

# Ericaceae floral evolution

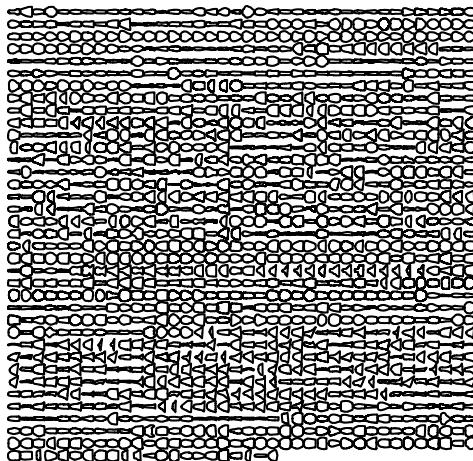
2021-10-05

## Contents

<b>Morphometrics</b>	<b>2</b>
Corolla . . . . .	2
Anthers . . . . .	4
<b>Comparative methods</b>	<b>8</b>
ASR pollinator . . . . .	8
Shift detection . . . . .	10
Corolla . . . . .	10
Shape . . . . .	10
Size . . . . .	15
Anther . . . . .	20
Shape . . . . .	20
Size . . . . .	24
Boxplots . . . . .	29
PGLS results . . . . .	32
Geography . . . . .	32
Pollinator . . . . .	33
Supplements . . . . .	36
Shifts corolla shape and size . . . . .	36
Shifts anther shape and size . . . . .	41

# Morphometrics

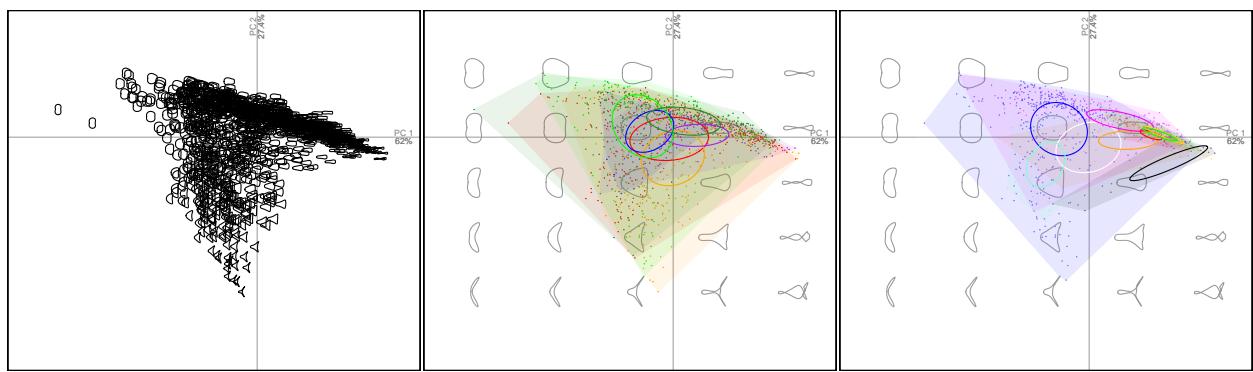
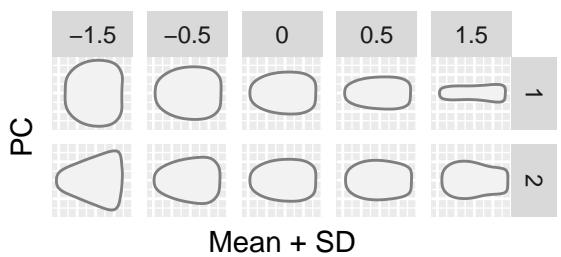
## Corolla



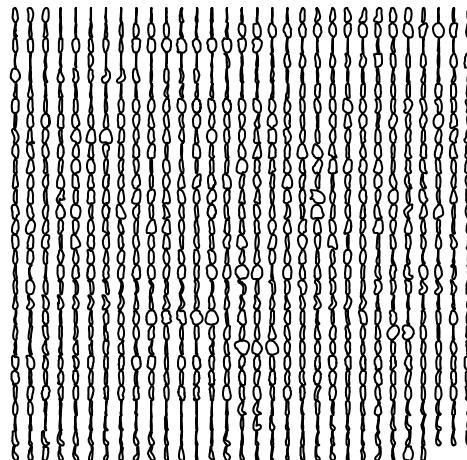
Sample sizes

Var2	Freq
Africa	387
Asia	326
Australia	161
Europe	30
North_America	192
South_America	294

Var2	Freq
-	558
honeyeater	47
hummingbird	178
hummingbird_OW	23
insect	477
lepidoptera	12
long_proboscid_fly	16
sunbird	55
wind	24



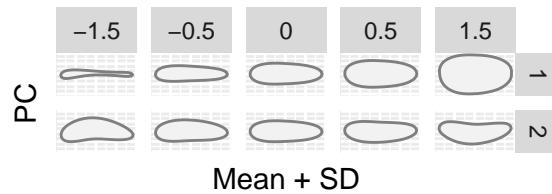
## Anthers

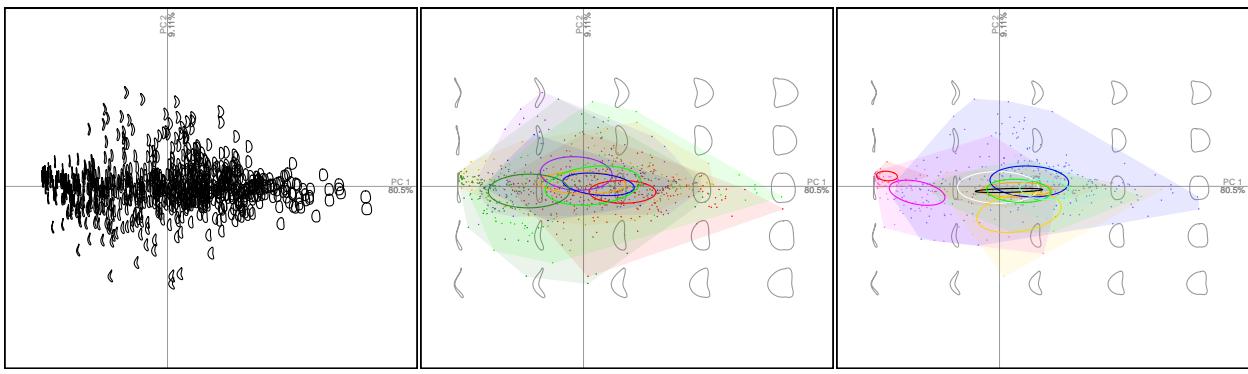


Sample sizes

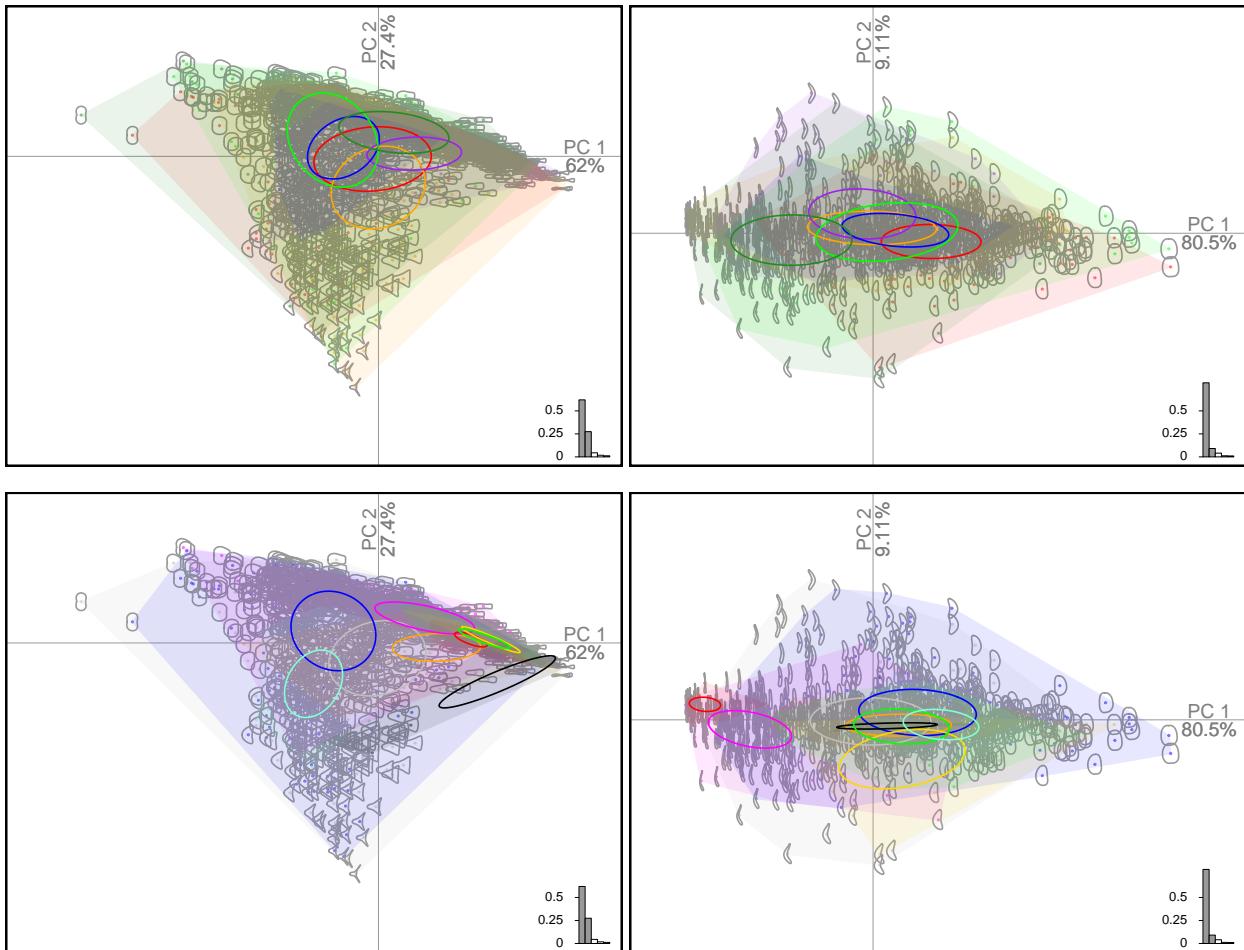
Var2	Freq
Africa	276
Asia	180
Australia	117
Europe	30
North_America	138
South_America	186

Var2	Freq
-	378
honeyeater	16
hummingbird	100
hummingbird_OW	13
insect	355
lepidoptera	3
long_proboscid_fly	11
sunbird	32
wind	19



