

SUPPORTING INFORMATION

Evolutionary biogeography of *Manihot* (Euphorbiaceae), a rapidly radiating Neotropical genus restricted to dry environments

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Table S1

List of the samples used for the molecular phylogeny. Specimen identification is given together with herbarium location, collector and collection number, collection place and date. Abbreviations for herbaria: DAV: University of California, Davis. K: Royal Botanic Gardens, Kew, UK. P: Muséum National d'Histoire Naturelle, Paris, France. MO: Missouri Botanical Garden, Saint Louis, MO. NY: New York Botanical Garden, NY. A few species were collected in nature, in French Guiana (“live”). Abbreviations for Brazilian states: BA: Bahia. CE: Ceará. DF: Distrito Federal. GO: Goiás. MG: Minas Gerais. MT: Mato Grosso. PA: Pará. PB: Pernambuco. RO: Rondônia. SP: São Paulo. Abbreviations for Mexican states: COL: Colima. COAH: Coahuila. GRO: Guerrerro. JA: Jalisco. MICH: Michoacán. NA: Nayarit. OA: Oaxaca. PUE: Puebla. SON: Sonora.

| Sample name | Herbarium | Collection place | Collector | Number | Year collected |
|----------------------------------|-----------|--|-----------------------------|--------|----------------|
| <i>Cnidoscolus urens</i> | live | French Guiana, Kourou | McKey | --- | 2002 |
| <i>Jatropha gossypifolia</i> 1 | live | French Guiana | McKey & Léotard | --- | 2004 |
| <i>Jatropha gossypifolia</i> 2 | live | French Guiana | McKey & Léotard | --- | 2005 |
| <i>M. aesculifolia</i> 1 | DAV | Mexico, GRO, Jicayá de Tovar | de Avila | 551 | 1988 |
| <i>M. aesculifolia</i> 2 | DAV | Mexico, NA, El Llano | Webster | 17097 | 1972 |
| <i>M. alutacea</i> 1 | MO | Brazil, GO | Aparecida da Silva | 1922 | --- |
| <i>M. alutacea</i> 2 | K | Brazil | Pirani | --- | 1987 |
| <i>M. alutacea</i> 3 | MO | Brazil, GO, Cavalcante | Allem & Werneck | 3667 | 1986 |
| <i>M. angustiloba</i> 1 | P | Mexico, MICH, Churintzio | Labat | 1813 | 1986 |
| <i>M. angustiloba</i> 2 | DAV | Mexico, SON, Yécora | Torres & Tenorio | 3872 | 1991 |
| <i>M. anomala</i> 1 | MO | Bolivia, Santa Cruz, Ñuflo de Cháves | Neffa et al. | 1113 | 2004 |
| <i>M. anomala</i> 2 | P | Brazil, GO | Weddell | 184 | 1844 |
| <i>M. anomala</i> 3 | P | Brazil, GO, Alexânia | Allem & Werneck | 3651 | 1986 |
| <i>M. attenuata</i> | MO | Brazil, GO | Marquete et al. | 2739 | --- |
| <i>M. baccata</i> | NY | Brazil, MA, Santa Luzia | Allem & Silva | 4465 | 1998 |
| <i>M. brachyandra</i> | NY | Brazil, BA, Abaíra | Harley, Lughahda & Queiroz | 50515 | 1992 |
| <i>M. brachyloba</i> (♀ cassava) | live | French Guiana, Saül | Mangenet | --- | 2007 |
| <i>M. brachyloba</i> 1 | MO | Brazil, PA, Baía do Sol | Maas, Texeira & Koek-Noorma | 7791 | 1990 |
| <i>M. brachyloba</i> 2 | K | Brazil | Maas | 7791 | 1990 |
| <i>M. caerulescens</i> 1 | P | Brazil, BA, Senhor do Bonfim | Harley | 16349A | 1874 |
| <i>M. caerulescens</i> 2 | P | Brazil, BA, Palmeiras | Allem & Vieira | 1779 | 1979 |
| <i>M. carthaginensis</i> 1 | MO | Colombia, Cartagena | Cuadros | 4525 | 198X |
| <i>M. carthaginensis</i> 2 | DAV | Venezuela, Falcón, Paraguaná, Punto Fijo | van der Werff | 3528 | 1979 |
| <i>M. caudata</i> | P | Mexico, JA | Diguet | 286 | --- |
| <i>M. cecropiafolia</i> 1 | MO | Brazil, DF | Vieira & Werneck | --- | 1981 |
| <i>M. cecropiafolia</i> 2 | P | Brazil, GO, Niquelândia | Allem | 2823 | --- |
| <i>M. cecropiafolia</i> 3 | P | Brazil, GO | Glaziou | 22139 | 1895 |
| <i>M. cecropiafolia</i> 4 | P | Brazil, GO, Niquelândia | Allem | 2827 | 1982 |
| <i>M. chlorosticta</i> | MO | Mexico, JA | Gentry | 74473 | 1991 |
| <i>M. compositifolia</i> | NY | Brazil, BA, Buerarema | Allem | 3365 | 1985 |
| <i>M. dichotoma</i> 1 | P | Brazil, SP, Campinas | Cruz | 110 | 1965 |
| <i>M. dichotoma</i> 2 | P | Brazil, BA, near Manoel Vitorino; cultivated | Allem | 4525 | --- |

