Table S1. Simulations of strong among-clade substitution rate variation: estimates of age of broom crown node. The ‘true’ (simulated) age of the broom crown node is 25 Ma. The upper and lower values represent the 95% BCIs from BEAST.

| Birth-death model | Uncorrelated lognormal (UCLN) clock | Random local clocks (RLC) | Tree size (#tips) |
|-------------------|-------------------------------------|---------------------------|------------------|
|                   | Mean      | Lower  | Upper   | Mean      | Lower  | Upper   | Bush | Broom | Tree |
| Tree 1            | 4.3898    | 3.3359 | 5.8821  | 21.3570   | 12.5507| 34.8548 | 21   | 8     | 29   |
| 2                 | 4.9736    | 2.9500 | 7.6157  | 30.1473   | 19.0482| 41.8640 | 13   | 17    | 30   |
| 3                 | 3.8854    | 2.1107 | 5.8598  | 30.1382   | 19.8739| 38.5784 | 10   | 22    | 32   |
| 4                 | 4.0507    | 2.6852 | 5.6188  | 31.2605   | 19.4952| 40.2527 | 10   | 23    | 33   |
| 5                 | 3.596     | 0.9990 | 7.4140  | 29.3506   | 17.9086| 38.2796 | 31   | 4     | 35   |
| 6                 | 4.6116    | 1.8907 | 11.3034 | 29.4219   | 16.4058| 42.2400 | 11   | 11    | 22   |
| 7                 | 4.8263    | 2.0299 | 11.0917 | 29.3311   | 16.3736| 40.0179 | 6    | 13    | 19   |
| 8                 | 3.1049    | 1.8206 | 4.4384  | 20.9054   | 11.3086| 34.0304 | 6    | 20    | 26   |
| 9                 | 3.7666    | 2.7397 | 4.9016  | 32.2281   | 21.2457| 39.5230 | 14   | 28    | 42   |
| 10                | 3.9043    | 2.0976 | 5.8400  | 29.6382   | 19.0891| 37.8991 | 10   | 21    | 31   |
| Mean all trees    | 4.1109    | 2.2659 | 6.9966  | 28.3778   | 17.3299| 38.7540 |      |       |      |
| Yule model        |           |        |         |           |        |         |      |       |      |
| Tree 1            | 4.4294    | 3.2375 | 5.7842  | 27.9442   | 14.8074| 41.0589 | 21   | 8     | 29   |
| 2                 | 5.4678    | 3.5517 | 8.0696  | 34.9647   | 23.3738| 43.3503 | 13   | 17    | 30   |
| 3                 | 4.8769    | 2.8928 | 8.0410  | 33.5540   | 23.7047| 39.6243 | 10   | 22    | 32   |
| 4                 | 4.5256    | 3.2146 | 6.2645  | 28.8422   | 18.6666| 38.1780 | 10   | 23    | 33   |
| 5                 | 3.6056    | 1.2237 | 7.9621  | 28.9050   | 17.8108| 35.5290 | 31   | 4     | 35   |
| 6                 | 5.9209    | 2.3499 | 17.5212 | 31.0299   | 18.7476| 43.0976 | 11   | 11    | 22   |
| 7                 | 6.6250    | 2.4529 | 24.8610 | 25.2272   | 14.8151| 37.2683 | 6    | 13    | 19   |
| 8                 | 4.0330    | 2.6144 | 6.1761  | 25.0006   | 14.9336| 36.9937 | 6    | 20    | 26   |
| 9                 | 4.3842    | 3.3293 | 5.7383  | 28.3256   | 19.0340| 37.1197 | 14   | 28    | 42   |
| 10                | 5.2411    | 2.6502 | 13.6818 | 30.3407   | 20.6046| 38.0061 | 10   | 21    | 31   |
| Mean all trees    | 4.9110    | 2.7517 | 10.4100 | 29.4134   | 18.6498| 39.0226 |      |       |      |
**Table S2.** Clock rates in substitutions/site/Myr x 10^{-4}: Mean (95% BCI) estimated by BEAST under each clock model for selected clades. Rates for whole trees (monocots and Xanthorrhoeaceae) are values of the ‘meanRate’ parameter and its 95% HPD calculated in Tracer from the BEAST log file (post-burnin) under the preferred models for tree-growth (Yule in every case), and estimated separately for each clock and each partition (where BF tests supported partitioning). Rates for selected clades within Xanthorrhoeaceae (remaining rows of table) are the mean and 95% confidence interval of the ‘rate median’ parameter values across all branches within the target clade, as plotted on the annotated maximum clade credibility tree using FigTree v1.4.0 (Rambaut 2012). As Xanthorrhoea stem is a single node, its rate median value and 95% HPD values are presented instead. There are no data for the RLC clock from the Monocots-cpDNA dataset because the analyses did not reach stationarity.

| Dataset       | Monocots-cpDNA          | Xanthorrhoeaceae-cpDNA | Xanthorrhoeaceae-rpb2 |
|---------------|-------------------------|------------------------|-----------------------|
|               | Clock                   | Partition              |                       |                       |                       |                       |                       |
|               | UCLN                    | ndhF                   | noncoding             | UCLN                  | RLC                    | UCLN                  | RLC                    |
| Monocots      | 10.7 (9.7-11.7)         | all                    | 7.5 (6.3-8.7)         | 6.4 (5.1-7.7)         | 15.4 (10.7-20.9)       | 69.8 (50.7-88.6)      | 8.2 (5.8-10.9)         | 35.6 (25.8-45.2)       |
| Xanthorrhoeae | -                       | -                      | 2.1 (1.1-3.5)         | 2.0 (0.2-14.3)        | 15.0 (7.4-27.1)        | 53.4 (21.2-107.2)     | 15.2 (11.5-19.5)       | 70.7 (58.3-85.7)       |
| Xanthorrhoea  | -                       | -                      | 5.0 (4.7-5.4)         | 0.69 (0.68-0.70)      | 14.2 (14.1-14.2)       | 24.0 (22.6-25.4)      | 1.2 (1.0-1.3)          | 3.2 (2.8-3.6)          |
| crown         | -                       | -                      | -                     | -                     | -                      | -                     | -                      |                       |
| X. gracilis + | -                       | -                      | -                     | -                     | -                      | -                     | -                      |                       |
| X. macronema  | 14.2 (13.8-14.5)        | -                      | -                     | -                     | 27.2 (21.4-33.0)       | -                     | -                      | -                      |
| Rest of      | -                       | -                      | -                     | -                     | -                      | -                     | -                      | -                      |
| Xanthorrhoea  | 14.2 (14.1-14.3)        | -                      | -                     | -                     | 23.7 (22.2-25.2)       | -                     | -                      | -                      |
| Hemerocallid- | -                       | -                      | 6.8 (5.9-7.8)         | 6.7 (6.5-7.0)         | 14.9 (14.1-15.7)       | 53.2 (20.8-85.7)      | 15.2 (15.2-15.2)       | 70.7 (70.7-70.7)       |
| oideae        | -                       | -                      |                       |                       |                       |                       |                       |                       |
| Asphodeloideae| -                       | -                      | 9.0 (6.2-11.8)        | 12.9 (11.8-14.0)      | 14.9 (14.2-15.7)       | 72.8 (23.5-122.2)     | 15.5 (15.2-15.8)       | 71.3 (71.1-71.5)       |