



Supplement of

Seasonal and long-term patterns of reproductive phenology in the Wet Tropics rainforests of Australia

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Supplementary material

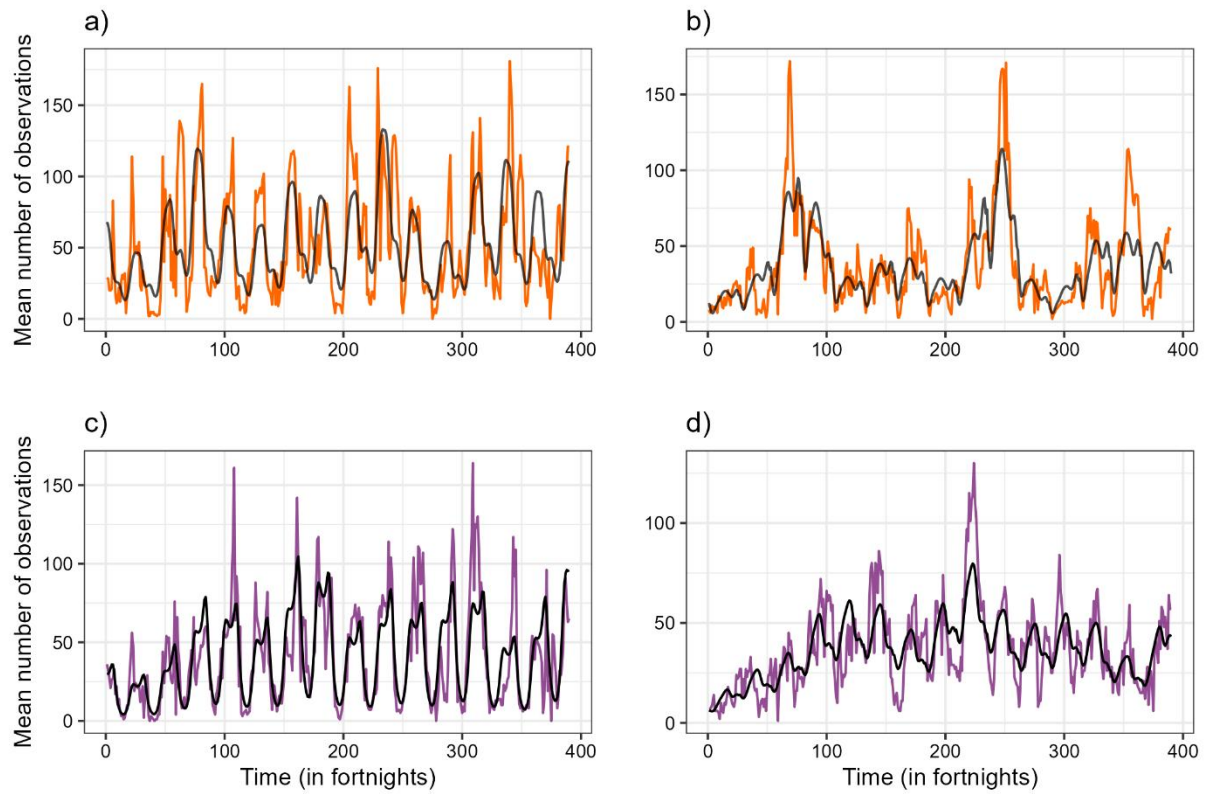


Fig. S1. Temporal predicted GAMs (black line) plotted against raw data of abiotic a) flowering (orange line), b) fruiting (orange line), and biotic c) flowering (purple line), and d) fruiting (purple line) at the Skyrail rainforest site.

