**Structural characterization and comparative analyses of the chloroplast genome of Eastern Asian species *Cardamine* *occulta* (Asian *C. flexuosa* With.) and other *Cardamine* species**

**Supplementary Table S3.** Comparison of site models, positive selective amino acid loci and estimation of parameters for thirteen protein-coding genes in the species of *Cardamine* genera

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Protein-coding gene | Model | np | Ln L | **Estimates of parameters** | | | | Model compared | LRT  P-value | Positive sites |
| *atpB* | M3 | 33 | -1664.227 | p: | 0.65554 | 0.27524 | 0.06923 | M0 vs. M3 | 0.421980775 | [] |
| ω: | 0 | 0 | 2.12416 |
| M0 | 29 | -1666.169 | ω0: | 0.13413 | | | Not Allowed |
| M2a | 32 | -1664.464 | p: | 0.93077 | 0 | 0.06923 | M1a vs. M2a | 0.789486930 | [] |
| ω: | 0 | 1.0 | 2.12416 |
| M1a | 30 | -1664.227 | p: | 0.87176 | 0.12824 |  | Not Allowed |
| ω: | 0 | 1.0 |  |
| M8 | 32 | -1664.155 | p0=0.93077 | p=0.00785 | q=2.37685 |  | M7 vs. M8 | 0.395330561 | 5 F 0.815 |
| (p1= 0.0692) | ω= 2.12411 |  |  |
| M7 | 30 | -1664.155 | p= | 0.04065 | q= | 0.21400 | Not Allowed |
| M8a | 31 | -1664.464 | p0=0.87176 | p=0.00500 | q=1.34170 | | M8a vs. M8 | 0.491487565 | Not Allowed |
| (p1= 0.1282) | ω= 1.00000 | | |
| *ccsA* | M3 | 33 | -1849.121 | p: | 0.94982 | 0.04395 | 0.00623 | M0 vs. M3 | 0 | [] |
| ω: | 0.18936 | 3.01085 | 50.07663 |
| M0 | 29 | -1898.927 | ω0: | 0.21973 | | | Not Allowed |
| M2a | 32 | -1850.067 | p: | 0.76191 | 0.23142 | 0.00668 | M1a vs. M2a | 0 | [] |
| ω: | 0.06541 | 1 | 44.65258 |
| M1a | 30 | -1886.838 | p: | 0.86793 | 0.13207 |  | Not Allowed |
| ω: | 0 | 1 |  |
| M8 | 32 | -1850.317 | p0=0.99333 | p=0.02855 | q=0.10302 |  | M7 vs. M8 | 0 | 99 Q 0.988\*, 176 W 1.000\*\*, 182 K 0.957\*, 184 F 0.679, 329 – 1.000\*\* |
| (p1= 0.00667) | ω= 47.00904 |  |  |
| M7 | 30 | -1888.988 | p= | 0.03697 | q= | 0.15611 | Not Allowed |
| M8a | 31 | -1886.853 | p0=0.86809 | p=7.55086 | q=99.000 | | M8a vs.M8 | 0 | Not Allowed |
| (p1= 0.1319) | ω= 1.00000 | | |
| *cemA* | M3 | 33 | -1101.414 | p: | 0.99563 | 0 | 0.00437 | M0 vs. M3 | 0 | [] |
| ω: | 0.47575 | 4.06871 | 234.48671 |
| M0 | 29 | -1144.177 | ω0: | 0.15800 | | | Not Allowed |
| M2a | 32 | -1101.414 | p: | 0.99563 | 0 | 0.00437 | M1a vs. M2a | 0 | [] |
| ω: | 0.47575 | 1.0 | 234.47818 |
| M1a | 30 | -1144.177 | p: | 0.99999 | 0.00001 |  | Not Allowed |
| ω: | 0.15800 | 1.0 |  |