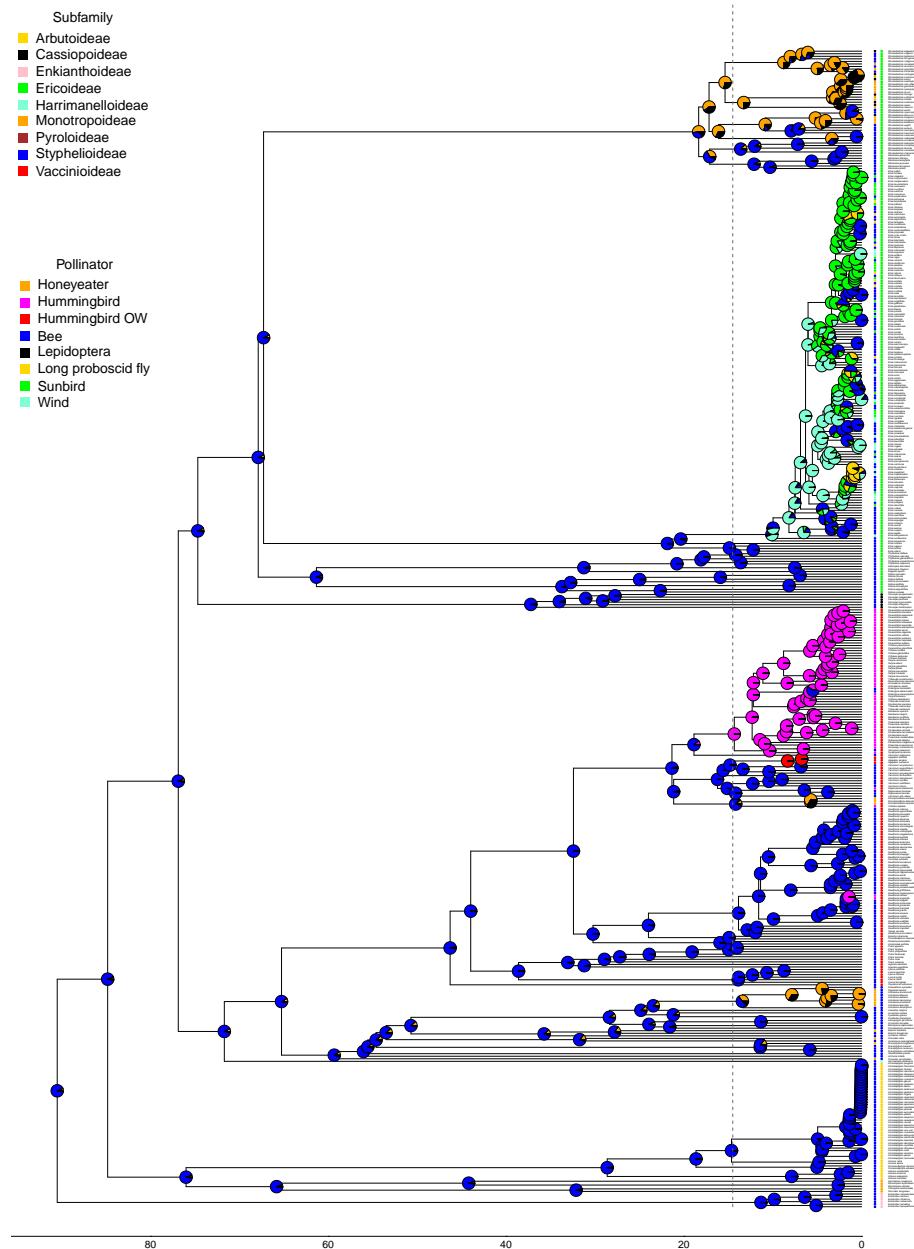


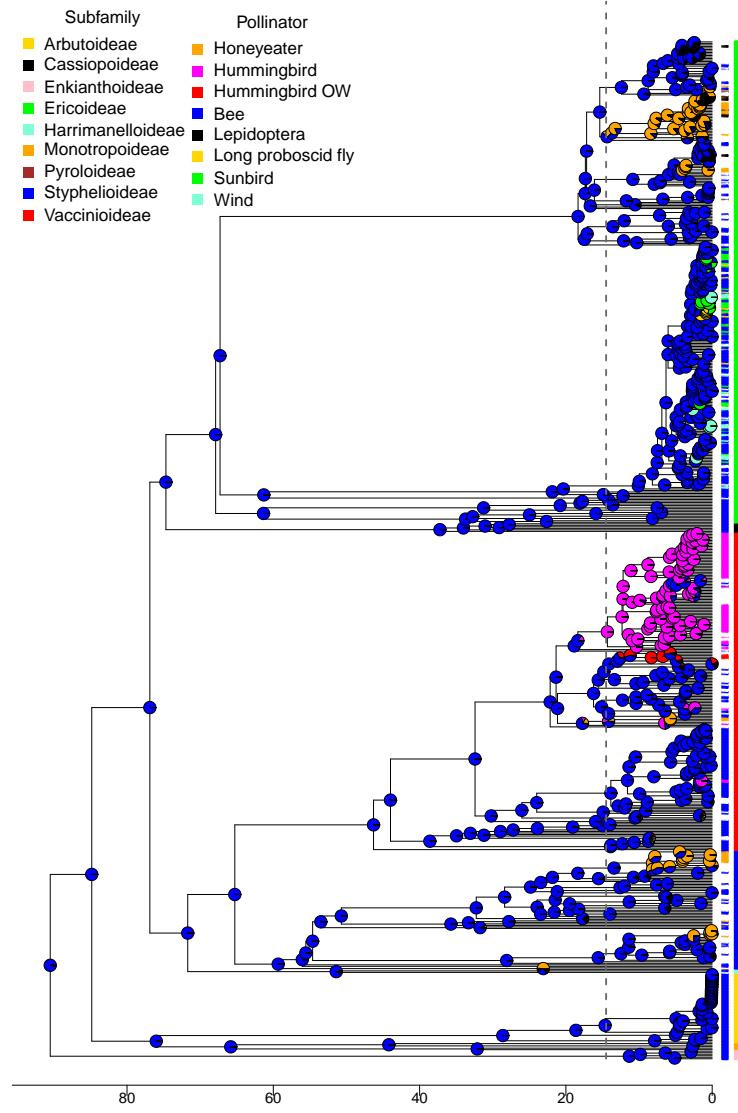
structure	variable	group1	n	mean	sd	Letter
corolla	continent	Africa	284	6.19	6.66	a
corolla	continent	Asia	483	16.01	12.69	b
corolla	continent	Australia	147	9.66	11.21	c
corolla	continent	Europe	43	5.17	4.26	a
corolla	continent	North_america	152	6.37	6.33	a
corolla	continent	South_america	315	14.58	11.28	b
corolla	pollinator	Bee	326	5.26	3.55	c
corolla	pollinator	Honeyeater	32	21.06	8.08	ab
corolla	pollinator	Hummingbird	132	20.86	11.57	ab
corolla	pollinator	Hummingbird_ow	21	24.17	10.82	a
corolla	pollinator	Lepidoptera	17	40.02	21.25	d
corolla	pollinator	Long_proboscid_fly	8	14.53	7.62	b
corolla	pollinator	Sunbird	31	18.05	6.94	b
corolla	pollinator	Wind	20	1.67	1.23	e
anther	continent	Africa	165	1.16	1.00	a
anther	continent	Asia	199	4.59	6.74	b
anther	continent	Australia	127	2.00	1.66	c
anther	continent	Europe	8	1.78	1.09	abcd
anther	continent	North_america	55	1.81	0.94	c
anther	continent	South_america	294	8.26	9.01	d
anther	pollinator	Bee	162	1.59	0.92	e
anther	pollinator	Honeyeater	28	2.90	2.46	ab
anther	pollinator	Hummingbird	128	12.73	10.44	c
anther	pollinator	Hummingbird_ow	18	19.93	11.67	d
anther	pollinator	Lepidoptera	13	4.34	3.06	a
anther	pollinator	Sunbird	12	1.75	0.68	be
anther	pollinator	Wind	16	0.84	0.41	f



## Comparative methods

### ASR pollinator





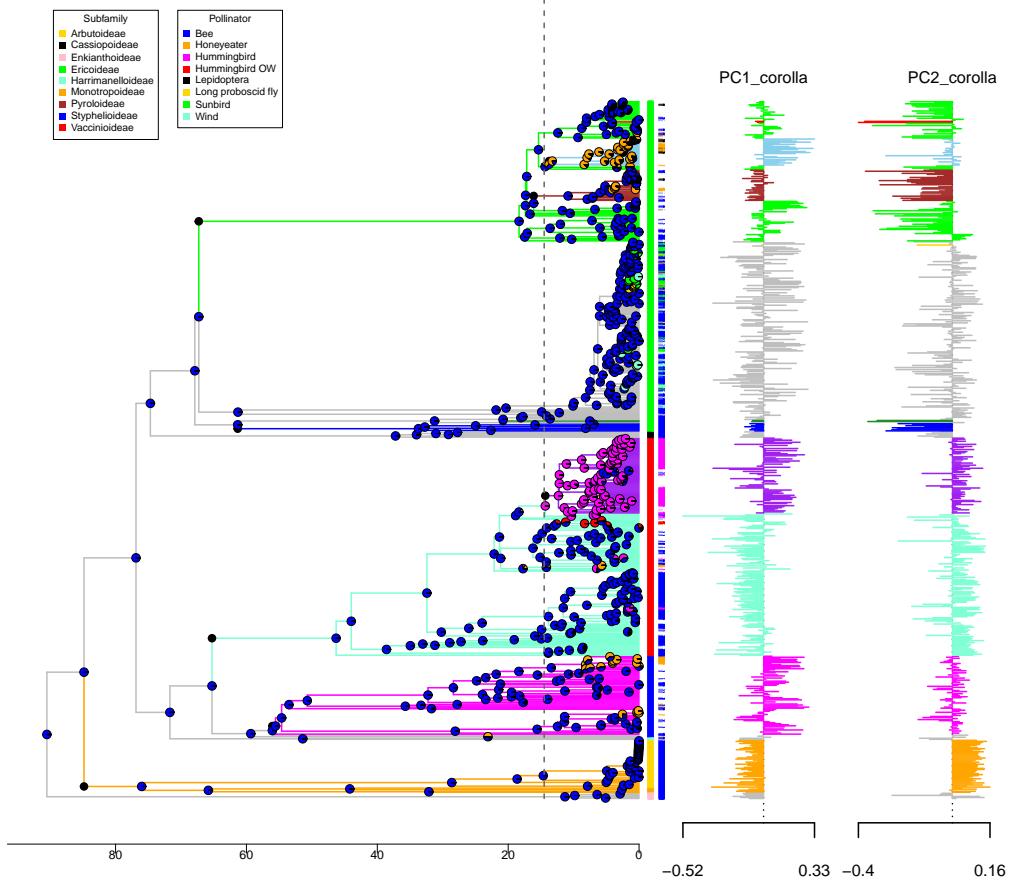
pollinator	species	to	from	species.1	to.1	from.1
honeyeater	454	8	19	672	11	4
hummingbird	454	4	2	672	4	2
hummingbird_OW	454	1	0	672	1	1
insect	454	79	13	672	4	60
lepidoptera	454	7	1	672	6	1
long_proboscid_fly	454	10	12	672	8	1
sunbird	454	7	50	672	21	1
wind	454	8	19	672	15	0