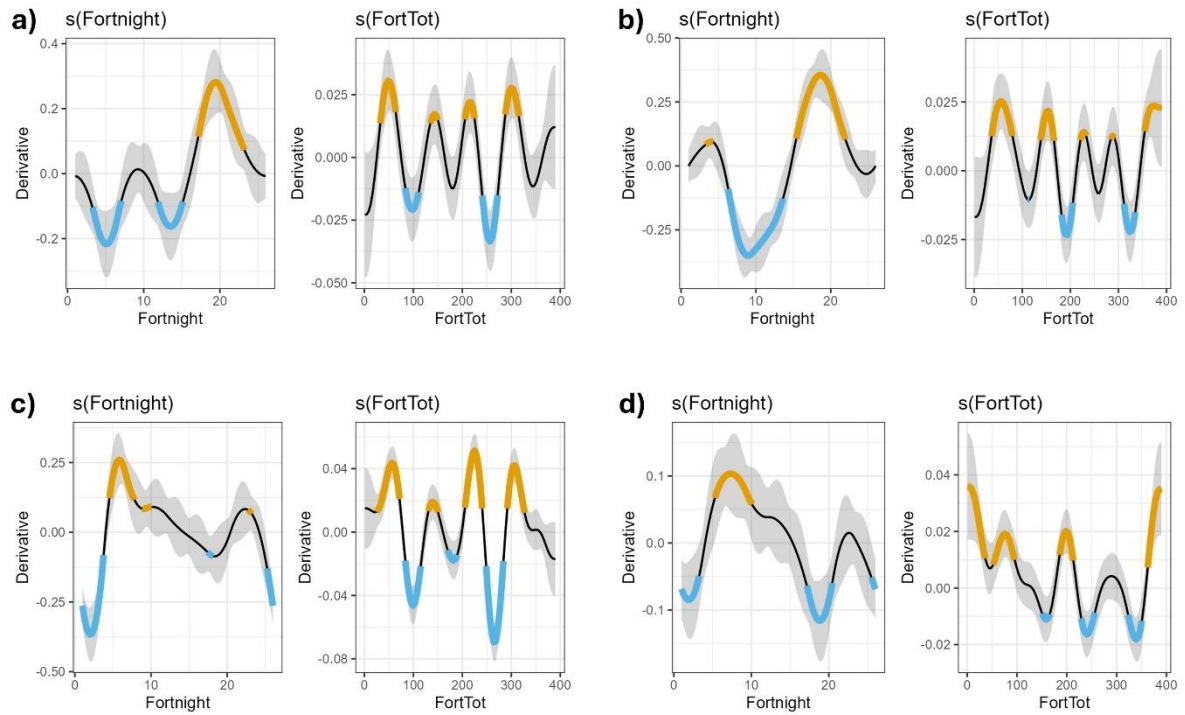


Fig. S2. First derivatives of temporal predicted GAMs (seasonal on the left and long-term trend on the right) showing significant increase (orange) and decrease (blue) in smoother slope of a) abiotic flowering, b) biotic flowering, c) abiotic fruiting and d) biotic fruiting.

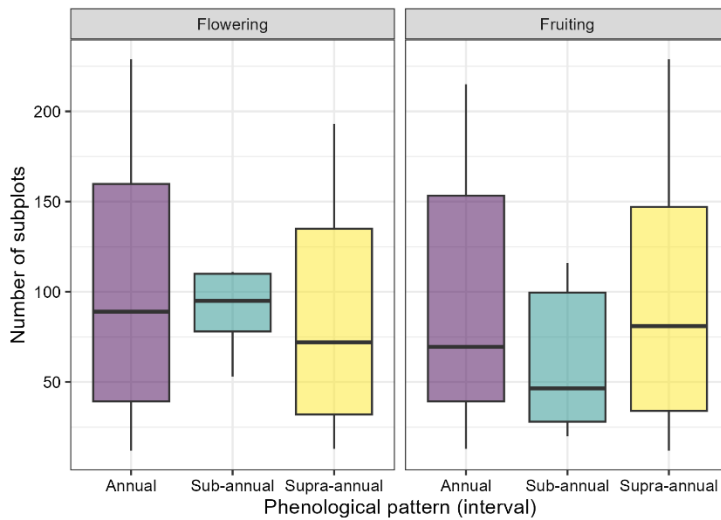


Fig. S3. Number of subplots studies within each phenological interval.