Table S1 (continued)

| Sample name | Herbarium | Collection place | Collector | Number | Year collected |
|---|-----------|--|------------------------------|--------|----------------|
| <i>M. epruinosa</i> 1 | P | Brazil, PB, Salgueiro | Allem & Werneck | 3319 | 1985 |
| <i>M. epruinosa</i> 2 | P | Brazil, BA, Ibotirama | Allem, Webster & Werneck | 3018 | 1984 |
| <i>M. esculenta</i> ssp. <i>esculenta</i> (cassava) 1 | CIAT | common cassava landrace | --- | --- | --- |
| <i>M. esculenta</i> ssp. <i>esculenta</i> (cassava) 2 | live | French Guiana, Sinnamary | Duputié | --- | 2004 |
| <i>M. esculenta</i> ssp. <i>esculenta</i> (cassava) 3 | live | French Guiana, Savane Matiti | Duputié | --- | 2005 |
| <i>M. esculenta</i> ssp. <i>flabellifolia</i> 1 | live | French Guiana, Savane Matiti | Duputié | --- | 2006 |
| <i>M. esculenta</i> ssp. <i>flabellifolia</i> 2 | CIAT | Brazil | --- | --- | --- |
| <i>M. esculenta</i> ssp. <i>peruviana</i> | MO | Peru | Chrostowski | 70254 | --- |
| <i>M. flemingiana</i> | P | Brazil, GO, Miranorte | Allem & Werneck | 3612 | 1986 |
| <i>M. fruticulosa</i> | NY | Brazil, GO, Alexânia | Allem & Werneck | 3639 | 1986 |
| <i>M. glaziovii</i> 1 | live | French Guiana, Sinnamary; in cultivation | McKey & Léotard | --- | 2004 |
| <i>M. glaziovii</i> 2 | P | Brazil, CE, Belém do Machado | Cruz | 117 | 1965 |
| <i>M. gracilis</i> | DAV | Brazil, MG | Romero et al. | 2888 | 1996 |
| <i>M. grahami</i> | P | Argentina, Puerto Piray | Renvoize & Wilmot-Dear | 3177 | --- |
| <i>M. guaranitica</i> (?) | P | Paraguay. Cultivated for its edible root; probably cassava | Belausa | 1717 | 1876 |
| <i>M. guaranitica</i> 1 | NY | Argentina, Formosa | Maranta | 371 | 1983 |
| <i>M. guaranitica</i> 2 | NY | Brazil, MS, Corumbá | Webster | 25317 | 1984 |
| <i>M. hunzikeriana</i> | MO | Paraguay, Alto Paraná | Schinini & Caballero Marmori | 27215 | 1990 |
| <i>M. irwinii</i> 1 | DAV | Brazil, GO | Anderson | 7871 | 1987 |
| <i>M. irwinii</i> 2 | P | Brazil, GO, Corumbá | Allem, Vieira & Werneck | 2829 | 1982 |
| <i>M. januarensis</i> | P | Brazil, MG, Itacarambi | Allem | 4581 | 1998 |
| <i>M. leptophylla</i> | P | Peru, Arequipa, Puerto Maldonado | Smith et al. | 1426 | 1989 |
| <i>M. maracasensis</i> 1 | NY | Brazil, BA, Andaraí | Allem | 2955 | 1984 |
| <i>M. maracasensis</i> 2 | P | Brazil, BA, Andaraí | Allem, Webster & Werneck | 2956 | 1984 |
| <i>M. maracasensis</i> 3 | DAV | Brazil, BA | Allem, Webster & Werneck | 2978 | 1984 |
| <i>M. maracasensis</i> 4 | K | Brazil, BA, Andaraí | Allem | 2957 | 1984 |
| <i>M. marajoara</i> | K | French Guiana | Harley | 24772 | 1988 |
| <i>M. michaelis</i> | P | Mexico, COL, Colima | Jancey | --- | 1965 |
| <i>M. mossamedensis</i> | P | Brazil, GO, Formosa | Allem, Webster & Werneck | 4039 | --- |
| <i>M. oaxacana</i> | DAV | Mexico, OA | Webster, Miller & Miller | 12955 | 1962 |
| <i>M. orbicularis</i> 1 | P | Brazil, GO, Cavalcante | Allem & Werneck | 3474 | 1986 |
| <i>M. orbicularis</i> 2 | K | Brazil, GO, Colinas do Sul | Allem | 3471 | 1986 |
| <i>M. orbicularis</i> 3 | P | Brazil, GO | Allem | 4373 | |
| <i>M. peltata</i> | P | Brazil, GO, Alto Paraíso | Allem | 4091 | |
| <i>M. pilosa</i> 1 | P | Brazil, MG, Mariana | Allem & Werneck | 3390 | 1986 |
| <i>M. pilosa</i> 2 | MO | Brazil, BA | Thomas | 9060 | 1992 |
| <i>M. pilosa</i> 3 | P | Brazil, MG, Piraúba | Allem & Werneck | 3395 | 1986 |
| <i>M. pohlii</i> | K | Brazil | Pirani | 2939 | 1994 |
| <i>M. pruinosa</i> 1 | P | Brazil, MT | Harley et al. | 10583 | 1968 |