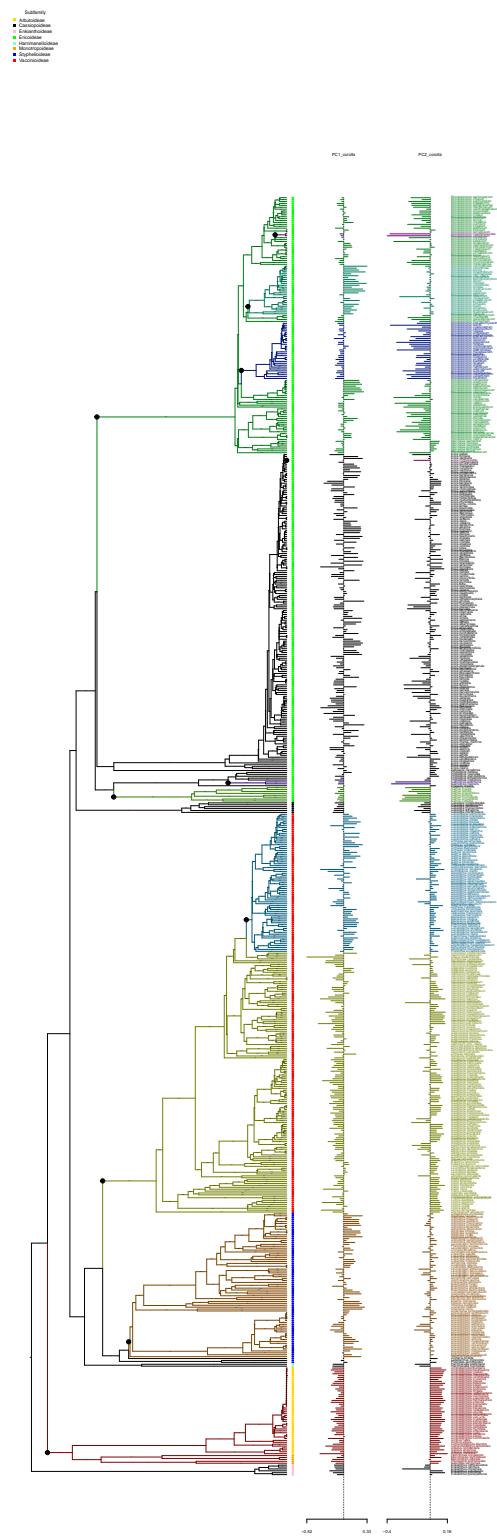
## Shift detection

### Corolla

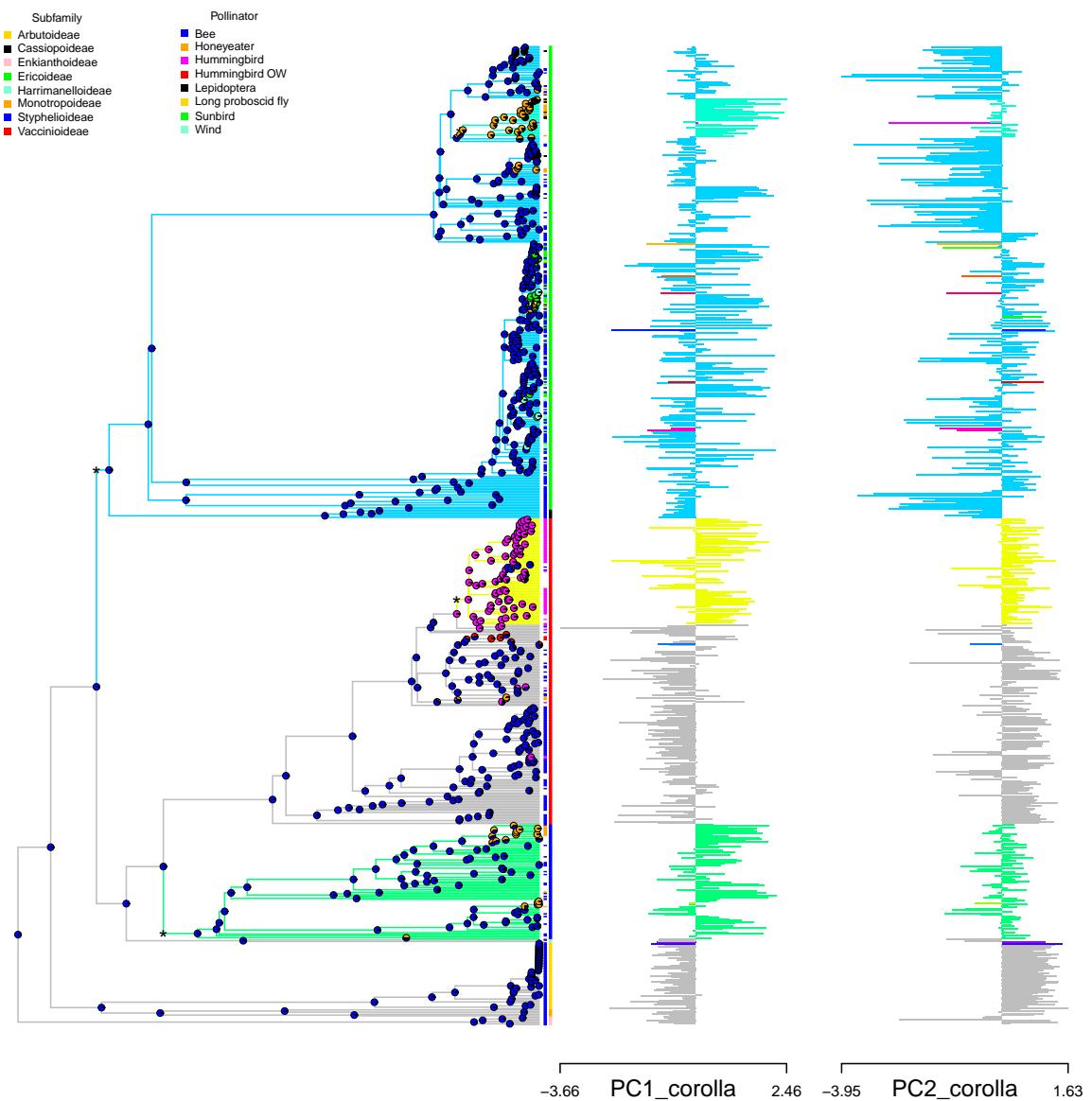
### Shape

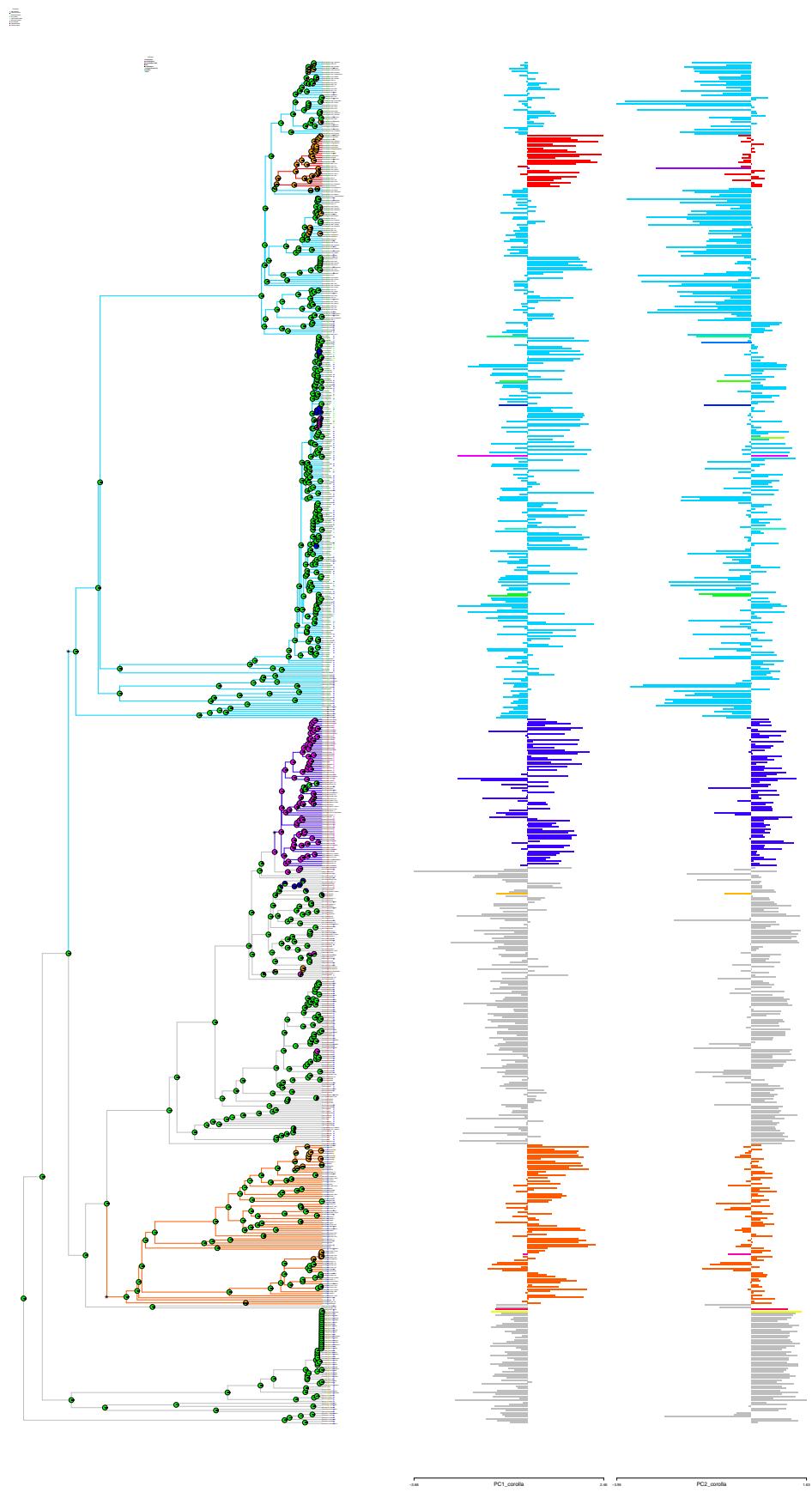
- PhylogeneticEM





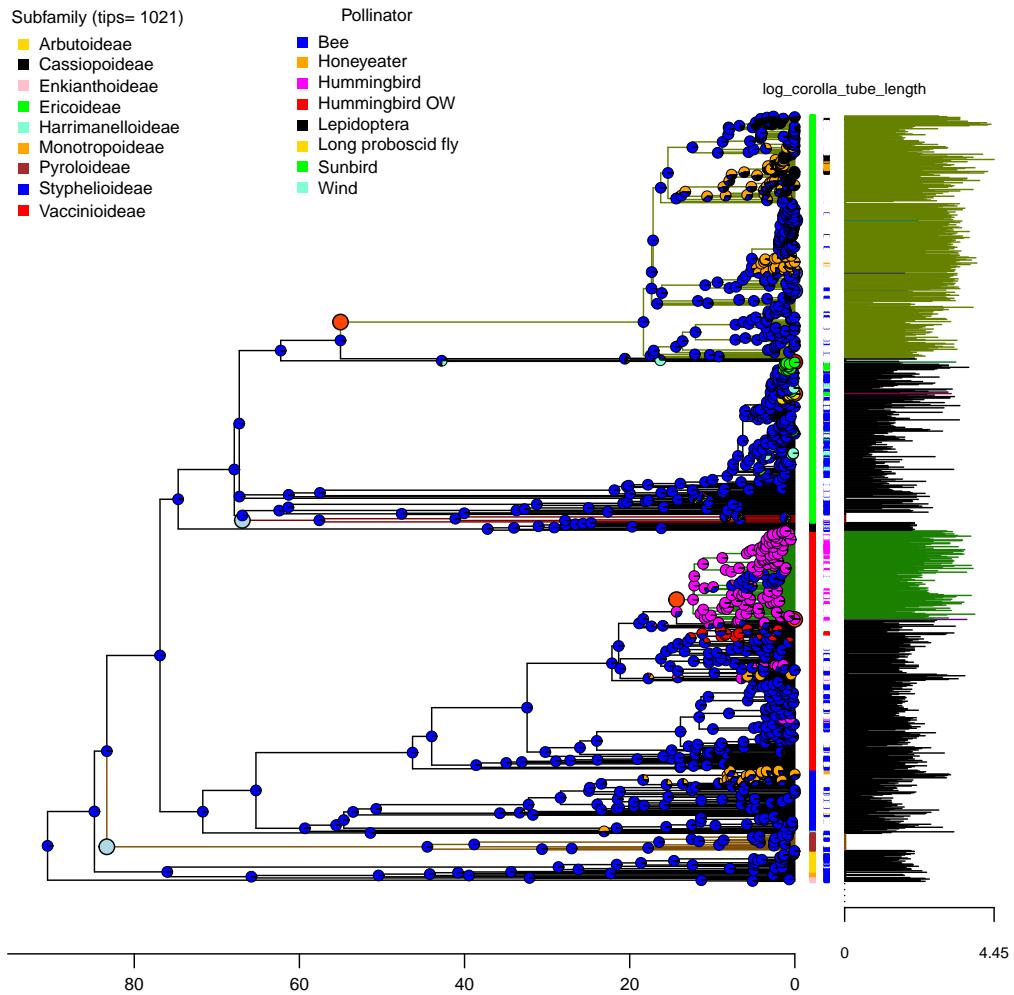
• l1ou

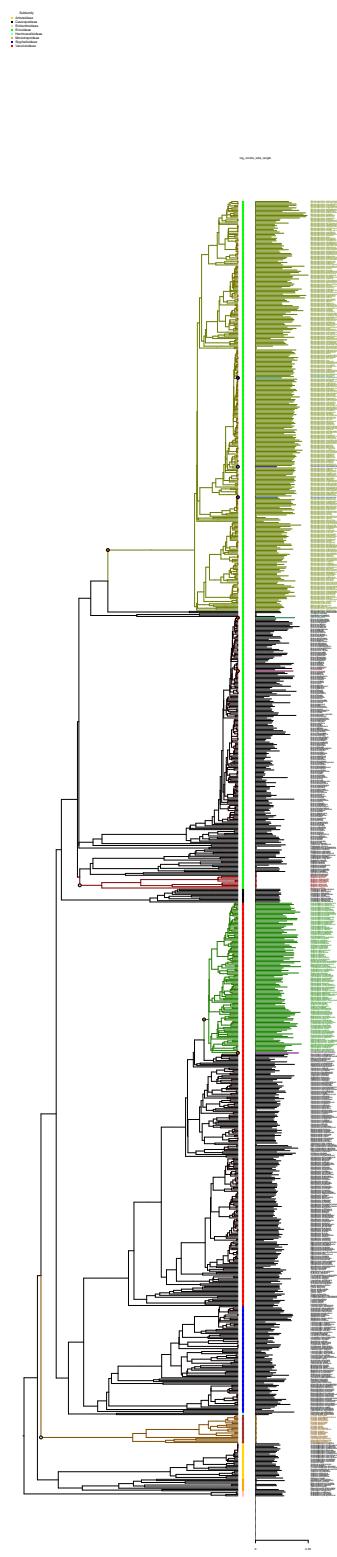




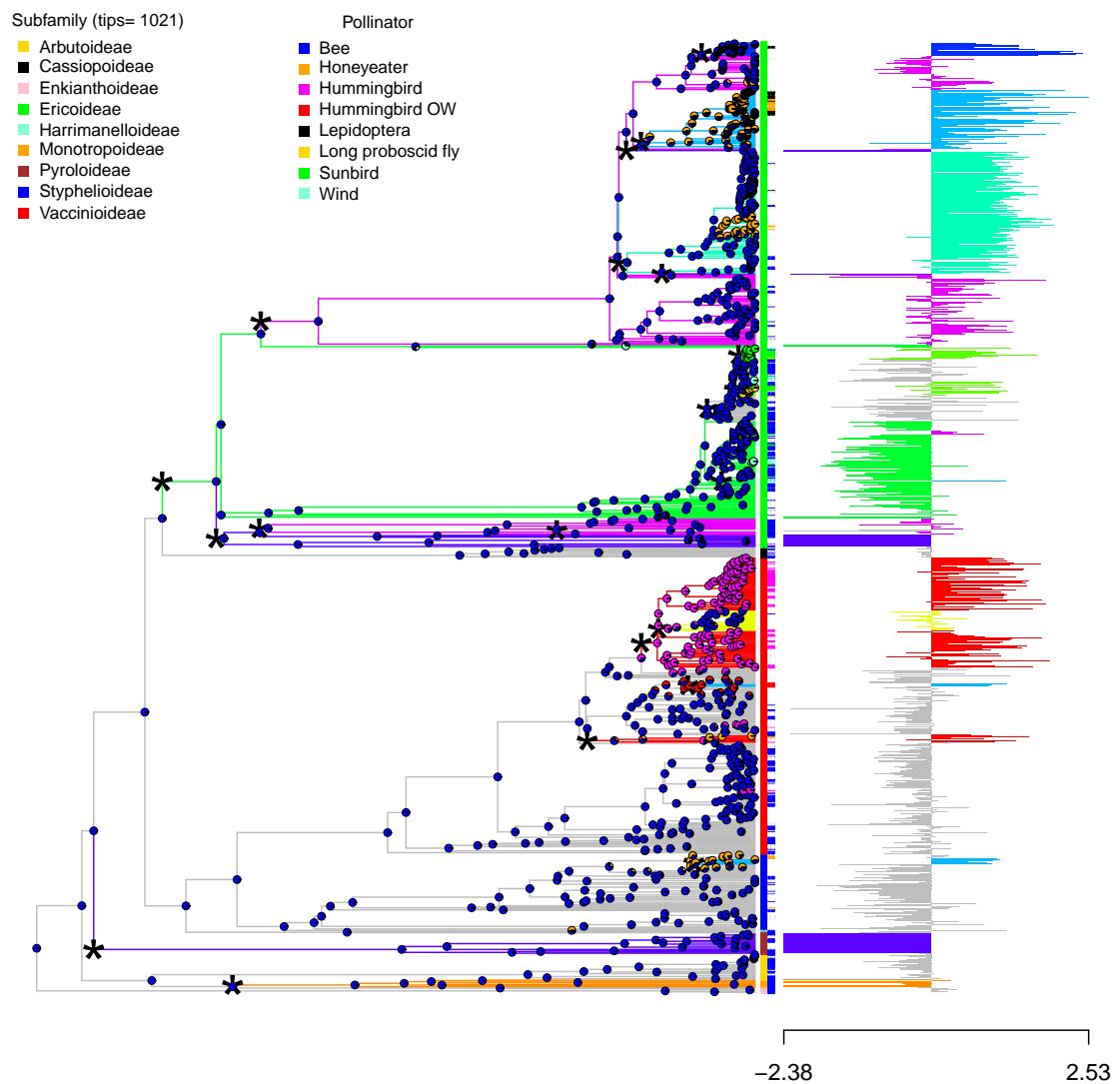
## Size

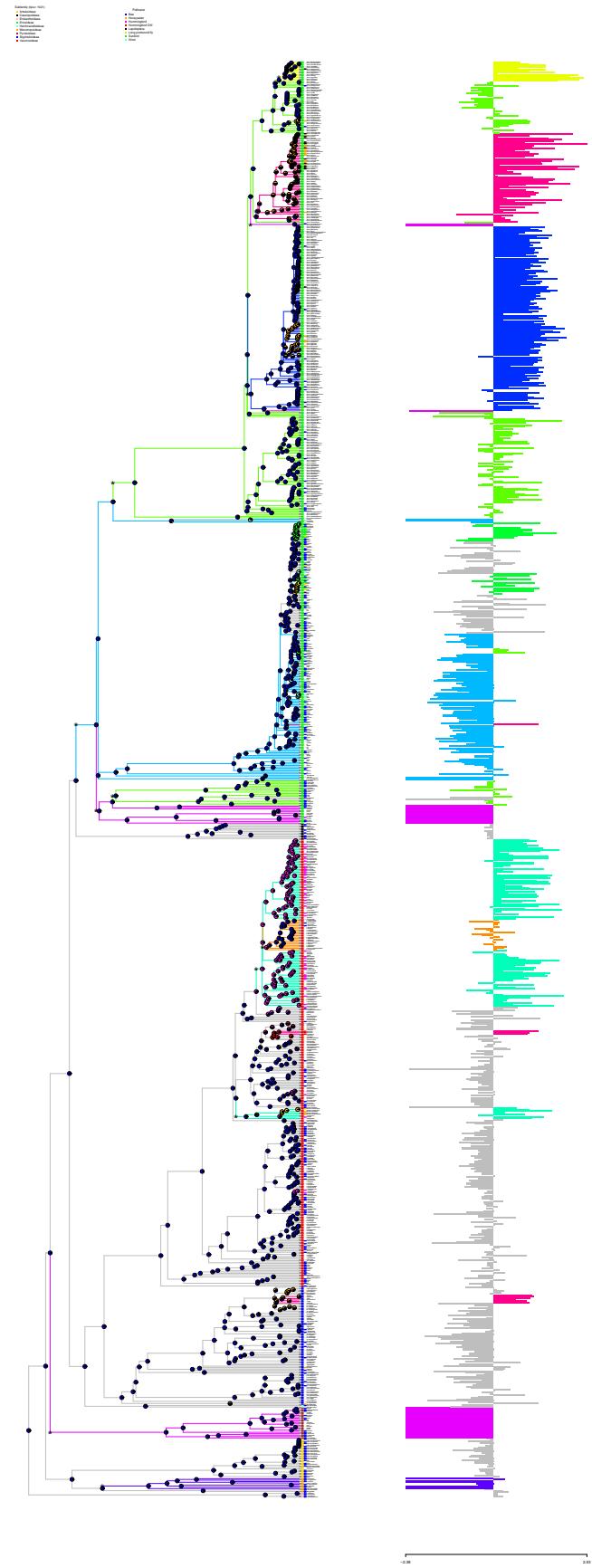
- PhylogeneticEM





• 11ou



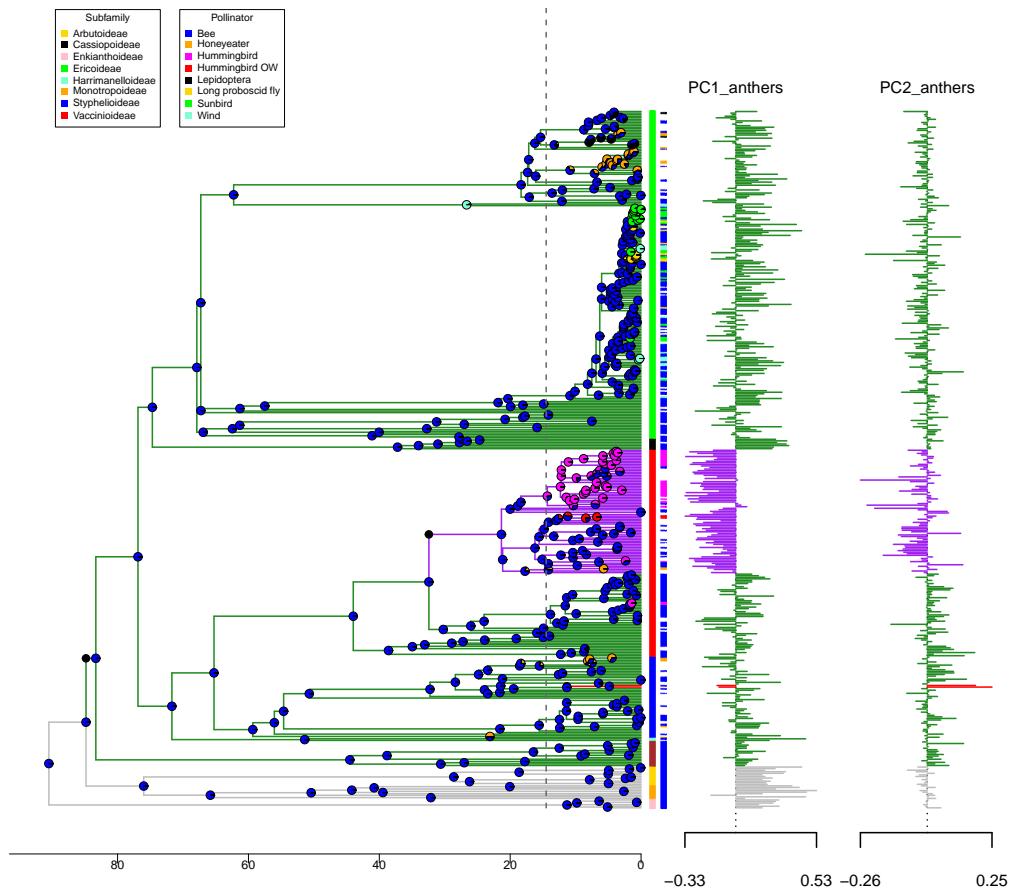


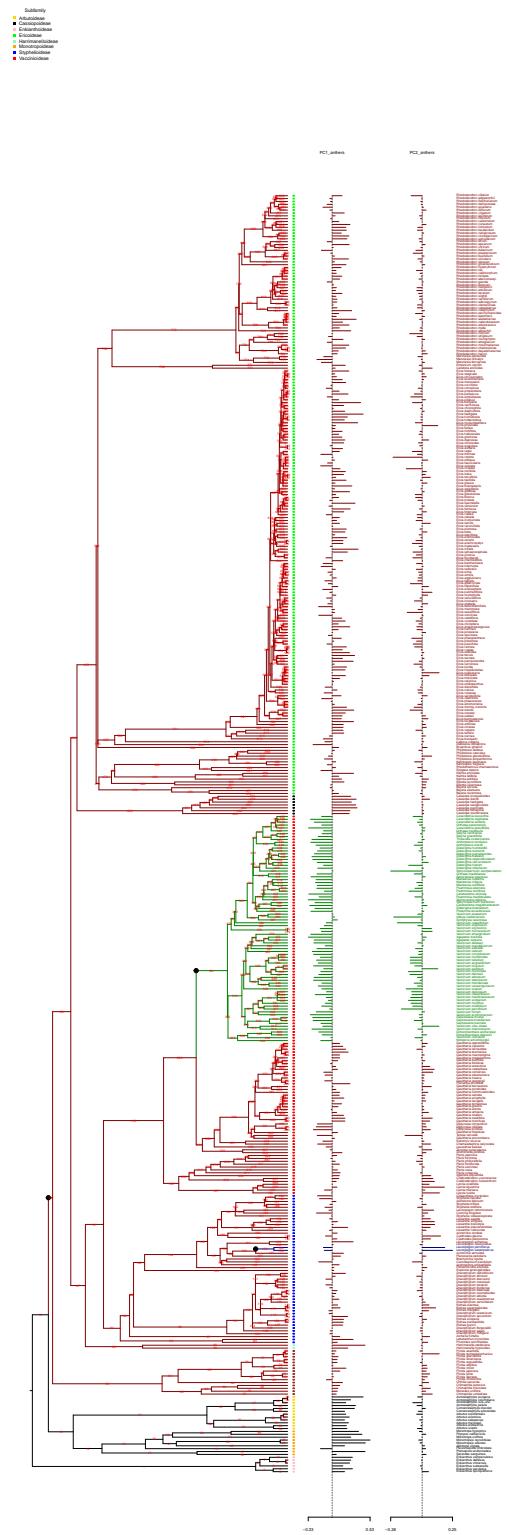
PGLS corolla

## Anther

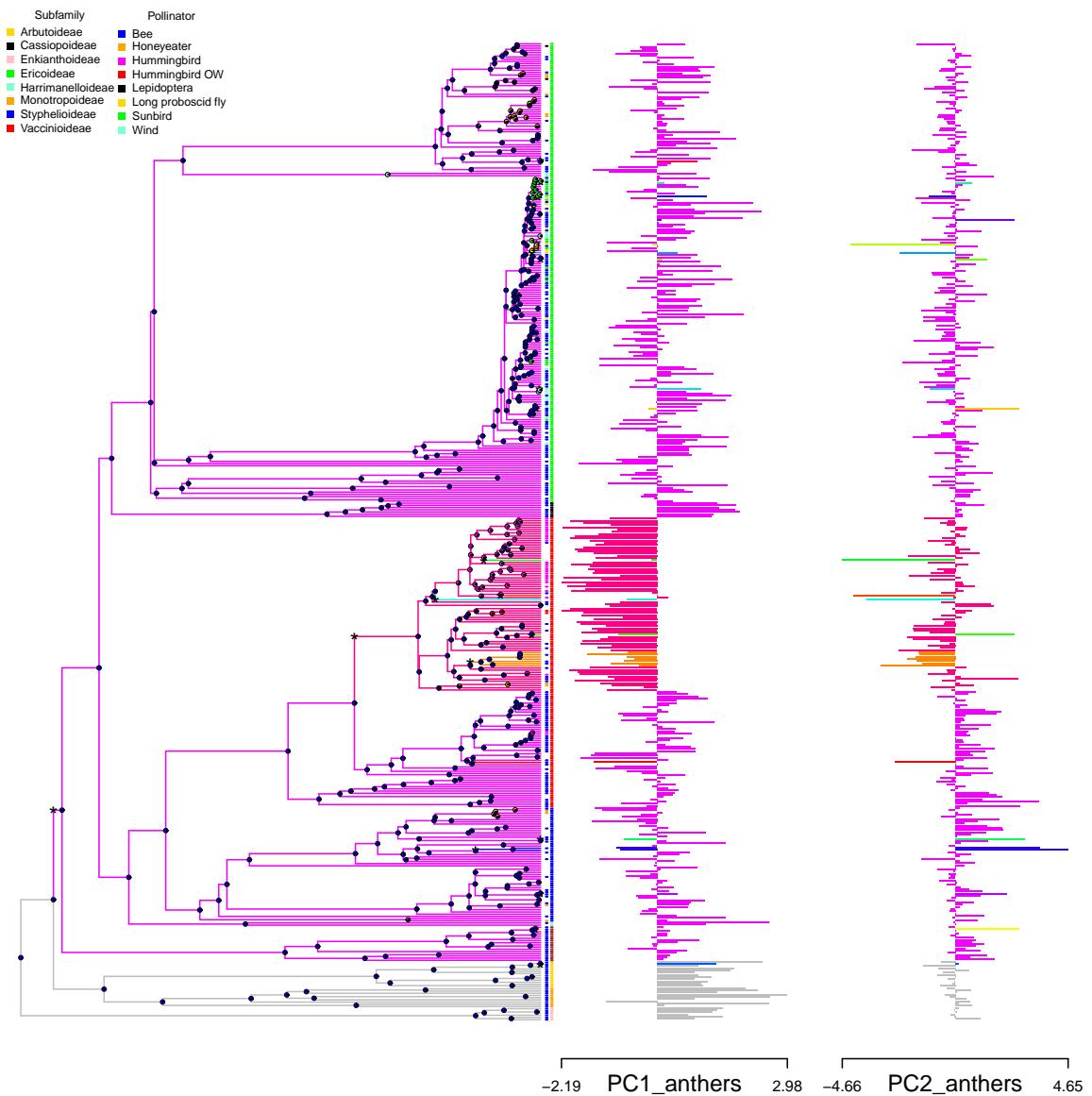
### Shape

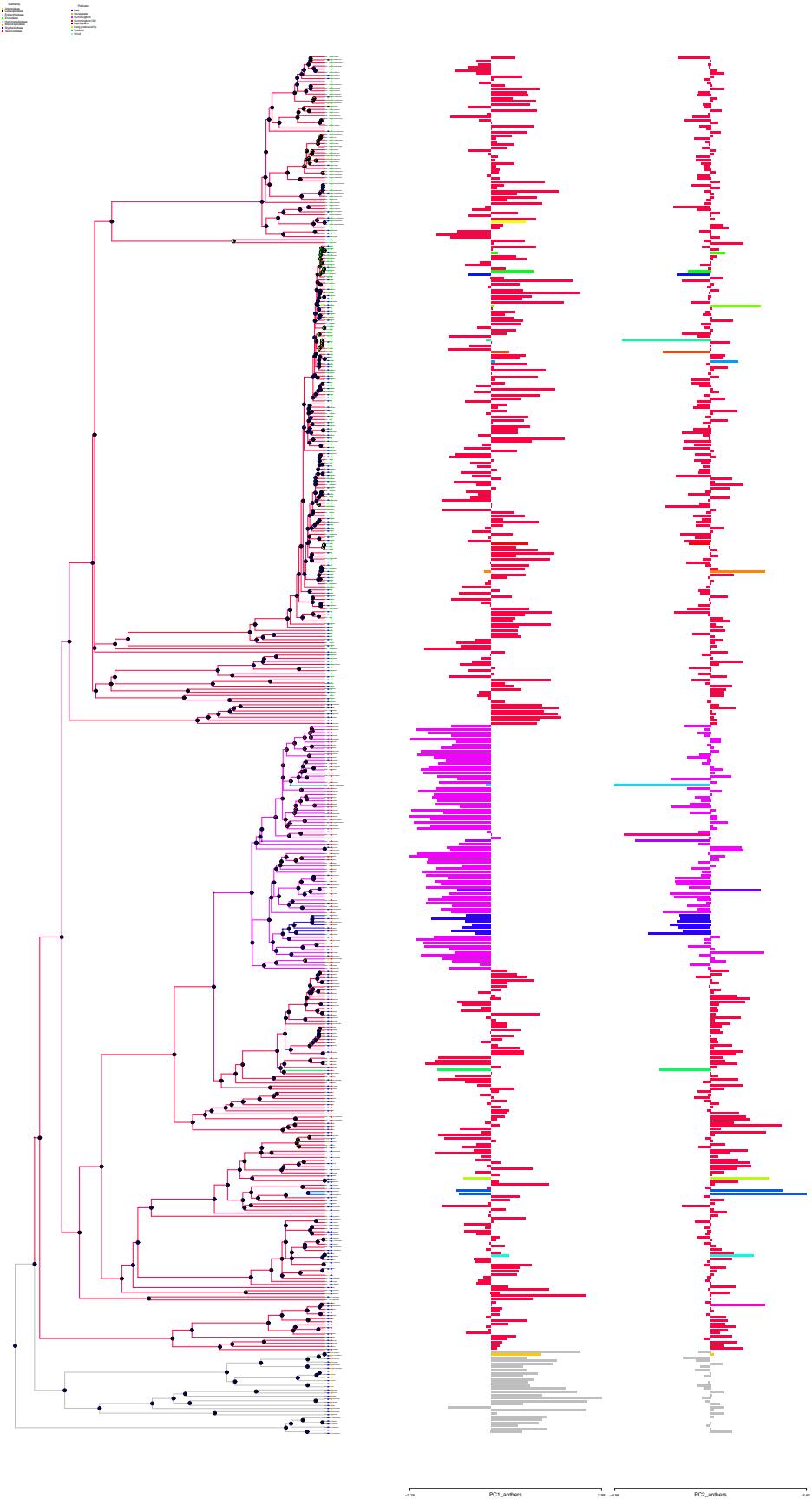
- PhylogeneticEM





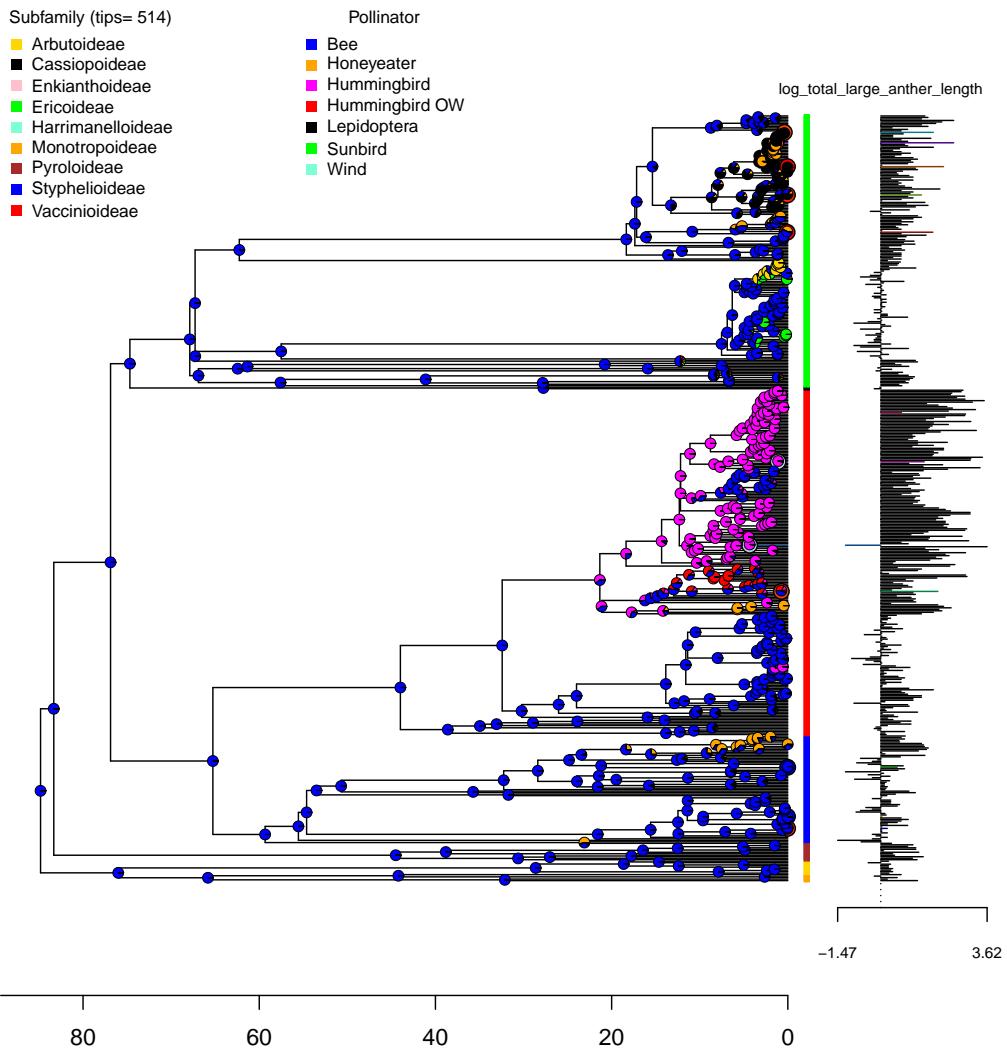
• l1ou

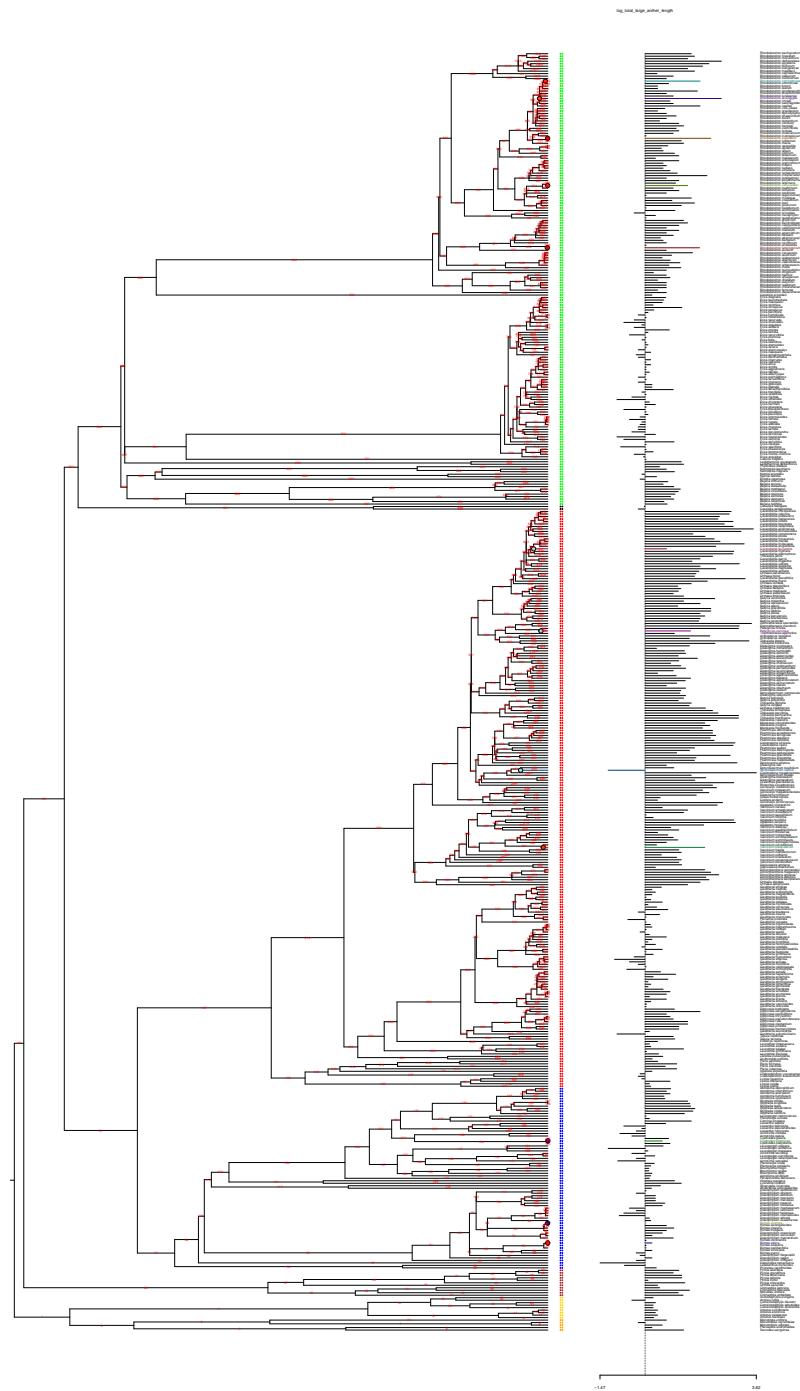




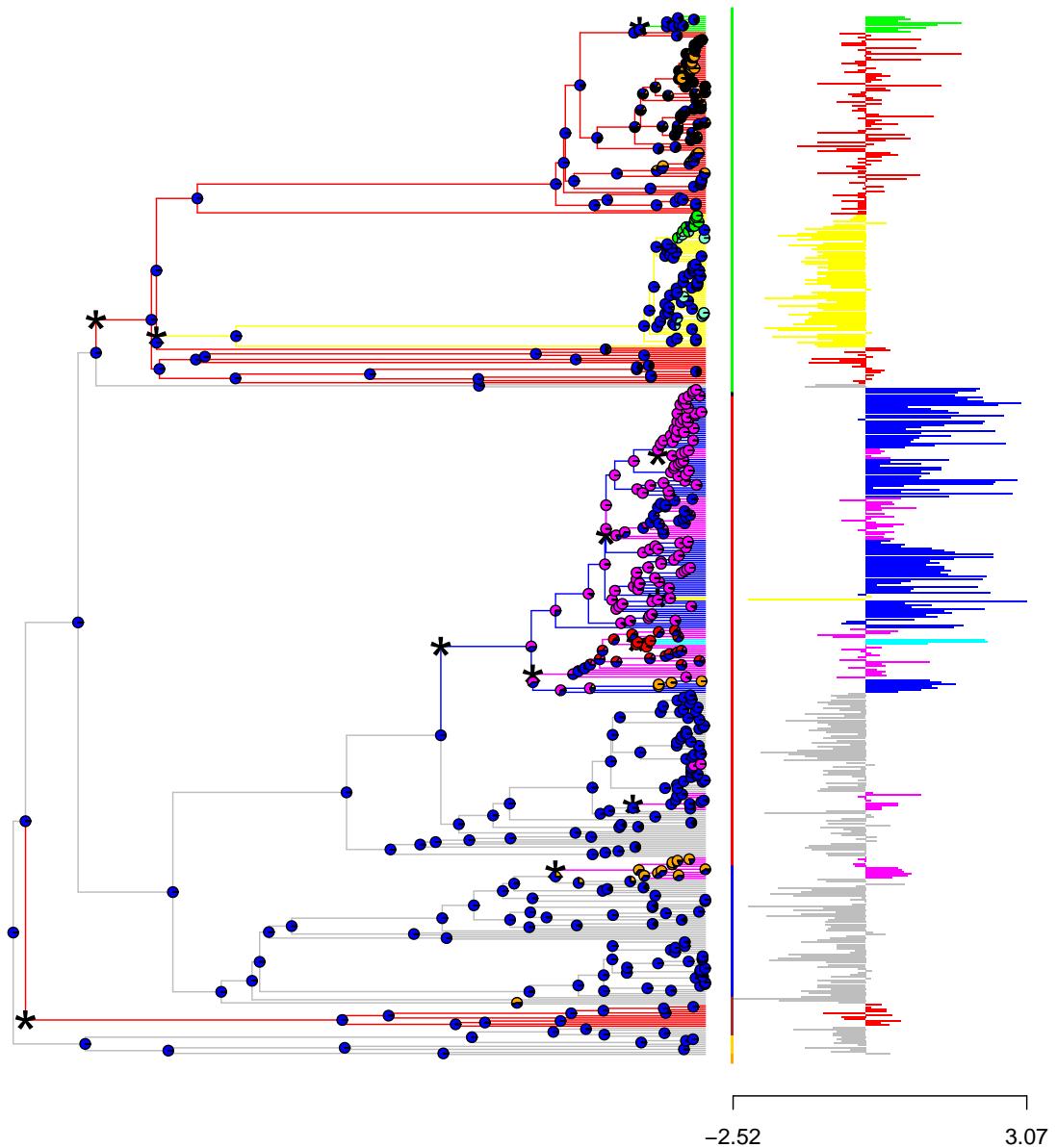
## Size

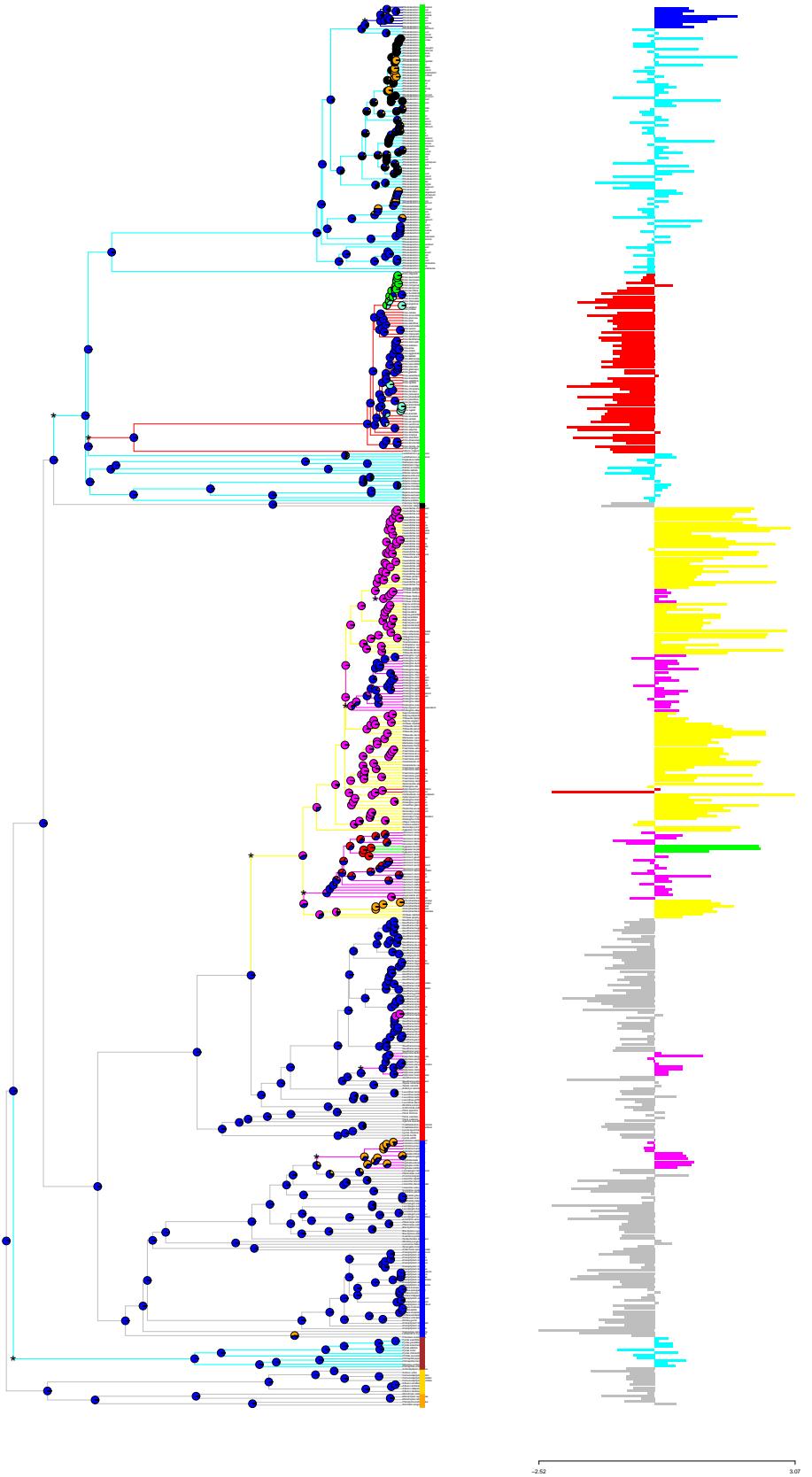
- PhylogeneticEM





- l1ou



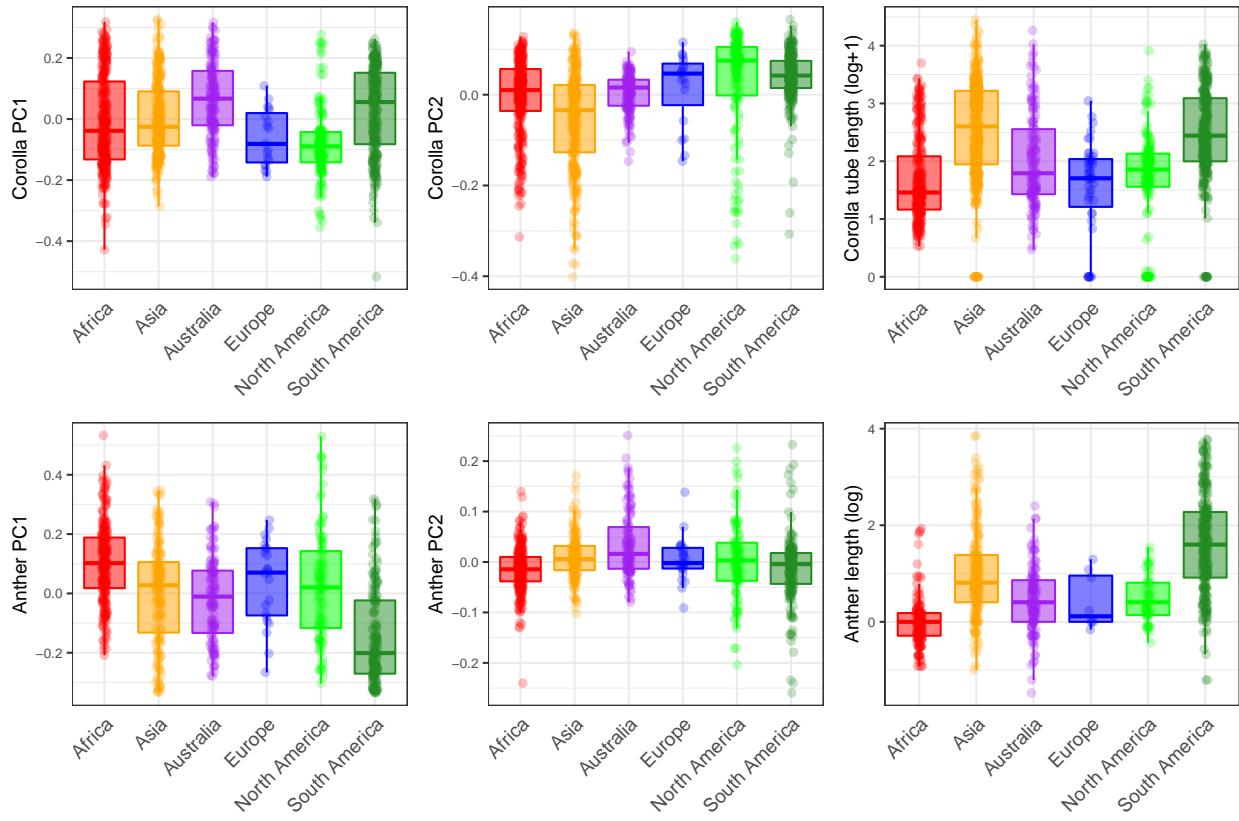


PGLS anther

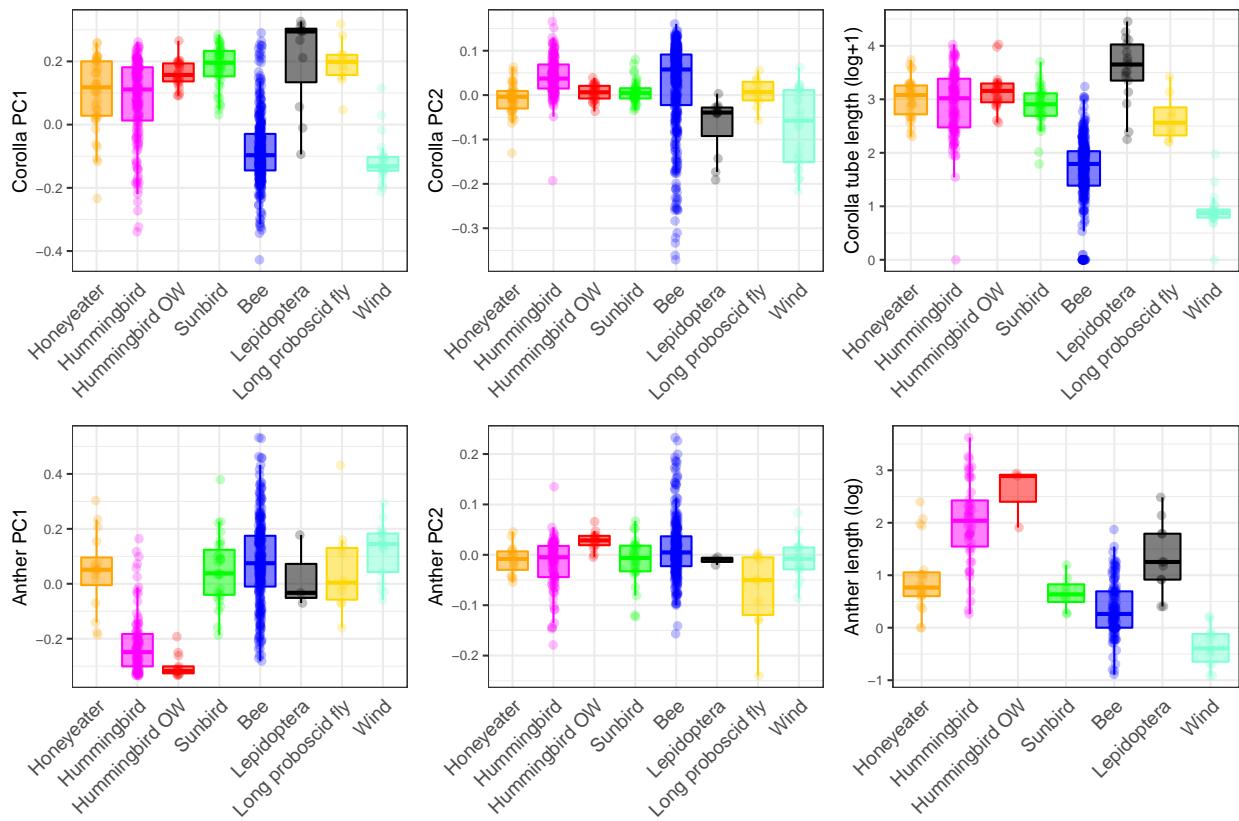
structure	variable	group1	n	mean	sd
corolla	continent	South_america	84	14.15	10.49
corolla	continent	Africa	131	6.63	7.30
corolla	continent	Asia	68	15.76	15.22
corolla	continent	Australia	26	17.44	16.53
corolla	continent	Europe	17	5.13	3.83
corolla	continent	North_america	82	5.32	4.44