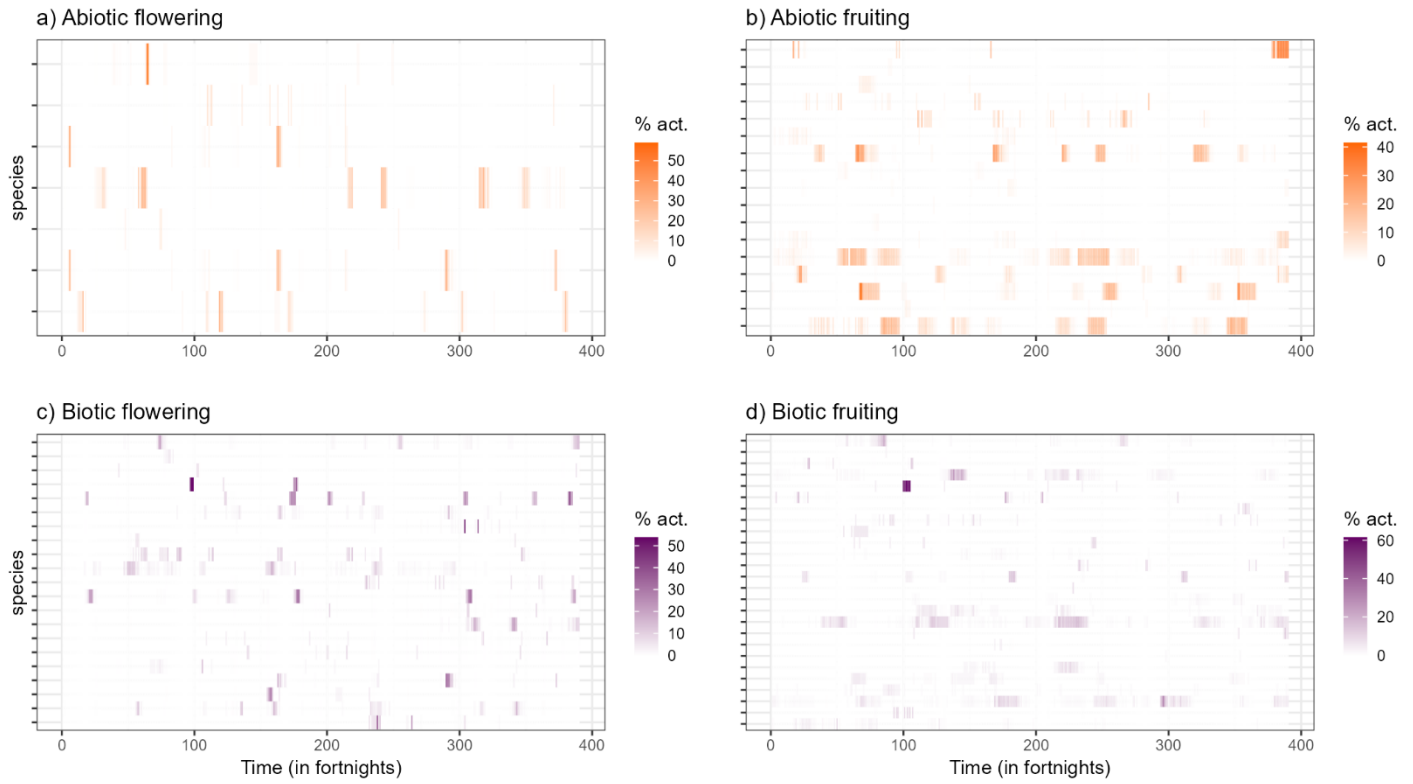


Fig. S4. Percentage of activity of supra-annual species within abiotically (orange) and biotically (purple) dispersed communities fortnightly for the whole studied period from January 2000 to December 2014.

Table S1. Phenological calendar with information on each studied species, showing type of seed dispersal (A for abiotic, Z for biotic), phenological strategy (sub-annual (sub), annual or supra-annual (supra)), annual coefficient of variation (CV), season of activity, mean angle calculated through circular statistics (r-vector indicating degree of seasonality), circular SD, mean date in month, and if the species is changing through time as per linear-circular regression analysis (n.s. for non-significant).