Table S1 (continued)

| Sample name | Herbarium | Collection place | Collector | Number | Year collected |
|-----------------------------|-----------|------------------------------------|-------------------------|--------|----------------|
| <i>M. pruinosa</i> 2 | P | Brazil, GO, Ipora | Allem, Vieira & Werneck | 2803 | 1982 |
| <i>M. purpureocostata</i> 1 | MO | Brazil | Cavalcanti | 1391 | --- |
| <i>M. purpureocostata</i> 2 | MO | Brazil | Fonseca | 549 | --- |
| <i>M. purpureocostata</i> 3 | P | Brazil, GO, Cavalcante | Allem & Werneck | 3666 | 1986 |
| <i>M. pusilla</i> | P | Brazil, DF, Gama | Allem & Werneck | 3635 | 1986 |
| <i>M. quinqueloba</i> 1 | DAV | Brazil, GO | Machado et al. | 2998 | 1996 |
| <i>M. quinqueloba</i> 2 | P | Brazil | Glaziou | 22133 | 1895 |
| <i>M. quinqueloba</i> 3 | P | Brazil, GO, Niquelândia | Allem | 4183 | --- |
| <i>M. quinquepartita</i> 1 | P | Brazil, RO, Cacoal | Allem & Werneck | 3548 | 1986 |
| <i>M. quinquepartita</i> 2 | live | French Guiana, Saül | McKey & Ménard | --- | 2006 |
| <i>M. quinquepartita</i> 3 | live | French Guiana, Saül | McKey & Ménard | --- | 2006 |
| <i>M. sagittatopartita</i> | DAV | Brazil, GO, Niquelândia | Fonseca | 1385 | 1996 |
| <i>M. salicifolia</i> 1 | MO | Brazil, GO, Alexânia | Allem | 3640 | --- |
| <i>M. salicifolia</i> 2 | P | Brazil, GO, Uruaçu | Allem, Vieira & Werneck | 2665 | 1980 |
| <i>M. salicifolia</i> 3 | NY | Brazil, DF, Rio | Maguire | 56496 | 1963 |
| <i>M. sparsifolia</i> 1 | P | Brazil, GO, Niquelândia | Allem & Werneck | 3473 | 1986 |
| <i>M. sparsifolia</i> 2 | K | Brazil, GO, Niquelândia | Allem | 2814 | 1982 |
| <i>M. subspicata</i> | NY | Mexico, NL, Mamulique | Rogers | 525 | 1968 |
| <i>M. surinamensis</i> 1 | P | Guyana, Rupununi, Shea Rock | Jansen-Jacobs et al. | 4826 | 1995 |
| <i>M. surinamensis</i> 2 | MO | Guyana | Jansen-Jacobs et al. | 4827 | 1995 |
| <i>M. surinamensis</i> 3 | K | Guyana, Rupununi, Shea Rock | Jansen-Jacobs et al. | 4825 | 1995 |
| <i>M. tomatophylla</i> | NY | Mexico, COAH, Arteaga | Steinmann & Werneck | 1657 | 2001 |
| <i>M. tomentosa</i> 1 | MO | Brazil | Aparecida da Silva | 2426 | --- |
| <i>M. tomentosa</i> 2 | P | Brazil, GO, Salto de Itiquira | Allem & Werneck | 3654 | 1986 |
| <i>M. tomentosa</i> 3 | P | Brazil, GO | Allem & Werneck | 3630 | 1986 |
| <i>M. tripartita</i> | MO | Brazil, DF | Irwin et al. | 26717 | 1970 |
| <i>M. tristis</i> 1 | P | Brazil, GO, 24 km N of Niquelândia | Allem & Werneck | 3468 | 1986 |
| <i>M. tristis</i> 2 | K | French Guiana | de Granville | 12931 | 1995 |
| <i>M. violacea</i> 1 | P | Brazil, GO, Alexânia | Allem, Vieira & Werneck | 2697 | 1980 |
| <i>M. violacea</i> 2 | P | Brazil, BA, Lençóis | Allem | 2975 | 1984 |
| <i>M. violacea</i> 3 | P | Brazil, GO, Goiás Velho | Allem Vieira Werneck | 2652 | 1980 |
| <i>M. websterae</i> | DAV | Mexico, PUE, Izúcar de Matamoros | Webster & Ambruster | 20730 | 1976 |
| <i>M. zehntneri</i> | MO | Brazil, MG | Allem & Werneck | 3400 | --- |

Figure S1

Phylogeny of *Manihot*, based on the sequences of all three genes. This phylogeny therefore includes only 59 specimens. The tree shown here was obtained through a Bayesian analysis; the tree obtained by maximum likelihood had a similar topology. Posterior probabilities are indicated next to the nodes. No branch was collapsed.

Comparison of this figure with Figure 1 of the main text shows that the addition of *trnC–D* to the dataset does not modify the overall topology. Mesoamerican species form a grade, and species from South America are derived.