| M8 | 32 | -1101.419 | p0=0.99563 | p=17.15120 | q=18.82034 |  | M7 vs.M8 | 0 | 126 W 0.522, 230 – 1.000\*\* |
| (p1= 0. 0044) | ω= 234.77 |  |  |
| M7 | 30 | -1144.185 | p= | 18.71730 | q= | 0.06306 | Not Allowed |
| M8a | 31 | -1144.188 | p0=0.99999 | p=18.66353 | q=99.00 | | M8a vs.M8 | 0 | Not Allowed |
| (p1= 0.0001) | ω= 1.00000 | | |
| *matK* | M3 | 33 | -2708.319 | p: | 0.21347 | 0.72458 | 0.06195 | M0 vs. M3 | 0.000000009 | [] |
| ω: | 0 | 0.24854 | 4.62107 |
| M0 | 29 | -2729.945 | ω0: | 0.040898 | | | Not Allowed |
| M2a | 32 | -2708.312 | p: | 0.93523 | 0 | 0.06477 | M1a vs. M2a | 0.003138718 | [] |
| ω: | 0.18447 | 1.0 | 4.54162 |
| M1a | 30 | -2714.083 | p: | 0.70137 | 0.29863 |  | Not Allowed |
| ω: | 0 | 1.0 |  |
| M8 | 32 | -2710.422 | p0=0.79295 | p=0.00500 | q=1.81406 |  | M7 vs.M8 | 0.020748942 | 54 D 0.966\*, 71 E 0.752, 85 L 0.617, 120 P 0.774,121 F 0.769, 125 Y 0.933, 192 Y 0.614, 242 L 0.704, 251 L 0.998\*\*, 318 Q 0.754, 321 K 0.707, 420 N 0.984\*, 480 R 0.786 |
| (p1= 0.2071) | ω= 2.20816 |  |  |
| M7 | 30 | -2714.298 | p= | 0.00937 | q= | 0.01512 | Not Allowed |
| M8a | 31 | -2714.083 | p0=0.70137 | p=00500 | q=2.14888 | | M8a vs.M8 | 0.006812747 | Not Allowed |
| (p1=0.29863) | ω= 1.00000 | | |
| *ndhA* | M3 | 33 | -1718.939 | p: | 0.99430 | 0.00291 | 0.00279 | M0 vs. M3 | 0 | [] |
| ω: | 0.23748 | 0.23762 | 137.74657 |
| M0 | 29 | -1759.486 | ω0: | 0.13461 | | | Not Allowed |
| M2a | 32 | -1718.939 | p: | 0.99721 | 0 | 0.00279 | M1a vs. M2a | 0 | [] |
| ω: | 0.23747 | 1.0 | 137.75008 |
| M1a | 30 | -1759.486 | p: | 0.99999 | 0.00001 |  | Not Allowed |
| ω: | 0.13461 | 1.0 |  |
| M8 | 32 | -1718.944 | p0=0.99721 | p=30.95647 | q=99.000 |  | M7 vs.M8 | 0 | 121 H 0.644, 216 I 0.606, 279 W 0.655, 294 R 0.624, 361 - 1.000\*\* |
| (p1=0.00279) | ω= 137.76393 |  |  |
| M7 | 30 | -1759.496 | p= | 15.53136 | q= | 99.000 | Not Allowed |
| M8a | 31 | -1759.500 | p0=0.99999 | p=15.47085 | q=99.000 | | M8a vs.M8 | 0 | Not Allowed |
| (p1=0.00001) | ω= 1.00000 | | |
| *ndhD* | M3 | 33 | -2514.776 | p: | 0.75504 | 0.14069 | 0.10427 | M0 vs. M3 | 0.217437134 | [] |
| ω: | 0 | 0.69785 | 0.69797 |
| M0 | 29 | -2517.668 | ω0: | 0.16828 | | | Not Allowed |
| M2a | 32 | - 2514.822 | p: | 0.86713 | 0.06507 | 0.06780 | M1a vs. M2a | 1.0 | [] |
| ω: | 0.04678 | 1.0 | 1.0 |
| M1a | 30 | -2514.822 | p: | 0.86713 | 0.13287 |  | Not Allowed |
| ω: | 0.04679 | 1.0 |  |