Species	Family	Type seed dispersal	Pheno interval		Annual CV		Season of activity		Mean Angle (r vector)		Circular SD		Mean date (month)		Time change	
			Fl	Fr	Fl	Fr	Fl	Fr	Fl	Fr	Fl	Fr	Fl	Fr	Fl	Fr
<i>Acacia celsa</i>	Fabaceae	Z	Annual	Supra	0.54	1.27	Wet	Wet	71.46 (0.90) *	325.38 (0.99) *	25.87	6.93	3	11	ns	—
<i>Agathis robusta</i>	Araucariaceae	A	—	Sub	—	0.36	—	Wet	—	313.68 (0.37) *	—	80.73	—	11	—	Advancing
<i>Albizia procera</i>	Fabaceae	A	Annual	Annual	0.26	0.38	Wet	Dry	58.80 (0.91) *	185.12 (0.72) *	24.88	46.73	2	7	ns	Delaying
<i>Aleurites rockinghamensis</i>	Euphorbiaceae	Z	Annual	Annual	0.27	0.50	Wet	Dry	86.60 (0.78) *	264.87 (0.65) *	39.96	52.88	3	9	ns	ns
<i>Alphitonia petriei</i>	Rhamnaceae	Z	Sub	Sub	0.25	0.46	Wet	Dry	329.05 (0.24)	253.91 (0.17)	97.06	107.18	11	9	—	—
<i>Alphitonia whitei</i>	Rhamnaceae	Z	Annual	Annual	0.43	0.75	Dry	Wet	257.16 (0.89) *	358.9 (0.7) *	28.01	48.03	9	12	Advancing	Advancing
<i>Alstonia muelleriana</i>	Apocynaceae	A	Annual	Annual	0.36	1.00	Wet	Dry	17.59 (0.80) *	174.28 (0.58) *	37.98	59.47	1	6	Delaying	ns
<i>Alstonia scholaris</i>	Apocynaceae	A	Annual	Supra	0.81	1.66	Wet	—	306.69 (0.88) *	—	29.27	—	11	—	Advancing	—
<i>Argyrodendron peralatum</i>	Malvaceae	A	Annual	Supra	1.25	1.27	Wet	Wet	145.28 (0.84) *	295.65 (0.55) *	34.43	62.45	5	10	ns	ns
<i>Argyrodendron trifoliatum</i>	Malvaceae	A	Supra	Supra	1.42	1.29	Dry	Wet	213.10 (0.77) *	317.55 (0.88) *	41.59	28.73	8	11	—	—
<i>Atractocarpus fitzalanii</i>	Rubiaceae	Z	Annual	Supra	0.55	2.44	Wet	Wet	283.31 (0.92) *	306.27 (0.39) *	23.67	78.22	10	11	ns	—
<i>Beilschmiedia bancroftii</i>	Lauraceae	Z	Annual	Supra	1.13	1.15	Wet	Dry	121.49 (0.74) *	262.37 (0.27) *	44.19	93.24	5	9	ns	ns
<i>Blepharocarya involucrigera</i>	Anacardiaceae	A	Annual	Annual	0.61	0.63	Dry	Wet	250.91 (0.96) *	328 (0.76) *	16.99	42.10	9	11	Advancing	Advancing
<i>Brachychiton acerifolius</i>	Malvaceae	Z	Annual	—	0.45	—	Wet	—	340.71 (0.87) *	—	30.60	—	12	—	ns	—
<i>Caldcluvia australiensis</i>	Cunoniaceae	A	Annual	Annual	0.27	0.54	Wet	Wet	48.98 (0.80) *	125 (0.78) *	38.41	40.79	2	5	Advancing	ns
<i>Cardwellia sublimis</i>	Proteaceae	A	Annual	Annual	0.94	1.01	Wet	Dry	300.98 (0.95) *	151.59 (0.28) *	18.43	91.95	11	6	ns	—
<i>Carnarvonia araliifolia</i>	Proteaceae	A	Supra	Supra	1.53	1.81	Wet	Wet	85.07 (0.90) *	304.62 (0.82) *	26.37	36.51	3	11	—	—
<i>Castanospermum australe</i>	Fabaceae	Z	Annual	Supra	0.42	1.04	Wet	—	311.57 (0.90) *	—	26.31	—	11	—	ns	—
<i>Castanospira alphanthii</i>	Sapindaceae	Z	Supra	—	2.18	—	Wet	—	53.37 (0.94) *	—	20.23	—	2	—	—	—
<i>Cinnamomum laubattii</i>	Lauraceae	Z	Supra	Supra	1.17	1.47	Wet	Dry	60.16 (0.87) *	193.85 (0.73) *	29.84	45.23	3	7	ns	—
<i>Commersonia bartramia</i>	Malvaceae	Z	Annual	Annual	0.24	0.60	Wet	Wet	35.21 (0.71) *	133.96 (0.62) *	47.41	56.33	2	5	Advancing	Advancing
<i>Corymbia torelliana</i>	Myrtaceae	A	Annual	Annual	0.36	0.64	Wet	Wet	273.81 (0.88) *	302.4 (0.23) *	29.45	97.72	10	11	ns	ns
<i>Cryptocarya grandis</i>	Lauraceae	Z	Supra	Supra	2.42	2.21	Wet	Dry	15.90 (0.96) *	233.77 (0.66) *	17.30	51.95	1	8	—	—
<i>Cryptocarya hypospodia</i>	Lauraceae	Z	Sub	Supra	1.38	2.33	Wet	—	281.27 (0.44)	—	73.89	—	10	—	—	—
<i>Cryptocarya mackinnoniana</i>	Lauraceae	Z	Annual	Annual	0.49	0.63	Wet	Wet	15.33 (0.78) *	134.66 (0.3) *	40.82	88.77	1	5	Advancing	Delaying
<i>Cryptocarya murrayi</i>	Lauraceae	Z	Supra	Supra	2.07	3.67	Wet	—	85.16 (0.91) *	—	24.77	—	3	—	—	—