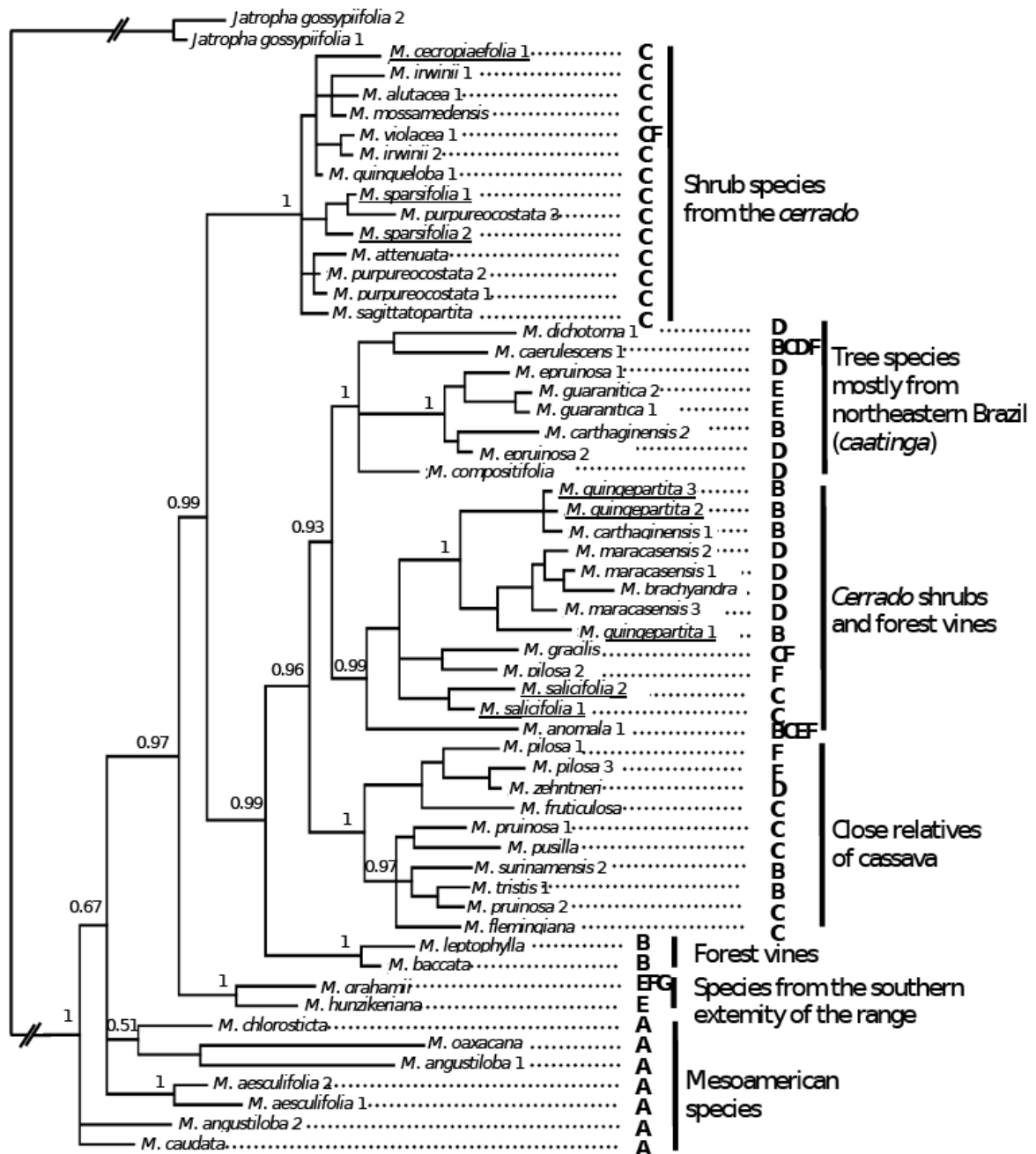


Figure S2

Reconstruction of character history: a) growth habit, b) fruit dehiscence, c) size of the elaiosome, d) seed size, e) presence of a starchy root or tuber, f) habitat.

Figure S2a

Reconstruction of the character “growth habit”, mapped onto the Bayesian tree. Posterior probability and bootstrap percentages for the ML reconstruction are shown next to the nodes (to the left and right, respectively, of the diagonal slash). Red: shrub; blue: tree; green: vine. Reconstruction method: parsimony. Viny growth habit has evolved at least three times independently (and a fourth time if we consider *M. esculenta* ssp. *flabellifolia* as a vine, which it can become when the surrounding vegetation becomes dense). The tree growth habit also evolved several times.

