

Table S4. Tree lengths for alternative topological hypotheses, number of steps longer than the less constrained topology, and *P* values from non-parametric Templeton tests (first tree of each tree file only), with steps between ‘fixed’ and ‘polymorphic’ states in ordered multistates weighted as 0.5. Constrained topologies: 1) Molecular scaffold alone; 3) Anthracobunidae constrained to join Paenungulata; 4) Desmostylia constrained to join Paenungulata; 5) *Eritherium* and *Phosphatherium* constrained to be stem proboscideans (cf. Gheerbrant 2012); and 6) *Cambaytherium* constrained to join anthracobunids to the exclusion of crown perissodactyls (See Fig. S5 for topologies).

Constraint	Length	Length difference	<i>P</i>	Anthracobunid sister taxon	Position of Desmostylia
1	3704.5	-	-	Crown Perissodactyla	Stem Perissodactyla
3	3711	6.5	0.7633	<i>Cambaytherium</i>	Stem Sirenia
4	3708	3.5	0.8072	Crown Perissodactyla	Stem Sirenia
5	3710	5.5	0.3104	Crown Perissodactyla	Stem Perissodactyla
6	3707.5	3	0.7466	Perissodactyla, unresolved	Perissodactyla, unresolved