Species	Family	Type seed dispersal	Pheno interval		Annual CV		Season of activity		Mean Angle (r vector)		Circular SD		Mean date (month)		Time change	
			Fl	Fr	Fl	Fr	Fl	Fr	Fl	Fr	Fl	Fr	Fl	Fr	Fl	Fr
<i>Darlingia darlingiana</i>	Proteaceae	A	Annual	Supra	0.77	2.80	Dry	—	258.83 (0.98) *	—	11.38	—	9	—	ns	—
<i>Doryphora aromatica</i>	Atherospermataceae	A	Sub	Supra	0.89	3.76	Dry	—	165.26 (0.49) *	—	68.27	—	6	—	Advancing	—
<i>Dysoxylum gaudichaudianum</i>	Meliaceae	Z	Supra	Annual	2.14	0.72	Wet	Wet	27.69 (1)	309.64 (0.71)	0.00	47.20	1	11	—	Advancing
<i>Dysoxylum oppositifolium</i>	Meliaceae	Z	—	Supra	—	2.38	—	Wet	—	—	—	—	—	—	—	—
<i>Dysoxylum papuanum</i>	Meliaceae	Z	Supra	Annual	1.48	0.74	Wet	Wet	115.28 (0.96)	293.49 (0.71)	17.37	47.32	4	10	—	Advancing
<i>Elaeocarpus angustifolius</i>	Elaeocarpaceae	Z	Annual	Annual	0.43	0.84	Wet	Dry	56.58 (0.86) *	214.22 (0.54) *	31.13	63.25	2	8	Delaying	—
<i>Elaeocarpus bancroftii</i>	Elaeocarpaceae	Z	Annual	Supra	1.08	0.79	Wet	Wet	101.89 (0.81) *	283.29 (0.19) *	36.72	103.86	4	10	ns	ns
<i>Elaeocarpus foveolatus</i>	Elaeocarpaceae	Z	Annual	Supra	0.65	1.39	Wet	Dry	353.15 (0.86) *	172.87 (0.57) *	30.88	60.64	12	6	ns	—
<i>Emmenosperma cunninghamii</i>	Rhamnaceae	Z	Supra	Annual	1.27	0.65	Wet	Dry	48.46 (0.94)	226.66 (0.52)	21.00	65.48	2	8	—	Advancing
<i>Endiandra acuminata</i>	Lauraceae	Z	Supra	Supra	1.79	1.32	Wet	—	13.85 (0.85) *	—	32.59	—	1	—	—	—
<i>Eucalyptus pellita</i>	Myrtaceae	A	Annual	Annual	0.12	0.11	Wet	Dry	86.69 (0.86) *	191.33 (0.61) *	31.70	57.43	3	7	ns	ns
<i>Euroschinus falcata</i>	Anacardiaceae	Z	Supra	Supra	1.85	3.71	Wet	Wet	281.53 (0.99) *	276.92 (1) *	6.53	0.00	10	10	—	—
<i>Ficus destruens</i>	Moraceae	Z	—	Sub	—	0.28	—	Wet	—	136.6 (0.14)	—	113.71	—	5	—	—
