lineage A: 0-absent; 1-present. Peterson et al. (2010).

34. *Cyttaria* lineage B: 0-absent; 1-present. Peterson et al. (2010).

35. *Cyttaria* lineage C: 0-absent; 1-present. Peterson et al. (2010).

36. leaf type margin: 0-Dentate 1-Crenate 2-Serrate 3-Smooth 4-Smooth with crenate apex. Modified from Gandolfo and Romero (1992).

37. Teeth: 0-Simple 1-Composite (two or more teeth) Modified from Jordan and Hill (1999).

38. Space between teeth: 0-Regular 1-Irregular. Modified from Gandolfo and Romero (1992).

39. Teeth size: 0-Uniform 1-No uniform. Modified from Gandolfo and Romero (1992).

40. Primary vein: 0-Straight 1-Curved. Modified from Gandolfo and Romero (1992).

41. Number of secondary veins: 0-Between 4-8 pairs 1-Between 8-12 pairs 2-More than 12 pairs. Modified from Gandolfo and Romero (1992).

42. Secondary vein ending: 0-At the tooth 1-At the sinus 2-At the margin. Modified from Gandolfo and Romero (1992).

43. Apex morphology: 0-Acute 1-Rounded. Modified from Gandolfo and Romero (1992).

44. Base morphology: 0-Acute 1-Rounded. Modified from Gandolfo and Romero (1992).

45. Secondary veins: 0-Opposite along midvein 1-Alternate along midvein.

SOM 2. First and last appearance data for *Nothofagus*.

Taxa	FAD	LAD	Age	Reference
Fagaceae	90	0	Turonian	Nixon et al. 2001
Betulaceae	83,6	0	Late Santonian	Sims et al. 1999
Nothofagus subferruginea	47,8	11,63	Middle-upper Eocene/ Middle Miocene	Dusen 1899; Berry 1937; Fosdick et al. 2015
Nothofagus simplicidens	47,8	11,63	Middle-upper Eocene/ Middle Miocene	Dusen 1899; Fosdick et al. 2015
Nothofagus variabilis	47,8	11,63	Middle-upper Eocene/ Middle Miocene	Dusen 1899; Fosdick et al. 2015
Nothofagus serrulata	47,8	11,63	Middle-upper Eocene/ Middle Miocene	Dusen 1908; Fosdick et al. 2015
Nothofagis crenulata	33,9	15,97	Upper Oligocene/ Early Miocene	Dusen 1899; Tanai 1986
Nothofagus antarctica	0	0	Extant	Premoli et al. 2011; Heenan and Smissen 2013
Nothofagus nitida	0	0	Extant	Premoli et al. 2011; Heenan and Smissen 2013
Nothofagus pumilio	0	0	Extant	Premoli et al. 2011; Heenan and Smissen 2013
Nothofagus betuloides	0	0	Extant	Premoli et al. 2011; Heenan and Smissen 2013
Nothofagus dombeyi	0	0	Extant	Premoli et al. 2011; Heenan and Smissen 2013
Nothofagus alessandri	0	0	Extant	Premoli et al. 2011/Heenan and Smissen 2013
Nothofagus solandri	0	0	Extant	Premoli et al. 2011; Heenan and Smissen 2013
Nothofagus fusca	0	0	Extant	Premoli et al. 2011; Heenan and Smissen 2013
Nothofagus gunii	0	0	Extant	Premoli et al. 2011; Heenan and Smissen 2013
Nothofagus procera	0	0	Extant	Premoli et al. 2011; Heenan and Smissen 2013
Nothofagus glauca	0	0	Extant	Premoli et al. 2011; Heenan and Smissen 2013
Nothofagus obliqua	0	0	Extant	Premoli et al. 2011; Heenan and Smissen 2013
Nothofagus cunninghamii	0	0	Extant	Hill and Read 1991; Heenan and Smissen 2013
Nothofagus menziesii	0	0	Extant	Hill and Read 1991; Heenan and Smissen 2013
Nothofagus moorei	0	0	Extant	Hill and Read 1991; Heenan and Smissen 2013
Nothofagus grandis	0	0	Extant	Hill and Read 1991; Heenan and Smissen 2013
Nothofagus brassii	0	0	Extant	Hill and Read 1991; Heenan and Smissen 2013
Nothofagus perryi	0	0	Extant	Hill and Read 1991; Heenan and Smissen 2013
Nothofagus resinosa	0	0	Extant	Hill and Read 1991; Heenan and Smissen 2013
Nothofagus balansae	0	0	Extant	Hill and Read 1991; Heenan and Smissen 2013
Nothofagus aequilateris	0	0	Extant	Heenan and Smissen 2013