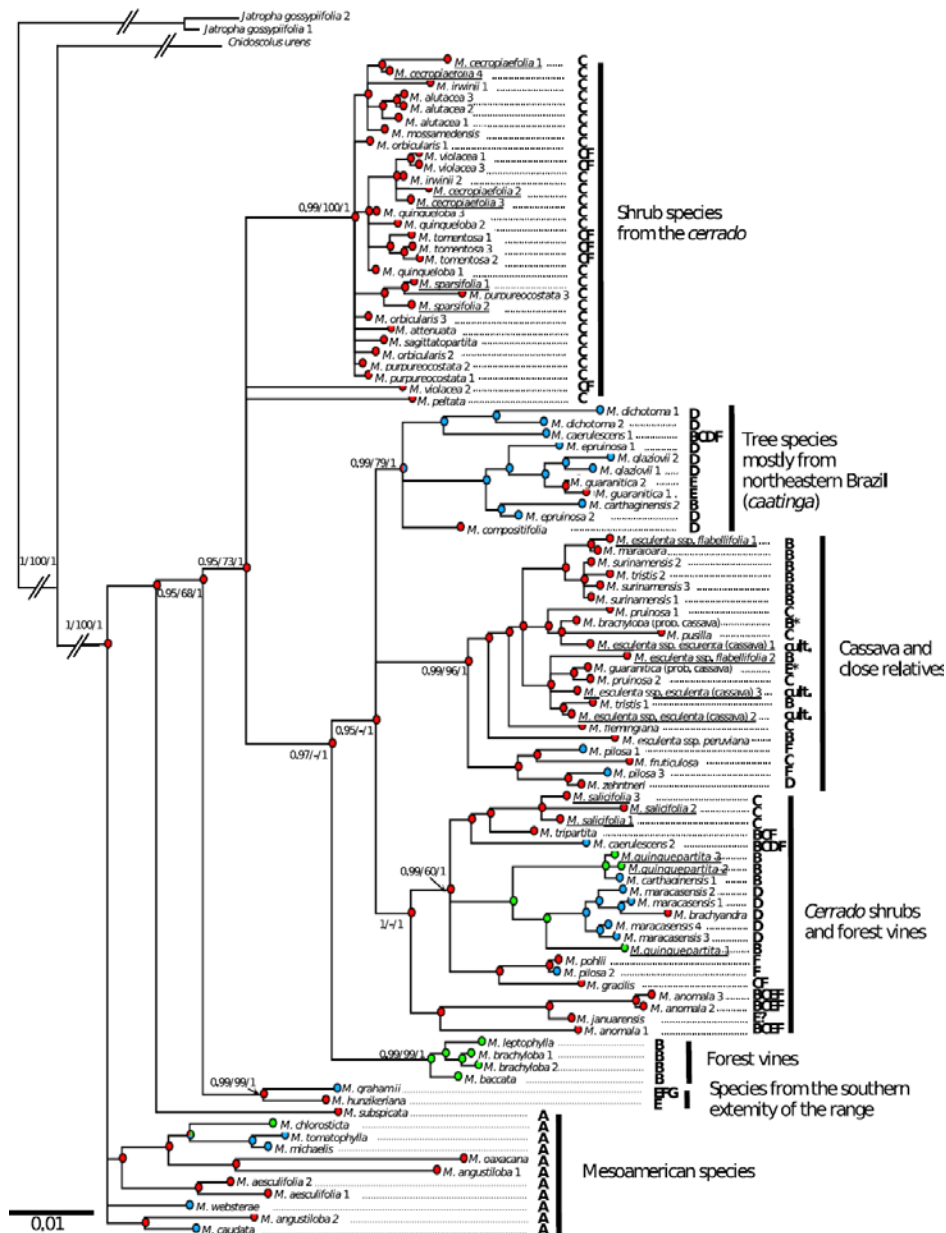


Figure S2b

Reconstruction of the character “fruit dehiscence”, mapped onto the Bayesian tree. Posterior probability and bootstrap percentages for the ML reconstruction are shown next to the nodes (to the left and right, respectively, of the diagonal slash). Red: dehiscent fruit; blue: indehiscent fruit; white: missing data. Reconstruction method: maximum likelihood, Mk1 model. Like the viny growth form, fruit indehiscence evolved at least three times independently, in taxa associated with forest-gap habitats.