<i>Ficus obliqua</i>	Moraceae	Z	—	Sub	—	0.31	—	Dry	—	182.68 (0.31) *	—	88.07	—	7	—	—
<i>Ficus virens</i>	Moraceae	Z	—	Sub	—	0.49	—	Wet	—	290.56 (0.18)	—	106.50	—	10	—	—
<i>Flindersia acuminata</i>	Rutaceae	A	Annual	Sub	0.48	0.49	Wet	Dry	325.8 (0.67) *	249.63 (0.32) *	50.80	86.78	11	9	ns	ns
<i>Flindersia bourjotiana</i>	Rutaceae	A	Annual	Supra	1.11	1.45	Dry	—	197.79 (0.81) *	—	36.91	—	7	—	ns	—
<i>Flindersia iffiaiana</i>	Rutaceae	A	Annual	Annual	0.46	0.70	Wet	Dry	354.43 (0.59) *	187.92 (0.45) *	59.16	72.40	12	7	Delaying	ns
<i>Flindersia pimenteliana</i>	Rutaceae	A	Annual	Annual	0.36	0.76	Wet	Dry	18.65 (0.89) *	250.6 (0.77) *	27.87	41.27	1	9	Advancing	Advancing
<i>Franciscodendron laurifolium</i>	Malvaceae	Z	Supra	Supra	1.40	0.93	Wet	Wet	304.91 (0.94) *	357.99 (0.95) *	20.71	18.87	11	12	—	—
<i>Geissois biagiana</i>	Cunoniaceae	Z	Annual	Annual	0.41	0.33	Wet	Wet	337.42 (0.91) *	43.88 (0.69) *	24.21	49.14	12	2	ns	Advancing
<i>Gillbeea adenopetala</i>	Cunoniaceae	A	Annual	Annual	0.37	0.39	Wet	Wet	280.14 (0.91) *	344.16 (0.89) *	24.34	28.12	10	12	Advancing	ns
<i>Gmelina fasciculiflora</i>	Lamiaceae	Z	Supra	Supra	1.35	1.56	Wet	Wet	333.62 (0.83) *	345.5 (0.9) *	35.00	26.12	12	12	—	—
<i>Grevillea baileyana</i>	Proteaceae	A	Supra	—	2.14	—	Wet	—	311.54 (0.99)	—	6.93	—	11	—	—	—
<i>Grevillea hilliana</i>	Proteaceae	A	Annual	Supra	0.63	1.46	Wet	—	312.39 (0.93) *	—	22.36	—	11	—	ns	—
<i>Lauracea sp.</i>	Lauraceae	Z	Supra	Supra	0.96	1.32	Wet	—	18.92 (0.7) *	—	48.45	—	1	—	Delaying	—
<i>Litsea bindoniana</i>	Lauraceae	Z	Supra	Supra	1.16	1.58	Wet	Wet	124.39 (0.85) *	145.38 (0.96) *	33.15	15.55	5	5	Delaying	—
<i>Litsea leefeana</i>	Lauraceae	Z	Supra	Supra	2.43	3.43	Wet	—	55.38 (1)	—	0.00	—	2	—	—	—

