



**Fig. 4a.** Ancestral state reconstructions for (1) cyathial gland merosity, (2) gland appendages, (3) caruncle, (4) growth form, (5) phyllotaxy, and (6) inflorescence position in *Euphorbia* and Euphorbioideae outgroups. Ancestral states for each character were estimated using likelihood optimizations across a randomly selected subset of 1000 post burn-in trees from the Bayesian inference analysis of the combined data set and plotted onto the 95% majority rule tree of the complete set of post burn-in trees. Pie charts at each node represent the proportion of trees in which the optimizations indicated were present, given a likelihood decision threshold of 2.0 (>2 log units better than the raw likelihood value(s) of the other states). Shown here are optimizations for Euphorbioideae outgroups and *Euphorbia* subgenus *Esula*; continued in Figs. 4b and 4c.

the root, the root of Clade C + D, and at the root nodes of Clades A, C, and D. The asymmetrical model of character evolution we used to optimize this trait favors a scenario of multiple, independent gains of caruncles within both Clades C and D; caruncles are absent from Clade A (Figs. 4b and 4c). In contrast, caruncles are present in all but one species we scored from Clade B, but they are reconstructed as unequivocally present at the root node of this clade in just over half of trees that we examined (Fig. 4a; present: 521, equivocal: 479).

Trees and shrubs are reconstructed as the ancestral growth form (Character 4) at all deep nodes within the phylogeny, including all backbone nodes of *Euphorbia* (root node of *Euphorbia*, woody: 937, equivocal: 63). Among the subgeneric clades, a transition to the herbaceous habit is likely to be a synapomorphy for Clade B (Fig. 4a). A non-succulent, woody growth form is the ancestral state at the root nodes of Clades A and C (Figs. 4b and 4c). The root node of Clade D is woody in just over half of the reconstructions, but equivocal in the rest (Fig. 4c; woody: 529, equivocal: 471).