corolla	pollinator	Bee	270	5.28	3.74
corolla	pollinator	Honeyeater	24	21.54	8.10
corolla	pollinator	Hummingbird	51	19.46	10.32
corolla	pollinator	Hummingbird_low	3	21.33	3.21
corolla	pollinator	Lepidoptera	14	40.93	21.61
corolla	pollinator	Long_proboscid_fly	8	14.53	7.62
corolla	pollinator	Sunbird	20	19.61	7.58
corolla	pollinator	Wind	18	1.39	0.61
anther	continent	South_america	79	6.93	7.21
anther	continent	Africa	51	1.11	0.57
anther	continent	Asia	36	3.56	4.43
anther	continent	Australia	28	2.65	2.40
anther	continent	Europe	6	2.06	1.13
anther	continent	North_america	31	2.05	1.06
anther	pollinator	Bee	126	1.63	0.96
anther	pollinator	Honeyeater	19	3.32	2.80
anther	pollinator	Hummingbird	50	9.85	7.63
anther	pollinator	Hummingbird_low	3	14.55	6.77
anther	pollinator	Lepidoptera	11	4.61	3.26
anther	pollinator	Sunbird	8	2.03	0.67
anther	pollinator	Wind	14	0.74	0.27

## Boxplots

Geography



Pollinator



## PGLS results

### Geography

Table 1: PGLS Geography and corolla traits

trait	group	N	Value	Std.Error	t-value	p-value	r2
<b>corolla PC1</b>	<b>Intercept: South America</b>	<b>88</b>	<b>-0.041</b>	<b>0.063</b>	<b>-0.654</b>	<b>1.000</b>	<b>0.347</b>
corolla PC1	Africa	147	-0.021	0.079	-0.268	1.000	0.347