| M8 | 32 | -2514.816 | p0=0.87439 | p=0.22817 | q=2.88039 |  | M7 vs. M8 | 0.848733535 | 73 N 0.707, 154 S 0.776, 302 L 0.711, 418 L 0.723 |
| (p1=0.12561) | ω= 1.0 |  |  |
| M7 | 30 | -2514.980 | p= | 0.04224 | q= | 0.20372 | Not Allowed |
| M8a | 31 | -2514.780 | p0=0.95318 | p=0.09262 | q=0.60936 | | M8a vs. M8 | 0.846034685 | Not Allowed |
| (p1=0.04682) | ω= 1.00000 | | |
| *ndhF* | M3 | 33 | -3824.413 | p: | 0.92359 | 0.06375 | 0.01266 | M0 vs. M3 | 0.000000017 | [] |
| ω: | 0.18273 | 1.52810 | 10.21627 |
| M0 | 29 | -3845.415 | ω0: | 0.33357 | | | Not Allowed |
| M2a | 32 | -3824.420 | p: | 0.85757 | 0.12859 | 0.01384 | M1a vs. M2a | 0.000793965 | [] |
| ω: | 0.15234 | 1.0 | 9.78131 |
| M1a | 30 | -3831.558 | p: | 0.70294 | 0.29706 |  | Not Allowed |
| ω: | 0 | 1.0 |  |
| M8 | 32 | -3824.437 | p0=0.98487 | p=0.42470 | q=1.14723 |  | M7 vs. M8 | 0.000593592 | 99 Q 0.988\*, 176 W 1.000\*\*, 182 K 0.957\*, 184 F 0.679, 329 – 1.000\*\* |
| (p1= 0.01513) | ω= 9.33724 |  |  |
| M7 | 30 | -3831.867 | p= | 0.01328 | q= | 0.02708 | Not Allowed |
| M8a | 31 | -3831.558 | p0=0.70294 | p=0.00500 | q=0.86292 | | M8a vs.M8 | 0.000160789 | Not Allowed |
| (p1=0.29706) | ω= 1.00000 | | |
|  | M3 | 33 | -1101.414 | p: | 0.99563 | 0 | 0.00437 | M0 vs. M3 | 0 | [] |
| ω: | 0.47575 | 4.06871 | 234.48671 |
| M0 | 29 | -1144.177 | ω0: | 0.15800 | | | Not Allowed |
| M2a | 32 | -1101.414 | p: | 0.99563 | 0 | 0.00437 | M1a vs. M2a | 0 | [] |
| ω: | 0.47575 | 1.0 | 234.47818 |
| M1a | 30 | -1144.177 | p: | 0.99999 | 0.00001 |  | Not Allowed |
| ω: | 0.15800 | 1.0 |  |
| M8 | 32 | -1101.419 | p0=0.99563 | p=17.15120 | q=18.82034 |  | M7 vs.M8 | 0 | 126 W 0.522, 230 – 1.000\*\* |
| (p1= 0. 0044) | ω= 234.77 |  |  |
| M7 | 30 | -1144.185 | p= | 18.71730 | q= | 0.06306 | Not Allowed |
| M8a | 31 | -1144.188 | p0=0.99999 | p=18.66353 | q=99.00 | | M8a vs.M8 | 0 | Not Allowed |
| (p1= 0.0001) | ω= 1.00000 | | |
| *ndhG* | M3 | 33 | -926.302 | p: | 0.86122 | 0.13312 | 0.00566 | M0 vs. M3 | 0 | [] |
| ω: | 0.0 | 2.23018 | 90.38643 |
| M0 | 29 | -961.938 | ω0: | 0.12458 | | | Not Allowed |
| M2a | 32 | -926.876 | p: | 0.76825 | 0.22608 | 0.00566 | M1a vs. M2a | 0 | [] |
| ω: | 0.0 | 1.0 | 82.99427 |
| M1a | 30 | -958.904 | p: | 0.85442 | 0.14558 |  | Not Allowed |
| ω: | 0 | 1.0 |  |
| M8 | 32 | -944.043 | p0=0.92028 | p=0.00500 | q=1.75560 |  | M7 vs.M8 | 0.000000130 | 27 V 0.509, 90 S 0.901, 128 R 0.934, 177 - 1.000\*\* |
| (p1= 0.07972) | ω= 8.91489 |  |  |