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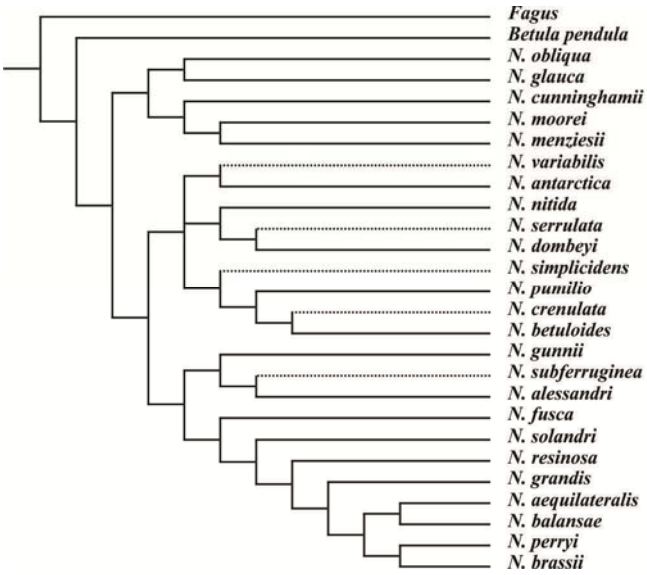
SOM 3. Support measures from time-calibrated tree.

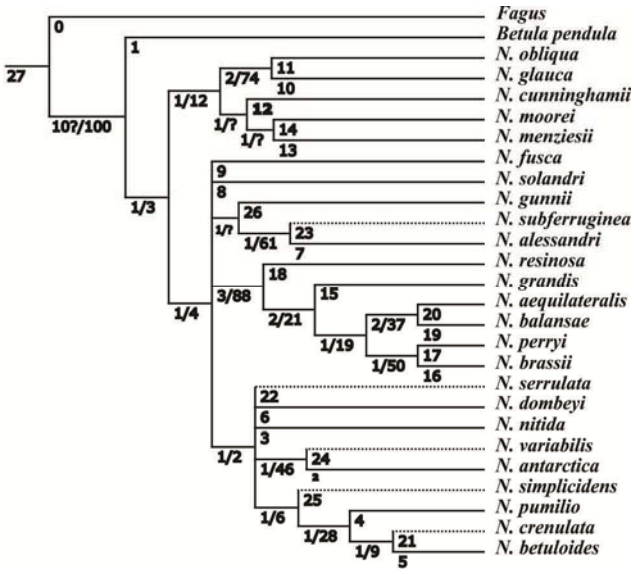
SCI (Stratigraphic Consistency Index	0,76
RCI (Relative Completeness Index)	-49,32
GER (Gap Excess Ratio)	0,79
MSM* (Manhattan Stratigraphic Measure) Pol and Norell (2001)	0,18
est.p.SCI	3,08E-016
est.p.RCI	0,01
est.p.GER	0,05
est.p.MSM*	0,21
GER*	0,98
GERt	0,88
MIG	505,22
p.Wills	0,02

SOM 4. Strict consensus trees.
Fig. A1: Strict consensus of six trees obtained by EWA. Fig. A_2: EWA branch support values (Bremer/Jackknife). Fig. B_1: Strict consensus of two trees obtained by BCA. Fig. B_2: BCA branch support values (Bremer/Jacknife). Fig. C_1: Strict consensus of three trees obtained by IWA using $k = 8$. Fig. C_2: IWA branch support values (Symmetric resampling). Dashed cladogram branches indicate fossil taxa.