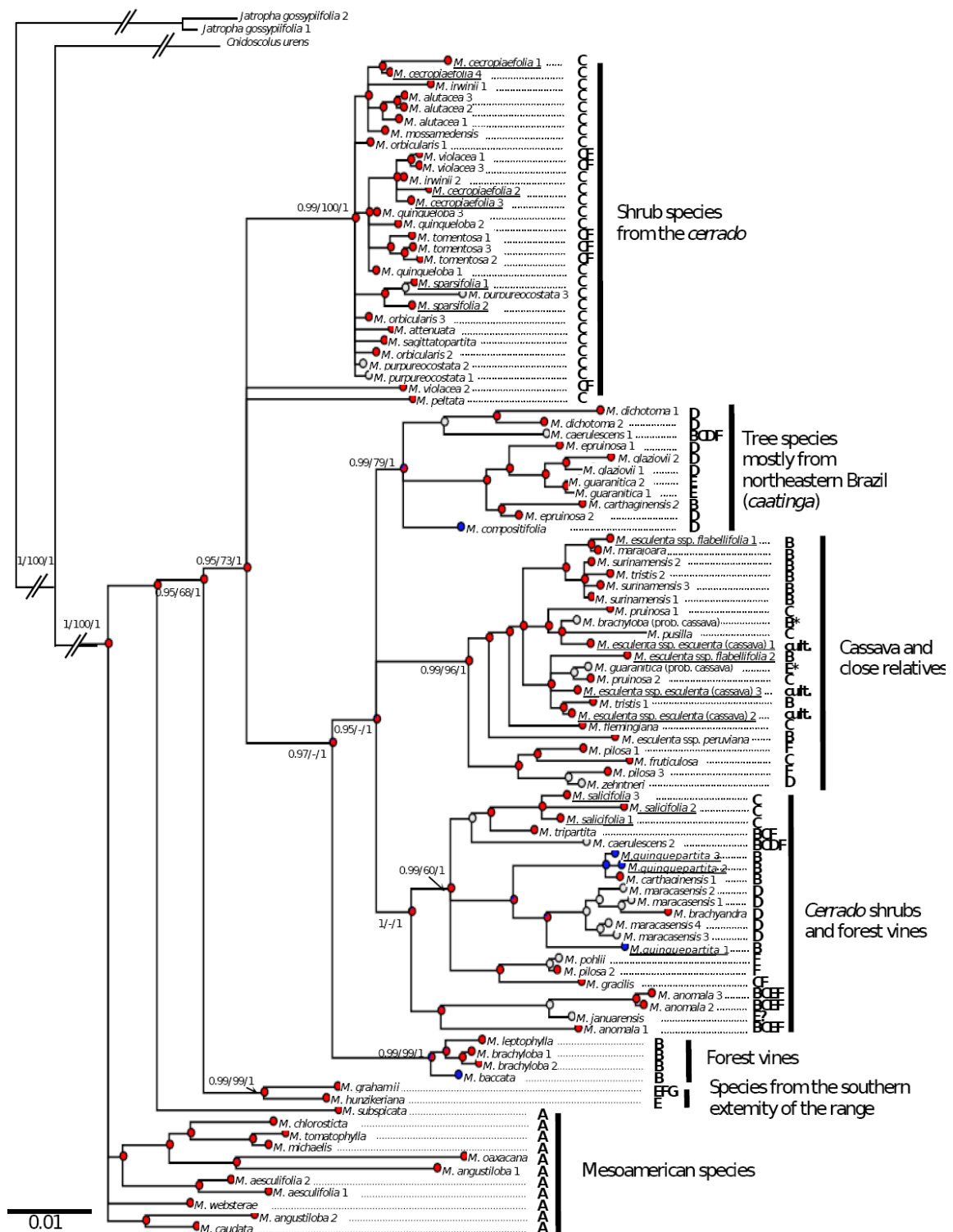


Figure S2c

Reconstruction of the character “elaiosome”, mapped onto the Bayesian tree. Red: inconspicuous elaiosome; light blue: moderately developed elaiosome; dark blue: conspicuous elaiosome; white: missing data. Reconstruction method: parsimony.

Within the clade of south American species, reduction in size of the elaiosome occurred several times.

A limitation of this analysis is that the functionality of the elaiosome (that is, its capacity to attract dispersing ants) is unknown for most species, notably for those recorded as having “inconspicuous” elaiosomes.