corolla PC1	Asia	72	-0.023	0.032	-0.704	1.000	0.347
corolla PC1	Australia	44	0.031	0.039	0.790	1.000	0.347
corolla PC1	Europe	12	-0.062	0.048	-1.298	0.975	0.347
corolla PC1	North America	91	-0.054	0.031	-1.708	0.530	0.347
<b>corolla PC2</b>	<b>Intercept: South America</b>	<b>88</b>	<b>0.026</b>	<b>0.061</b>	<b>0.436</b>	<b>1.000</b>	<b>0.434</b>
corolla PC2	Africa	147	-0.033	0.066	-0.508	1.000	0.434
corolla PC2	Asia	72	-0.039	0.022	-1.727	0.509	0.434
corolla PC2	Australia	44	-0.024	0.026	-0.911	1.000	0.434
corolla PC2	Europe	12	0.023	0.032	0.744	1.000	0.434
corolla PC2	North America	91	-0.032	0.021	-1.488	0.687	0.434
<b>log corolla length</b>	<b>Intercept: South America</b>	<b>84</b>	<b>1.739</b>	<b>0.399</b>	<b>4.355</b>	<b>0.000</b>	<b>0.593</b>
log corolla length	Africa	131	-0.707	0.556	-1.271	0.817	0.593
log corolla length	Asia	68	-0.003	0.176	-0.019	1.000	0.593
log corolla length	Australia	26	0.074	0.225	0.331	1.000	0.593
log corolla length	Europe	17	-0.271	0.223	-1.218	0.817	0.593
log corolla length	North America	82	-0.451	0.163	-2.766	0.030	0.593

Table 2: PGLS Geography and anther traits

trait	group	N	Value	Std.Error	t-value	p-value	r2