Species	Family	Type seed dispersal	Pheno interval		Annual CV		Season of activity		Mean Angle (r vector)		Circular SD		Mean date (month)		Time change	
			Fl	Fr	Fl	Fr	Fl	Fr	Fl	Fr	Fl	Fr	Fl	Fr	Fl	Fr
<i>Melia azedarach</i>	Meliaceae	Z	Annual	Annual	0.68	0.40	Dry	Wet	260.98 (0.8) *	20.82 (0.64) *	38.59	54.25	9	1	ns	Advancing
<i>Melicope elleryana</i>	Rutaceae	Z	Sub	Supra	0.36	1.05	Wet	Dry	24.96 (0.52) *	165.66 (0.11) *	65.86	120.99	1	6	ns	—
<i>Musgravea heterophylla</i>	Proteaceae	A	Supra	Supra	1.23	1.12	Wet	Dry	116.77 (0.79) *	192.76 (0.77) *	38.90	41.78	4	7	Delaying	ns
<i>Musgravea stenostachya</i>	Proteaceae	A	Supra	Supra	2.14	1.33	Wet	—	94.34 (0.96) *	—	15.45	—	4	—	—	—
<i>Neolitsea dealbata</i>	Lauraceae	Z	—	—	—	3.86	—	—	—	—	—	—	—	—	—	—
<i>Neonauclea gordoniana</i>	Rubiaceae	A	Supra	Supra	1.49	1.34	Wet	Wet	101.44 (0.96)	127.78 (0.65)	17.37	53.57	4	5	—	Advancing
<i>Opisthiolepis heterophylla</i>	Proteaceae	A	Annual	Supra	0.46	1.15	Wet	Wet	329.22 (0.9) *	354.43 (0.96) *	25.74	16.71	11	12	ns	—
<i>Ormosia ormondii</i>	Fabaceae	A	Annual	—	0.53	—	Wet	—	326.24 (0.89) *	—	28.03	—	11	0	ns	—
<i>Paraserianthes toona</i>	Fabaceae	A	Supra	Supra	3.34	2.44	Dry	—	178.02 (0.99) *	—	8.85	—	6	0	—	—
<i>Placospermum coriaceum</i>	Proteaceae	A	Annual	Annual	0.83	0.86	Wet	Wet	290.77 (0.94) *	96.3 (0.61) *	20.10	56.79	10	4	Advancing	Advancing
<i>Podocarpus grayae</i>	Podocarpaceae	Z	—	Annual	—	0.79	—	Dry	—	253.98 (0.75)	—	43.06	—	9	—	ns
<i>Polyscias elegans</i>	Araliaceae	Z	Annual	Annual	0.41	0.32	Wet	Dry	85.87 (0.88) *	176.2 (0.77) *	28.80	40.98	3	6	Advancing	Delaying
<i>Polyscias murrayi</i>	Araliaceae	Z	Annual	Annual	0.26	0.87	Dry	Dry	175.64 (0.77) *	247.59 (0.88) *	41.17	28.64	6	9	ns	Advancing
<i>Prunus turneriana</i>	Rosaceae	Z	—	Annual	—	0.80	—	Dry	—	218.52 (0.59) *	—	58.48	—	8	—	Delaying
<i>Pseudoweinmannia lachnocarpa</i>	Cunoniaceae	A	Sub	Supra	0.91	3.87	Wet	—	99.31 (0.22)	—	98.96	—	4	—	—	—
<i>Sloanea australis</i>	Elaeocarpaceae	Z	Supra	Supra	2.49	3.55	Wet	Wet	290.66 (0.4)	276.92 (1)	77.47	0.00	10	10	—	—
<i>Sloanea langii</i>	Elaeocarpaceae	Z	Supra	Annual	1.51	1.00	Wet	Wet	88.47 (0.9) *	283.85 (0.99) *	26.01	6.93	3	10	Delaying	—
<i>Sloanea macbrydei</i>	Elaeocarpaceae	Z	Supra	Supra	1.16	1.59	Dry	Wet	263.54 (0.95) *	315.27 (0.74) *	17.54	44.90	9	11	ns	—
<i>Syzygium cormiflorum</i>	Myrtaceae	Z	Supra	Supra	2.46	2.29	Wet	Wet	277.71 (0.97) *	340.66 (0.91) *	14.24	24.38	10	12	—	—
<i>Syzygium kuranda</i>	Myrtaceae	Z	Annual	Supra	0.92	1.67	Wet	Wet	307.81 (0.9) *	137.44 (0.37) *	26.29	80.79	11	5	Advancing	—
<i>Syzygium luehmannii</i>	Myrtaceae	Z	Supra	Supra	1.98	2.47	Wet	Wet	332.31 (1)	36.93 (0.99)	0.00	6.53	12	2	—	—
<i>Syzygium wesa</i>	Myrtaceae	Z	Annual	Annual	0.43	0.97	Dry	Wet	228.36 (0.54) *	280.69 (0.92) *	63.57	23.26	8	10	ns	—
<i>Tarenna dallachiana</i>	Rubiaceae	Z	Annual	Annual	1.00	1.12	Wet	Wet	292.43 (0.9) *	36 (0.75) *	26.60	43.69	10	2	Advancing	—
<i>Terminalia sericocarpa</i>	Combretaceae	Z	Supra	Supra	3.05	3.78	—	—	—	—	—	—	—	—	—	—
<i>Trichospermum pleiostigma</i>	Malvaceae	A	Annual	Annual	0.69	0.82	Dry	Dry	229.64 (0.78) *	254.97 (0.87) *	40.77	29.87	8	9	ns	—
<i>Xanthophyllum octandrum</i>	Polygalaceae	Z	Supra	Supra	1.64	1.75	Wet	Wet	313.09 (0.92) *	81.14 (0.88) *	23.93	28.42	11	3	—	—
<i>Xanthostemon whitei</i>	Myrtaceae	A	Annual	Supra	0.84	1.97	Dry	Wet	155.54 (0.73) *	279.55 (0.62) *	45.13	55.74	6	10	ns	—