| M7 | 30 | -959.902 | p= | 0.03912 | q= | 0.20633 | Not Allowed |
| M8a | 31 | -958.904 | p0=0.85442 | p=00500 | q=1.29059 | | M8a vs.M8 | 0.000000050 | Not Allowed |
| (p1=0.14558) | ω= 1.00000 | | |
| *ndhI* | M3 | 33 | -958.5884 | p: | 0.94450 | 0.0 | 0.05550 | M0 vs. M3 | 0 | [] |
| ω: | 1.77443 | 50.93018 | 999.0 |
| M0 | 29 | -1306.805 | ω0: | 26.63503 | | | Not Allowed |
| M2a | 32 | -959.3158 | p: | 0.05576 | 0.88797 | 0.05627 | M1a vs. M2a | 0 | [] |
| ω: | 1.0 | 1.0 | 218.05257 |
| M1a | 30 | -1269.130 | p: | 0.99334 | 0.00666 |  | Not Allowed |
| ω: | 0. 04599 | 1.0 |  |
| M8 | 32 | -1040.933 | p0= 0.87903 | p= 0.00500 | q= 0.29664 |  | M7 vs.M8 | 0 | 3 I 0.993\*\*, 4 Y 0.916, 8 - 1.000\*\*, 10 Q 0.932, 18 I 0.912, 21 - 1.000\*\*, 24 - 1.000\*\*, 41 - 1.000\*\*, 49 - 1.000\*\*, 81 I 0.900, 99 T 0.905, 112 D 0.902, 115 T 0.911, 116 E 0.909, 122 - 1.000\*\*, 133 - 1.000\*\*, 139 - 1.000\*\*, 142 H 0.912, 153 - 1.000\*\*, 162 P 0.921 |
| (p1= 0.12097) | ω= 279.37893 |  |  |
| M7 | 30 | -1268.769 | p= | 0.13548 | q= | 1.56165 | Not Allowed |
| M8a | 31 | -1268.802 | p0=0.99999 | p= 0.37567 | q= 6.55551 | | M8a vs.M8 | 0 | Not Allowed |
| (p1=0.00001) | ω= 1.00000 | | |
| *petA* | M3 | 33 | -1526.071 | p: | 0.65554 | 0.27524 | 0.06923 | M0 vs. M3 | 0 | [] |
| ω: | 0 | 0 | 2.12416 |
| M0 | 29 | -1572.916 | ω0: | 0.13413 | | | Not Allowed |
| M2a | 32 | -1527.167 | p: | 0.99288 | 0.00392 | 0.00320 | M1a vs. M2a | 0 | [] |
| ω: | 0.16939 | 1.0 | 118.86854 |
| M1a | 30 | -1571.534 | p: | 0.92158 | 0.07842 |  | Not Allowed |
| ω: | 0.02479 | 1.0 |  |
| M8 | 32 | -1527.166 | p0=0.99407 | p=3.87936 | q=18.46906 |  | M7 vs. M8 | 0 | 31 S 0.724, 121 S 0.985\*, 187 G 0.506, 245 G 0.694, 246 L 0.610, 321 - 1.000\*\* |
| (p1= 0.00593) | ω= 119.41794 |  |  |
| M7 | 30 | -1572.011 | p= | 0.03076 | q= | 0.17603 | Not Allowed |
| M8a | 31 | -1571.534 | p0=0.92167 | p=2.56641 | q=99.000 | | M8a vs. M8 | 0 | Not Allowed |
| (p1= 0.07833) | ω= 1.00000 | | |
| *petD* | M3 | 33 | -765.411 | p: | 0.0 | 0.97219 | 0.02781 | M0 vs. M3 | 0.000000017 | [] |
| ω: | 0.0 | 0.0 | 10.86699 |
| M0 | 29 | -786.416 | ω0: | 0.20110 | | | Not Allowed |
| M2a | 32 | -765.411 | p: | 0.97219 | 0.0 | 0.02781 | M1a vs. M2a | 0.000118990 | [] |
| ω: | 0.0 | 1.0 | 10.86698 |
| M1a | 30 | -774.448 | p: | 0.92338 | 0.07662 |  | Not Allowed |
| ω: | 0 | 1.0 |  |
| M8 | 32 | 765.411 | p0=0.97219 | p=0.00500 | q=1.77299 |  | M7 vs. M8 | 0.000000596 | 1 M 1.000\*\*, 2 G 0.945, 3 V 0.882, 138 A 0.578 |