<b>anther PC1</b>	<b>Intercept: South America</b>	<b>52</b>	<b>0.097</b>	<b>0.069</b>	<b>1.403</b>	<b>0.615</b>	<b>0.527</b>
anther PC1	Africa	112	0.066	0.099	0.670	0.615	0.527
anther PC1	Asia	44	0.056	0.039	1.430	0.615	0.527
anther PC1	Australia	25	0.081	0.050	1.615	0.536	0.527
anther PC1	Europe	16	0.053	0.047	1.118	0.615	0.527
anther PC1	North America	63	0.060	0.033	1.801	0.436	0.527
<b>anther PC2</b>	<b>Intercept: South America</b>	<b>52</b>	<b>-0.005</b>	<b>0.014</b>	<b>-0.336</b>	<b>1.000</b>	<b>0.146</b>
anther PC2	Africa	112	-0.007	0.023	-0.314	1.000	0.146
anther PC2	Asia	44	0.016	0.013	1.233	0.873	0.146
anther PC2	Australia	25	0.022	0.016	1.376	0.849	0.146
anther PC2	Europe	16	0.018	0.016	1.123	0.873	0.146
anther PC2	North America	63	0.019	0.011	1.761	0.475	0.146
<b>log anther length</b>	<b>Intercept: South America</b>	<b>79</b>	<b>0.525</b>	<b>0.313</b>	<b>1.677</b>	<b>0.570</b>	<b>0.662</b>
log anther length	Africa	51	-0.484	0.724	-0.668	1.000	0.662
log anther length	Asia	36	-0.047	0.190	-0.247	1.000	0.662
log anther length	Australia	28	0.036	0.239	0.150	1.000	0.662
log anther length	Europe	6	-0.120	0.296	-0.404	1.000	0.662
log anther length	North America	31	-0.016	0.208	-0.075	1.000	0.662

## Pollinator

With hummingbird as the reference group:

Table 3: PGLS pollinator and corolla traits

trait	group	N	Value	Std.Error	t-value	p-value	r2
corolla PC1	Intercept: Hummingbird	58	0.014	0.064	0.224	1.000	0.547
corolla PC1	Bee	302	-0.090	0.034	-2.615	0.046	0.547
corolla PC1	Honeyeater	28	-0.057	0.043	-1.318	0.565	0.547
corolla PC1	Hummingbird OW	3	0.117	0.078	1.501	0.536	0.547
corolla PC1	Lepidoptera	8	0.012	0.053	0.223	1.000	0.547
corolla PC1	Long proboscid fly	8	0.147	0.048	3.039	0.015	0.547
corolla PC1	Sunbird	27	0.153	0.040	3.821	0.001	0.547
corolla PC1	Wind	20	-0.142	0.042	-3.424	0.005	0.547
corolla PC2	Intercept: Hummingbird	58	0.014	0.062	0.222	1.000	0.454
corolla PC2	Bee	302	-0.017	0.026	-0.653	1.000	0.454
corolla PC2	Honeyeater	28	0.018	0.033	0.532	1.000	0.454
corolla PC2	Hummingbird OW	3	-0.015	0.066	-0.226	1.000	0.454
corolla PC2	Lepidoptera	8	-0.033	0.038	-0.876	1.000	0.454
corolla PC2	Long proboscid fly	8	-0.026	0.034	-0.773	1.000	0.454
corolla PC2	Sunbird	27	-0.032	0.029	-1.074	1.000	0.454
corolla PC2	Wind	20	-0.086	0.031	-2.794	0.043	0.454
log corolla length	Intercept: Hummingbird	51	1.986	0.356	5.577	0.000	0.754
log corolla length	Bee	270	-0.535	0.160	-3.343	0.005	0.754
log corolla length	Honeyeater	24	0.101	0.217	0.463	0.643	0.754
log corolla length	Hummingbird OW	3	0.880	0.402	2.189	0.087	0.754
log corolla length	Lepidoptera	14	0.605	0.235	2.577	0.041	0.754
log corolla length	Long proboscid fly	8	0.394	0.215	1.839	0.133	0.754
log corolla length	Sunbird	20	0.783	0.188	4.176	0.000	0.754
log corolla length	Wind	18	-1.083	0.192	-5.647	0.000	0.754

Table 4: PGLS pollinator and anther traits

<b>trait</b>	<b>group</b>	<b>N</b>	<b>Value</b>	<b>Std.Error</b>	<b>t-value</b>	<b>p-value</b>	<b>r2</b>
<b>anther PC1</b>	<b>Intercept: Hummingbird</b>	<b>27</b>	<b>0.106</b>	<b>0.074</b>	<b>1.434</b>	<b>1.000</b>	<b>0.548</b>
anther PC1	Bee	228	0.046	0.044	1.054	1.000	0.548
anther PC1	Honeyeater	11	0.070	0.059	1.185	1.000	0.548
anther PC1	Hummingbird OW	2	-0.072	0.102	-0.703	1.000	0.548
anther PC1	Lepidoptera	2	-0.099	0.096	-1.035	1.000	0.548
anther PC1	Long proboscid fly	8	0.001	0.058	0.021	1.000	0.548
anther PC1	Sunbird	18	-0.044	0.052	-0.856	1.000	0.548
anther PC1	Wind	16	0.089	0.053	1.676	0.758	0.548
<b>anther PC2</b>	<b>Intercept: Hummingbird</b>	<b>27</b>	<b>-0.008</b>	<b>0.018</b>	<b>-0.455</b>	<b>1.000</b>	<b>0.174</b>
anther PC2	Bee	228	0.021	0.014	1.474	0.990	0.174
anther PC2	Honeyeater	11	0.004	0.020	0.184	1.000	0.174
anther PC2	Hummingbird OW	2	0.051	0.036	1.423	0.990	0.174
anther PC2	Lepidoptera	2	0.007	0.037	0.199	1.000	0.174
anther PC2	Long proboscid fly	8	-0.037	0.022	-1.687	0.741	0.174
anther PC2	Sunbird	18	0.012	0.018	0.679	1.000	0.174
anther PC2	Wind	16	0.018	0.019	0.942	1.000	0.174
<b>log anther length</b>	<b>Intercept: Hummingbird</b>	<b>50</b>	<b>0.994</b>	<b>0.276</b>	<b>3.606</b>	<b>0.002</b>	<b>0.727</b>
log anther length	Bee	126	-0.533	0.178	-2.999	0.015	0.727
log anther length	Honeyeater	19	-0.257	0.252	-1.020	0.922	0.727
log anther length	Hummingbird OW	3	0.938	0.391	2.398	0.069	0.727
log anther length	Lepidoptera	11	0.307	0.300	1.023	0.922	0.727
log anther length	Sunbird	8	0.156	0.271	0.575	0.922	0.727
log anther length	Wind	14	-0.945	0.234	-4.034	0.001	0.727

With Old World hummingbird as the reference group:

Table 5: PGLS pollinator and corolla traits: Hummingbird OW as ref

<b>trait</b>	<b>group</b>	<b>N</b>	<b>Value</b>	<b>Std.Error</b>	<b>t-value</b>	<b>p-value</b>	<b>r2</b>
<b>corolla PC1</b>	<b>Intercept: Hummingbird OW</b>	<b>3</b>	<b>0.131</b>	<b>0.091</b>	<b>1.445</b>	<b>0.670</b>	<b>0.547</b>
corolla PC1	Bee	302	-0.207	0.073	-2.831	0.034	0.547
corolla PC1	Honeyeater	28	-0.174	0.078	-2.234	0.156	0.547
corolla PC1	Hummingbird	58	-0.117	0.078	-1.501	0.670	0.547
corolla PC1	Lepidoptera	8	-0.105	0.083	-1.262	0.670	0.547
corolla PC1	Long proboscid fly	8	0.030	0.081	0.368	1.000	0.547
corolla PC1	Sunbird	27	0.036	0.076	0.471	1.000	0.547
corolla PC1	Wind	20	-0.259	0.077	-3.381	0.006	0.547
<b>corolla PC2</b>	<b>Intercept: Hummingbird OW</b>	<b>3</b>	<b>-0.001</b>	<b>0.084</b>	<b>-0.012</b>	<b>1.000</b>	<b>0.454</b>
corolla PC2	Bee	302	-0.002	0.062	-0.037	1.000	0.454
corolla PC2	Honeyeater	28	0.032	0.065	0.498	1.000	0.454
corolla PC2	Hummingbird	58	0.015	0.066	0.226	1.000	0.454
corolla PC2	Lepidoptera	8	-0.019	0.068	-0.275	1.000	0.454
corolla PC2	Long proboscid fly	8	-0.011	0.065	-0.175	1.000	0.454
corolla PC2	Sunbird	27	-0.017	0.063	-0.265	1.000	0.454
corolla PC2	Wind	20	-0.071	0.064	-1.110	1.000	0.454
<b>log corolla length</b>	<b>Intercept: Hummingbird OW</b>	<b>3</b>	<b>2.866</b>	<b>0.495</b>	<b>5.792</b>	<b>0.000</b>	<b>0.754</b>
log corolla length	Bee	270	-1.415	0.379	-3.737	0.001	0.754
log corolla length	Honeyeater	24	-0.779	0.407	-1.913	0.226	0.754
log corolla length	Hummingbird	51	-0.880	0.402	-2.189	0.146	0.754
log corolla length	Lepidoptera	14	-0.275	0.416	-0.661	1.000	0.754
log corolla length	Long proboscid fly	8	-0.485	0.405	-1.200	0.693	0.754
log corolla length	Sunbird	20	-0.097	0.391	-0.247	1.000	0.754
log corolla length	Wind	18	-1.963	0.393	-4.993	0.000	0.754

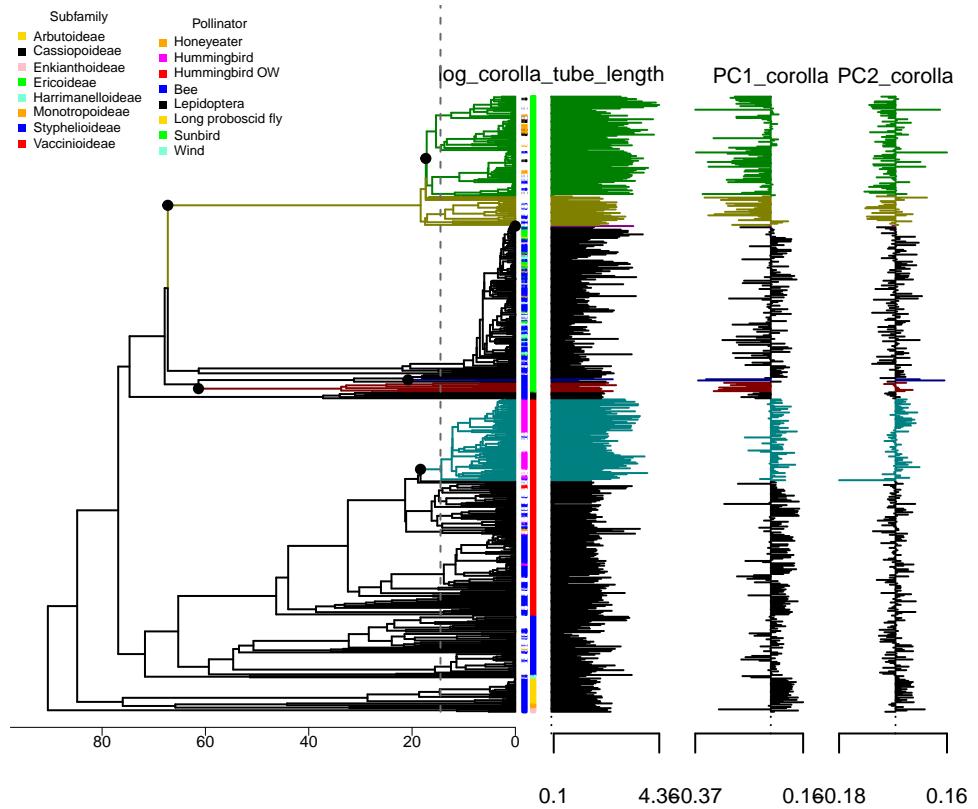
Table 6: PGLS pollinator and anther traits: Hummingbird OW as ref

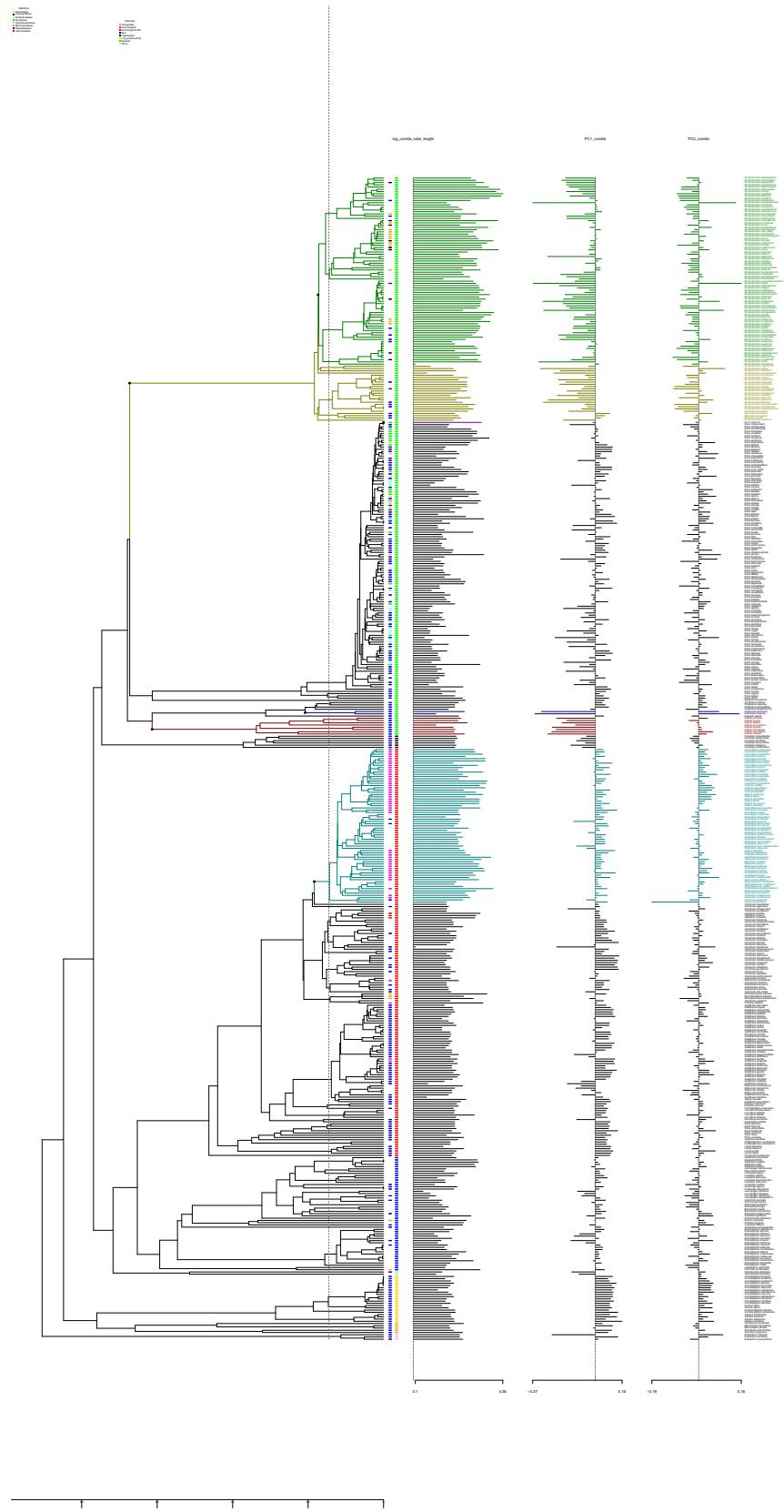
<b>trait</b>	<b>group</b>	<b>N</b>	<b>Value</b>	<b>Std.Error</b>	<b>t-value</b>	<b>p-value</b>	<b>r2</b>
<b>anther PC1</b>	<b>Intercept: Hummingbird OW</b>	<b>2</b>	<b>0.035</b>	<b>0.113</b>	<b>0.307</b>	<b>1.000</b>	<b>0.548</b>
anther PC1	Bee	228	0.118	0.095	1.231	1.000	0.548
anther PC1	Honeyeater	11	0.142	0.103	1.369	1.000	0.548
anther PC1	Hummingbird	27	0.072	0.102	0.703	1.000	0.548
anther PC1	Lepidoptera	2	-0.028	0.128	-0.216	1.000	0.548
anther PC1	Long proboscid fly	8	0.073	0.103	0.707	1.000	0.548
anther PC1	Sunbird	18	0.027	0.099	0.276	1.000	0.548
anther PC1	Wind	16	0.161	0.100	1.604	0.879	0.548
<b>anther PC2</b>	<b>Intercept: Hummingbird OW</b>	<b>2</b>	<b>0.043</b>	<b>0.036</b>	<b>1.173</b>	<b>1.000</b>	<b>0.174</b>
anther PC2	Bee	228	-0.030	0.035	-0.871	1.000	0.174
anther PC2	Honeyeater	11	-0.047	0.038	-1.255	1.000	0.174
anther PC2	Hummingbird	27	-0.051	0.036	-1.423	1.000	0.174
anther PC2	Lepidoptera	2	-0.043	0.049	-0.895	1.000	0.174
anther PC2	Long proboscid fly	8	-0.088	0.038	-2.284	0.185	0.174
anther PC2	Sunbird	18	-0.038	0.037	-1.048	1.000	0.174
anther PC2	Wind	16	-0.033	0.037	-0.901	1.000	0.174
<b>log anther length</b>	<b>Intercept: Hummingbird OW</b>	<b>3</b>	<b>1.932</b>	<b>0.440</b>	<b>4.391</b>	<b>0.000</b>	<b>0.727</b>
log anther length	Bee	126	-1.471	0.387	-3.806	0.001	0.727
log anther length	Honeyeater	19	-1.195	0.421	-2.835	0.020	0.727
log anther length	Hummingbird	50	-0.938	0.391	-2.398	0.052	0.727
log anther length	Lepidoptera	11	-0.631	0.453	-1.394	0.165	0.727
log anther length	Sunbird	8	-0.783	0.437	-1.790	0.150	0.727
log anther length	Wind	14	-1.884	0.416	-4.532	0.000	0.727