Table S2. Results from logistic regression testing functional traits on the probability of supra-annual flowering and fruiting in species studied in Barron Gorge National Park, Australia.

Phenophase	Model		Estimate	Std. Error	z-value	P-value
Flowering	Full model	(Intercept)	-7.56795	5.71901	-1.323	0.18574
		TypeFruitBin	2.41858	0.7912	3.057	0.00224 **
		Height_m	-0.03378	0.05615	-0.602	0.54741
		SeedSize_mm	-0.02479	0.03638	-0.681	0.49567
		WoodDens	3.96368	2.59904	1.525	0.12725
		d13C	-0.14596	0.17488	-0.835	0.40392
		SexBin	1.94711	1.48769	1.309	0.1906
Flowering	Selected model	(Intercept)	-1.3437	0.4584	-2.931	0.00338 **
		TypeFruitBin	1.2484	0.5528	2.258	0.02393 *
Fruiting	Full model	(Intercept)	0.04	6.76	0.006	0.995
		TypeFruitBin	-0.82	0.93	-0.88	0.379
		Height_m	-0.01	0.07	-0.132	0.895
		SeedSize_mm	0.11	0.07	1.669	0.095 .
		WoodDens	-2.61	3.32	-0.789	0.43
		d13C	-0.06	0.21	-0.273	0.785
		SexBin	17.00	1975.00	0.009	0.993
Fruiting	Selected model	(Intercept)	-9.12229	4.7435	-1.923	0.0545 .
		SeedSize_mm	0.09245	0.04154	2.225	0.0261 *
		d13C	-0.28138	0.15494	-1.816	0.0694 .