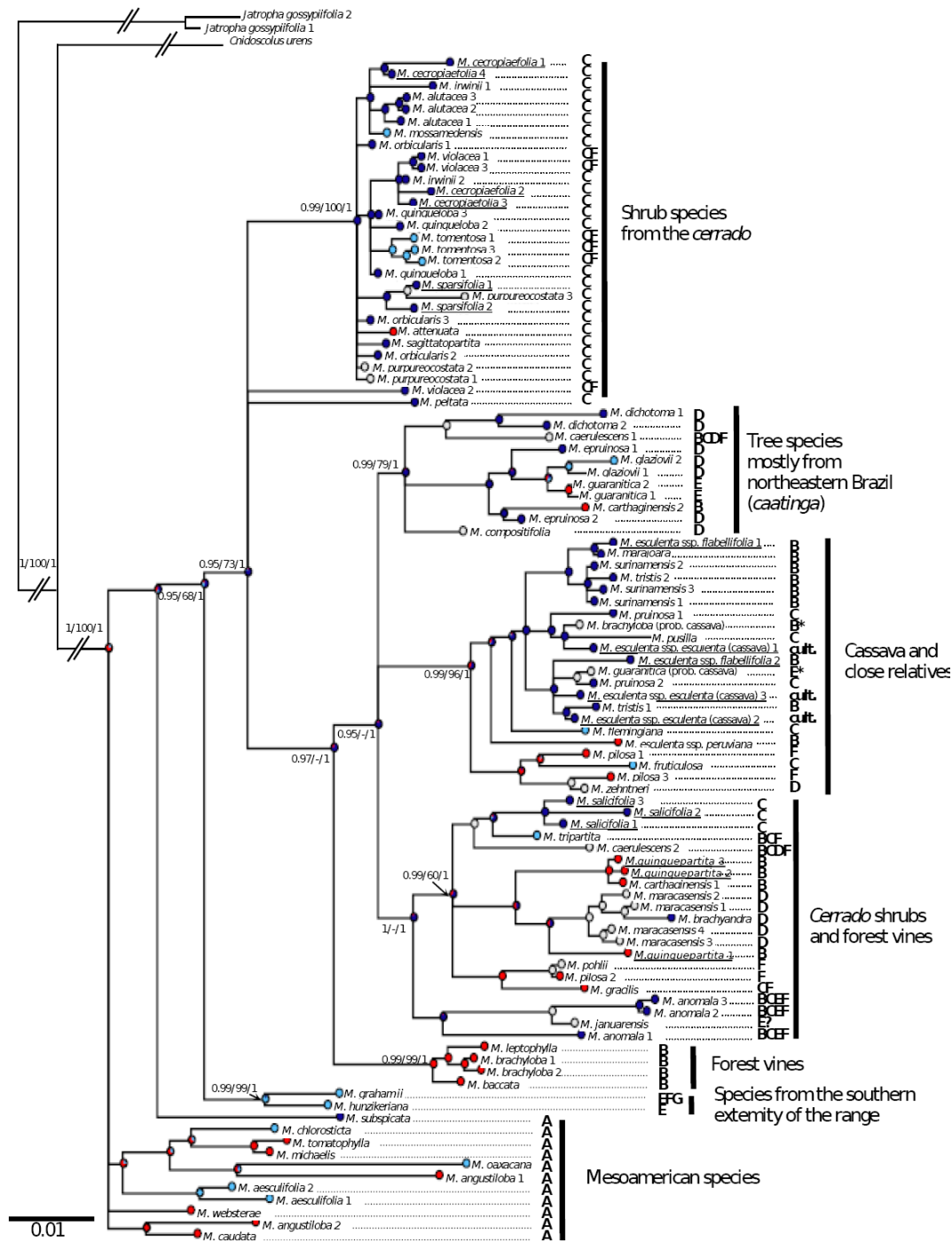


Figure S2d

Reconstruction of the character “seed size”, mapped onto the Bayesian tree. Red: small seeds (seed length < 1 cm); blue: large seeds (> 1 cm). Reconstruction method: likelihood, Mk1 model. Seed size is also very labile, both in Mesoamerican and South American species.