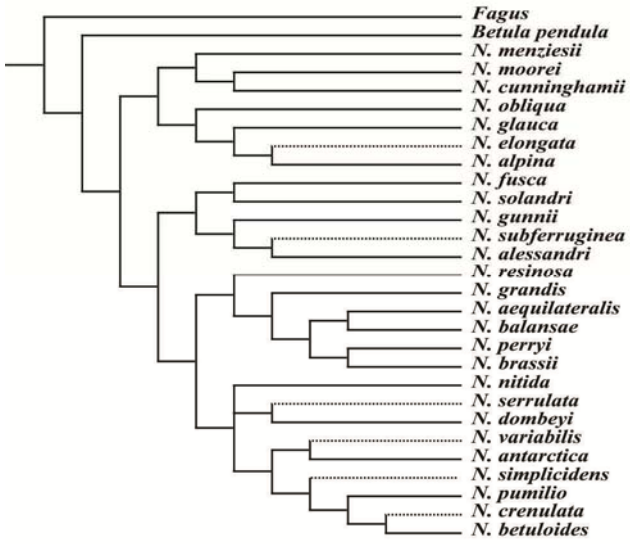
A_1



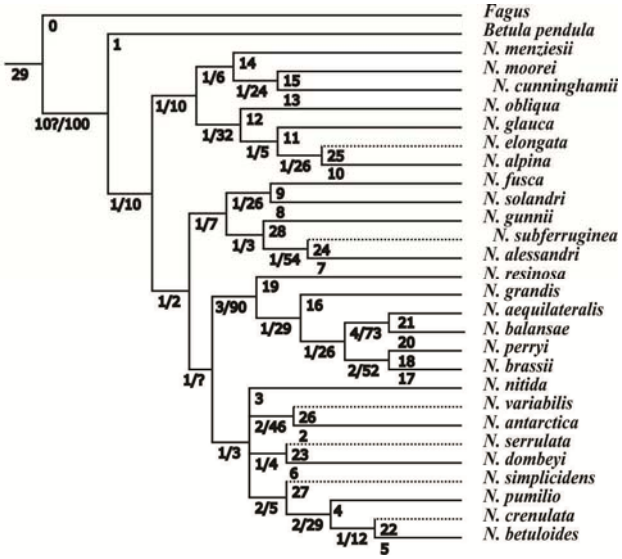
A_2



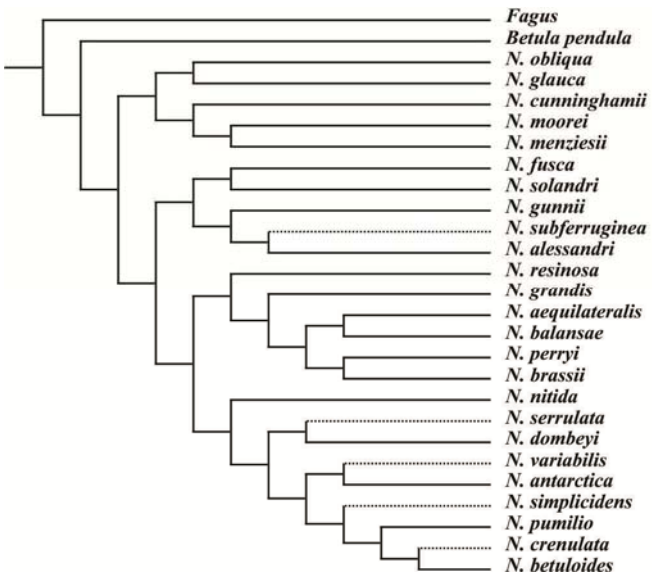
B_1



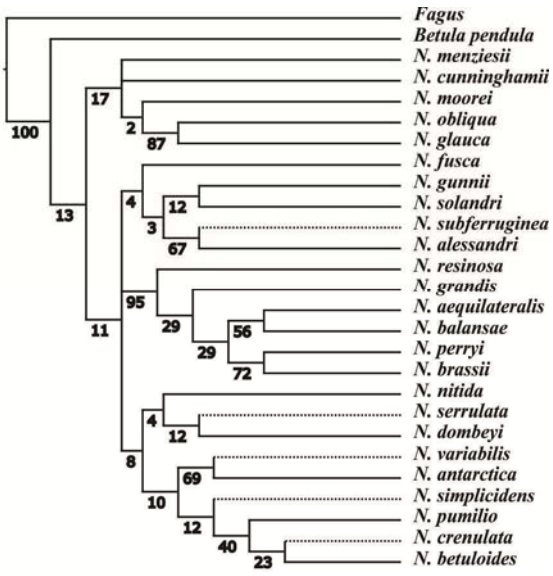
B_2



C_1


Fagus
Betula pendula
N. obliqua
N. glauca
N. cunninghamii
N. moorei
N. menziesii
N. fusca
N. solandri
N. gunnii
N. subferruginea
N. alessandri
N. resinosa
N. grandis
N. aequilateralis
N. balansae
N. perryi
N. brassii
N. nitida
N. serrulata
N. dombeyi
N. variabilis
N. antarctica
N. simplicidens
N. pumilio
N. crenulata
N. betuloides

C_2


Fagus
Betula pendula
N. menziesii
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N. moorei
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N. nitida
N. serrulata
N. dombeyi
N. variabilis
N. antarctica
N. simplicidens
N. pumilio
N. crenulata
N. betuloides
100
17
2
87
13
4
12
3
67
95
29
56
29
72
11
4
12
8
69
10
12
40
23