| (p1= 0.02781) | ω= 10.86695 |  |  |
| M7 | 30 | -779.745 | p= | 0.03304 | q= | 0.13714 | Not Allowed |
| M8a | 31 | -774.448 | p0=0.92338 | p=0.00500 | q=4.56640 | | M8a vs.M8 | 0.000021260 | Not Allowed |
| (p1= 007662) | ω= 1.00000 | | |
| *rps16* | M3 | 33 | -420.117 | p: | 0.19165 | 0.78349 | 0.02486 | M0 vs. M3 | 0.600415820 | [] |
| ω: | 0.46025 | 0.46025 | 9.27569 |
| M0 | 29 | -421.492 | ω0: | 0.54866 | | | Not Allowed |
| M2a | 32 | -420.117 | p: | 0.97514 | 0 | 0.02486 | M1a vs. M2a | 0.390468882 | [] |
| ω: | 0.46025 | 1.0 | 9.27570 |
| M1a | 30 | -421.057 | p: | 0.58534 | 0.41466 |  | Not Allowed |
| ω: | 0.16954 | 1.0 |  |
| M8 | 32 | -420.119 | p0=0.97517 | p=84.70914 | q=99.00000 |  | M7 vs.M8 | 0.365897514 | 5 Q 0.853 |
| (p1= 0.02483) | ω= 9.28538 |  |  |
| M7 | 30 | -421.124 | p= | 0.10166 | q= | 0.10094 | Not Allowed |
| M8a | 31 | -421.059 | p0=0.58508 | p=20.30824 | q=99.00 | | M8a vs.M8 | 0.170368476 | Not Allowed |
| (p1= 0.41492) | ω= 1.00000 | | |
| *ycf2* | M3 | 33 | -9725.602 | p: | 0.99124 | 0.00004 | 0.00871 | M0 vs. M3 | 0.000033417 | [] |
| ω: | 0.58453 | 4.62814 | 38.10537 |
| M0 | 29 | -9738.543 | ω0: | 0.88033 | | | Not Allowed |
| M2a | 32 | -9725.598 | p: | 0.99128 | 0 | 0.00872 | M1a vs. M2a | 0.000036053 | [] |
| ω: | 0.58482 | 1.0 | 38.09751 |
| M1a | 30 | -9735.829 | p: | 0.49392 | 0.50608 |  | Not Allowed |
| ω: | 0 | 1.0 |  |
| M8 | 32 | -9726.951 | p0=0.91408 | p=0.00500 | q=0.53433 |  | M7 vs.M8 | 0.000085780 | 45 H 0.534, 58 F 0.930, 89 L 0.540, 95 R 0.551, 128 G 0.555, 275 I 0.936, 279 G 0.536, 346 E 0.531, 433 W 0.544, 516 Q 0.531, 710 I 0.937, 733 Y 0.512, 742 R 0.558, 776 T 0.548, 849 Q 0.519, 856 A 0.542, 909 V 0.503, 925 Q 0.520, 960 F 0.529, 999 F 0.529, 1007 D 0.538, 1055 A 0.560,1077 I 0.522, 1296 Q 0.526, 1381 K 0.521, 1410 W 0.545, 1473 Q 0.523, 1482 H 0.503, 1616 L 0.994\*\*, 1789 Q 0.994\*\*, 1914 L 0.529, 1987 F 0.529, 2030 E 0.526, 2040 D 0.502, 2041 G 0.553, 2055 H 0.546, 2092 G 0.560, 2120 Y 0.509, 2254 L 0.544, 2263 D 0.501, 2264 R 0.557, 2280 M 0.507 |
| (p1= 0.08592) | ω= 10.58317 |  |  |
| M7 | 30 | -9736.315 | p= | 0.04175 | q= | 0.01950 | Not Allowed |
| M8a | 31 | -9735.829 | p0=0.49384 | p=00500 | q=1.35172 | | M8a vs.M8 | 0.000025103 | Not Allowed |
| (p1=0.50616) | ω= 1.00000 | | |

Note:

[] – No data available

np represents the degree of freedom

Positively selected sites (\* *p* > 95%; \*\* *p* > 99%)