## Supplements

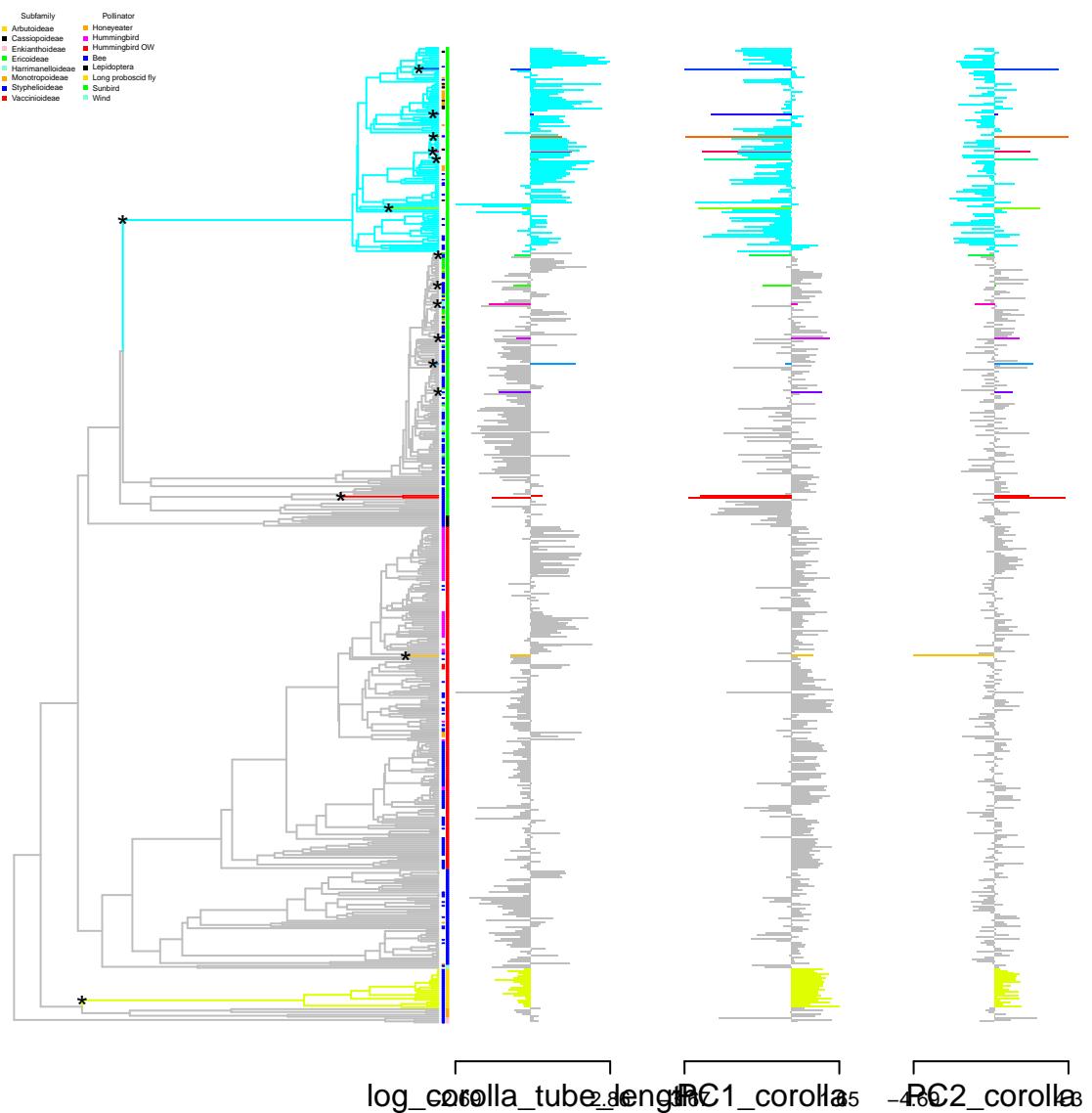
### Shifts corolla shape and size

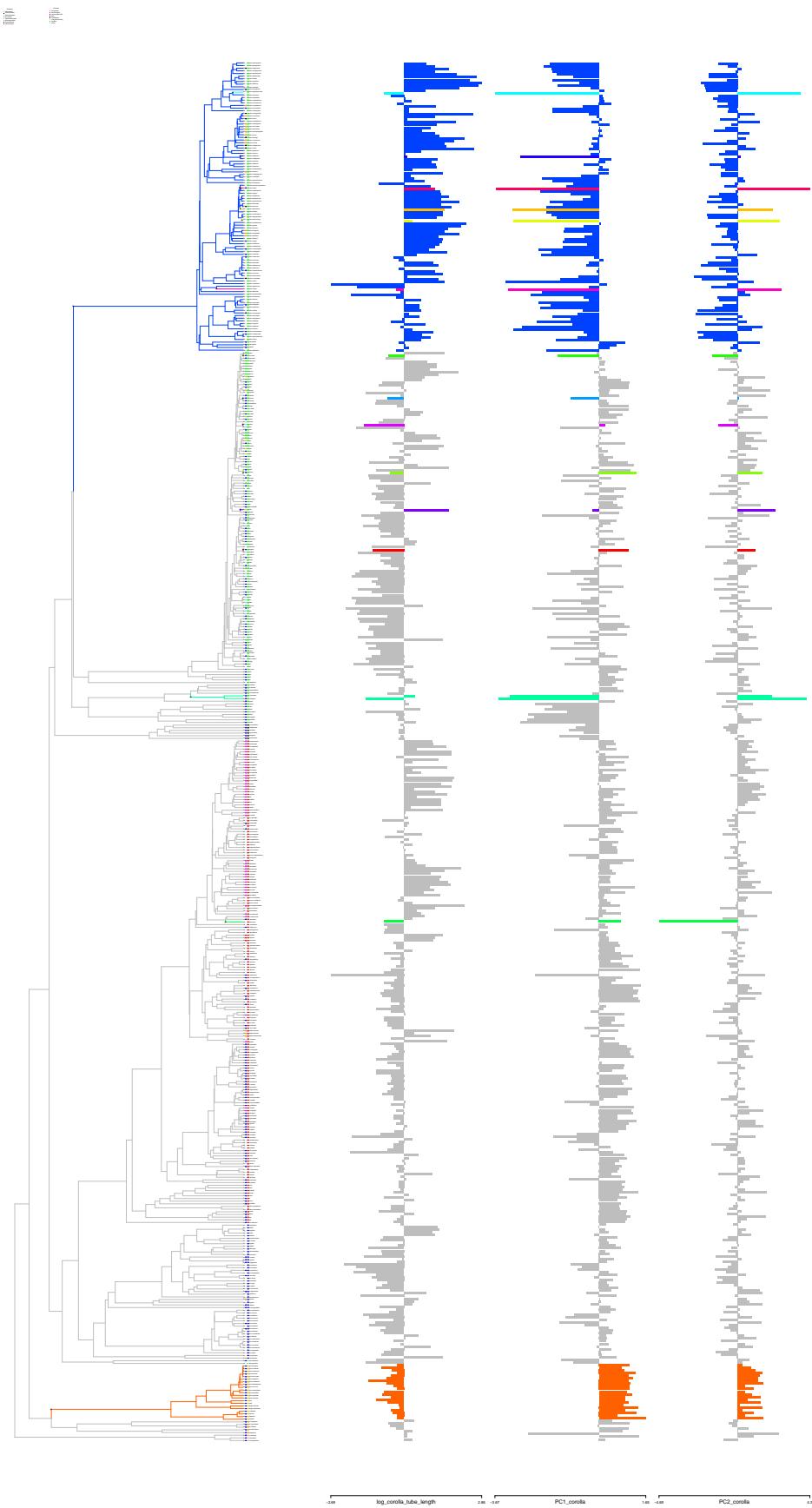
- PhylogeneticEM





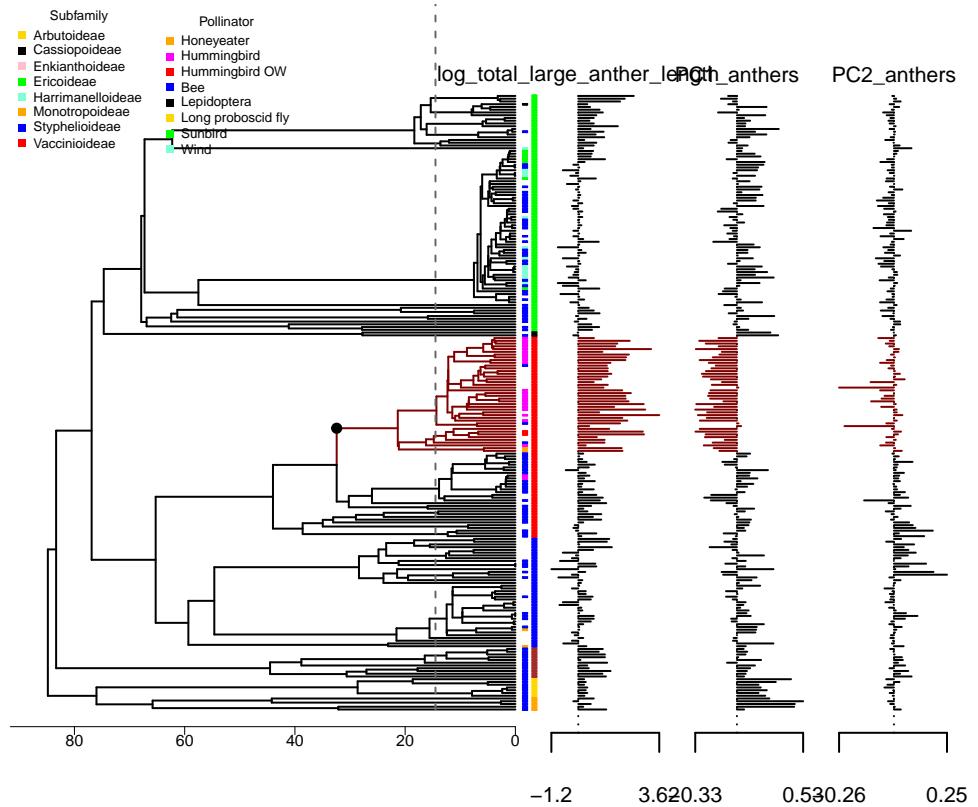
• l1ou

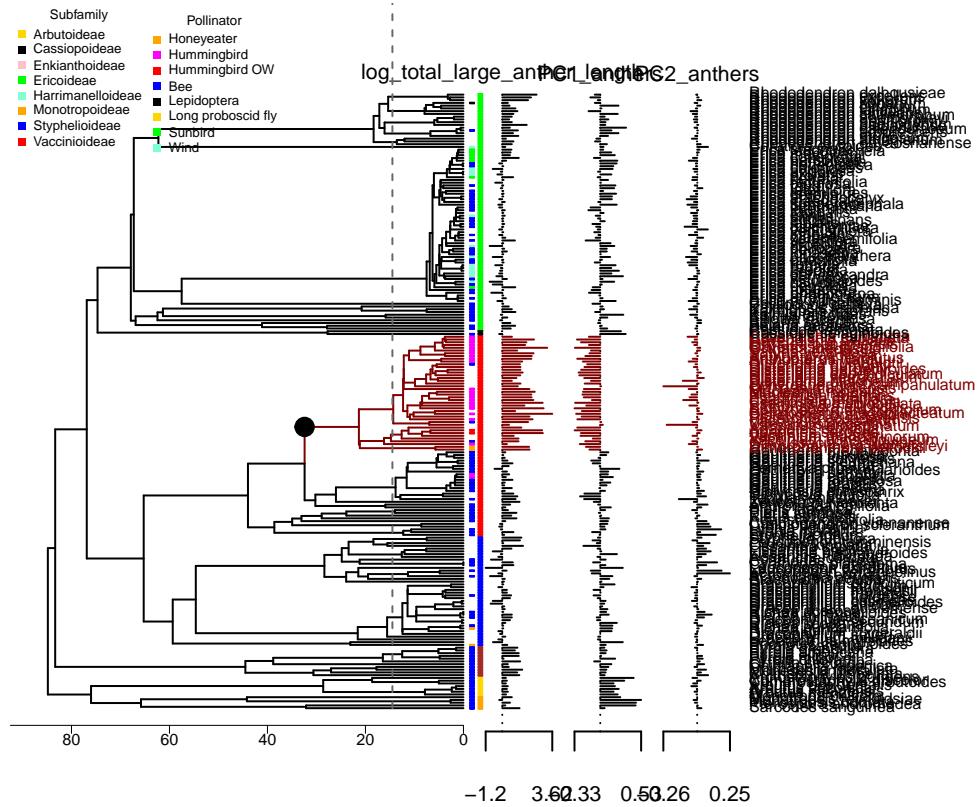




## Shifts anther shape and size

- PhylogeneticEM





• 11ou