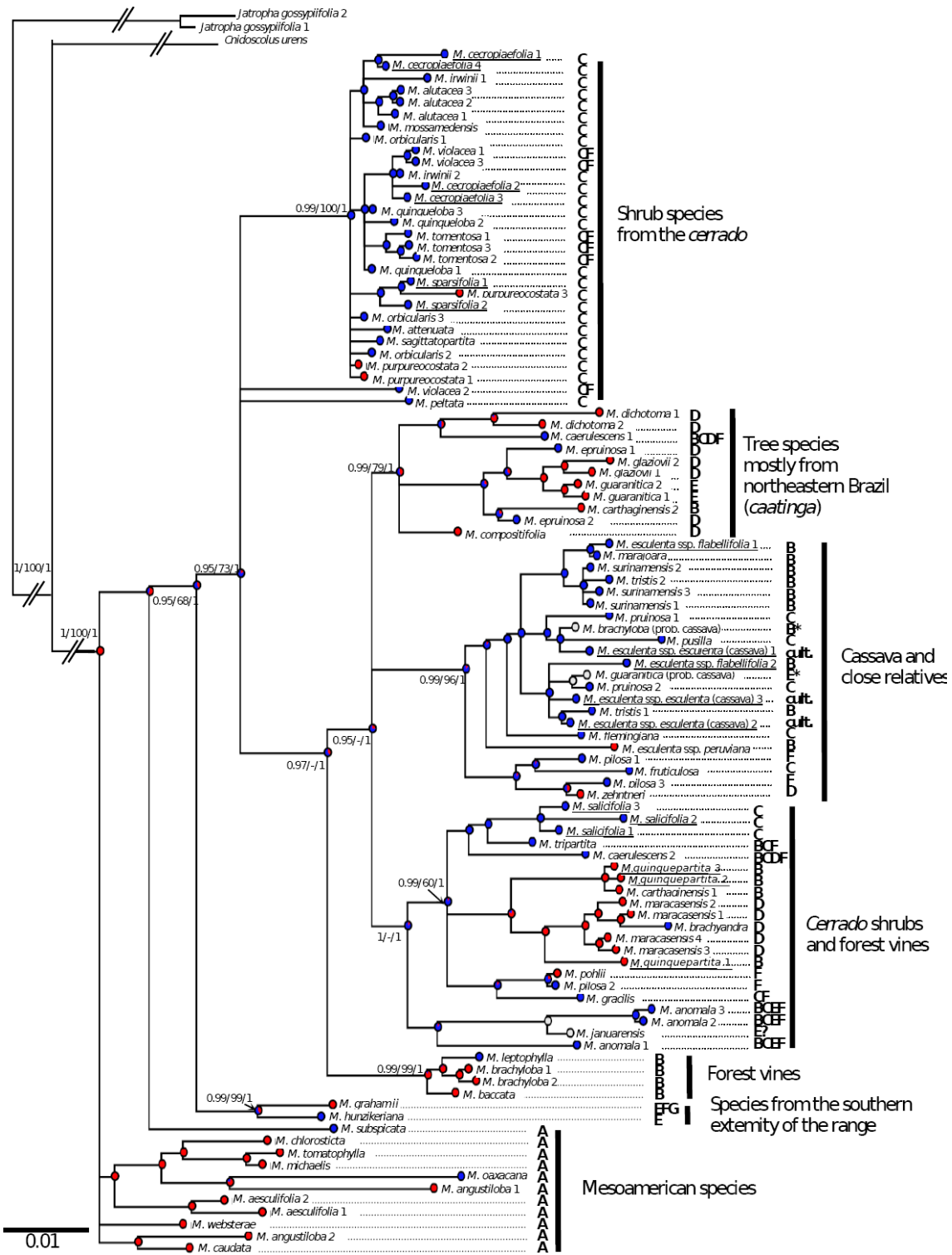


Figure S2e

Reconstruction of the character “presence of a starchy root or tuber”, mapped onto the Bayesian tree. Red: presence of a tuber or reserve root; blue: no such reserve organs; white: missing data. Reconstruction method: likelihood, Mk1 model.

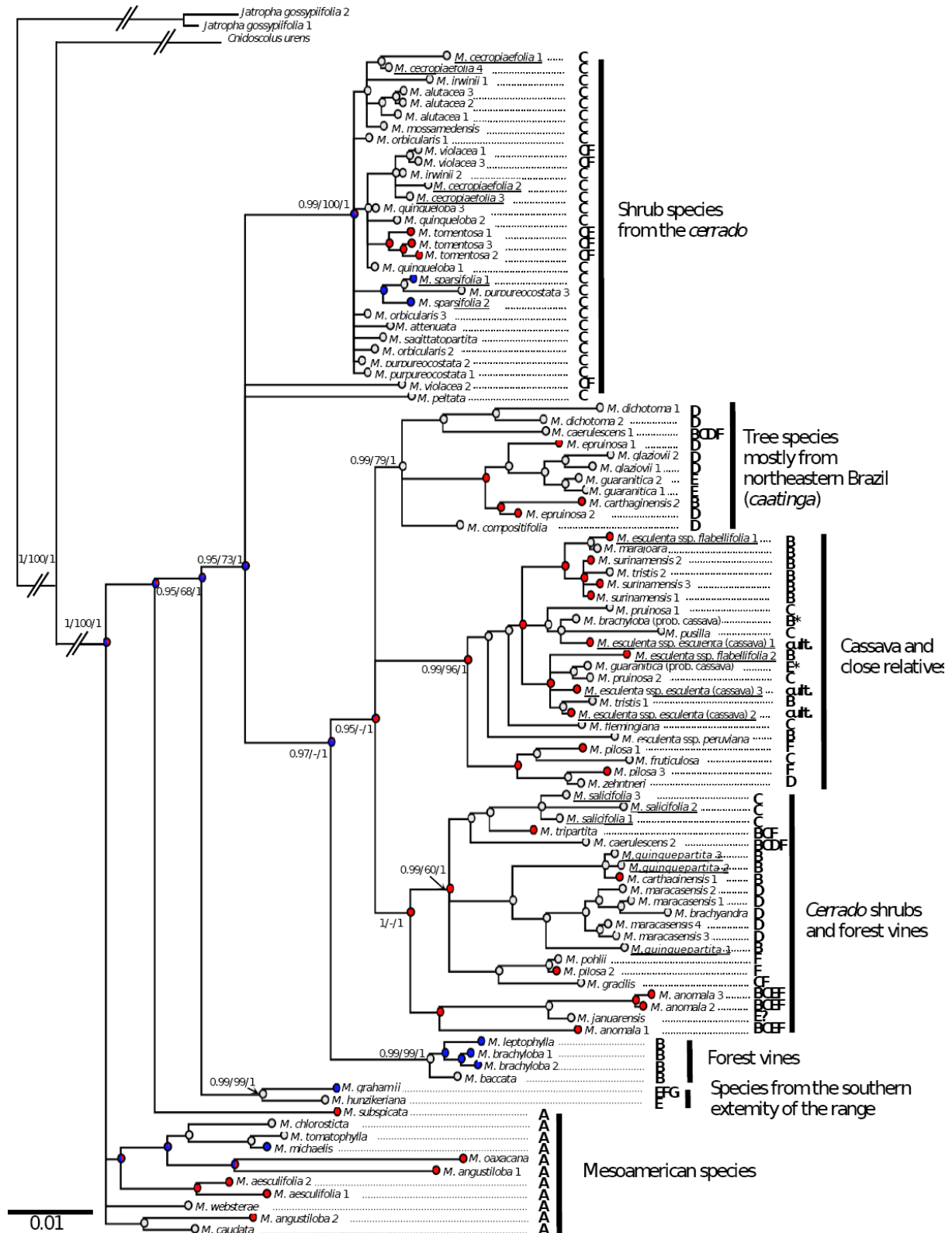


Figure S2f

Character reconstruction for habitat, mapped onto the Bayesian tree. Red: cerrado. Orange: on rocks in the cerrado or other savannas. Blue: caatinga. Yellow: savannas other than cerrado. Green: forest or forest-savanna ecotones. Black: cultivated. Reconstruction method: maximum parsimony.

