Mast-Trait

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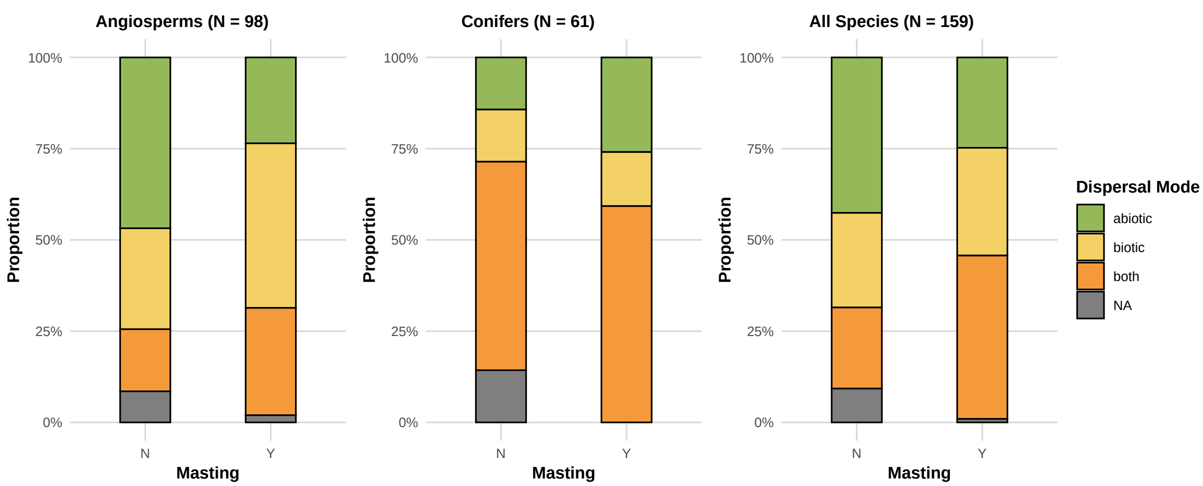
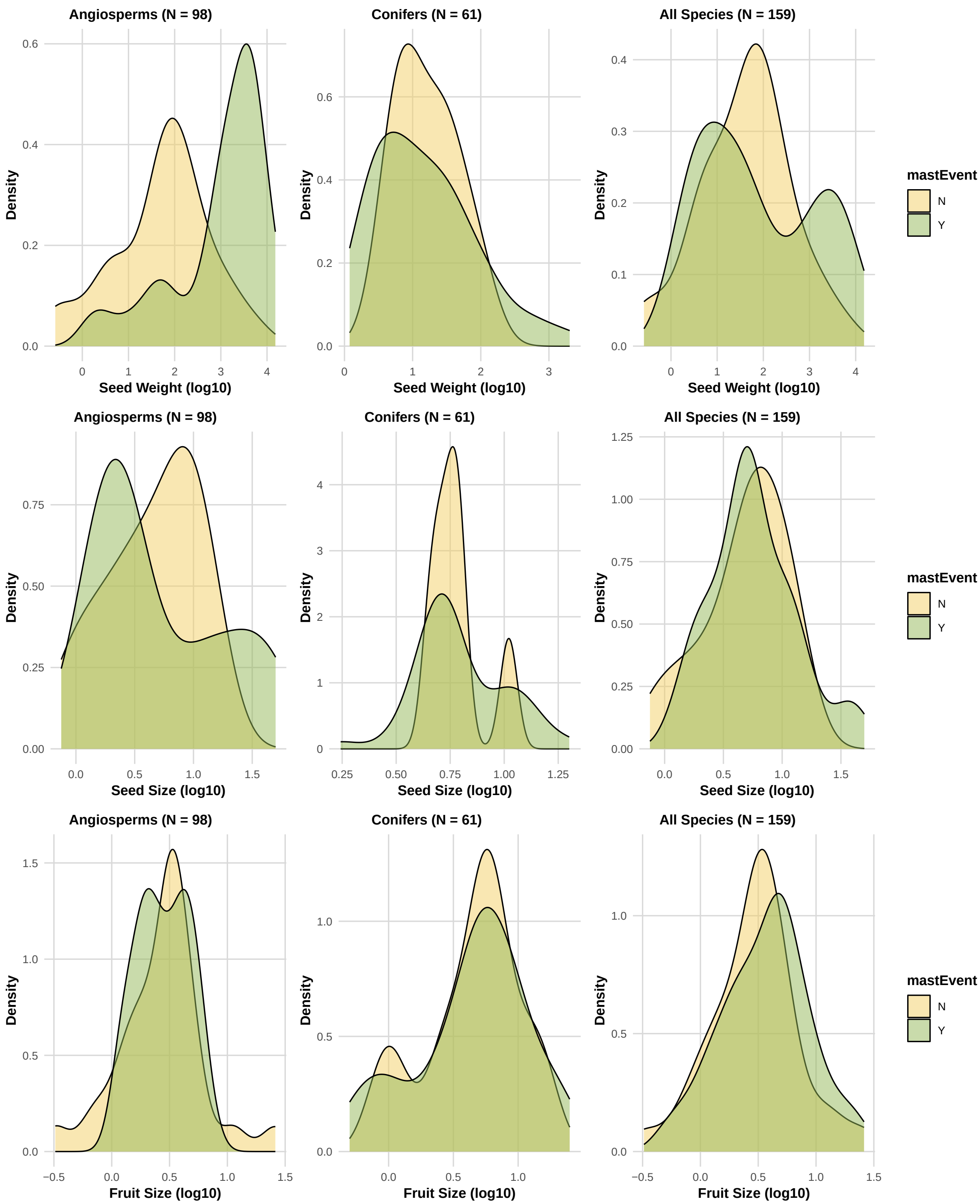
Hypotheses

Predator Satiation

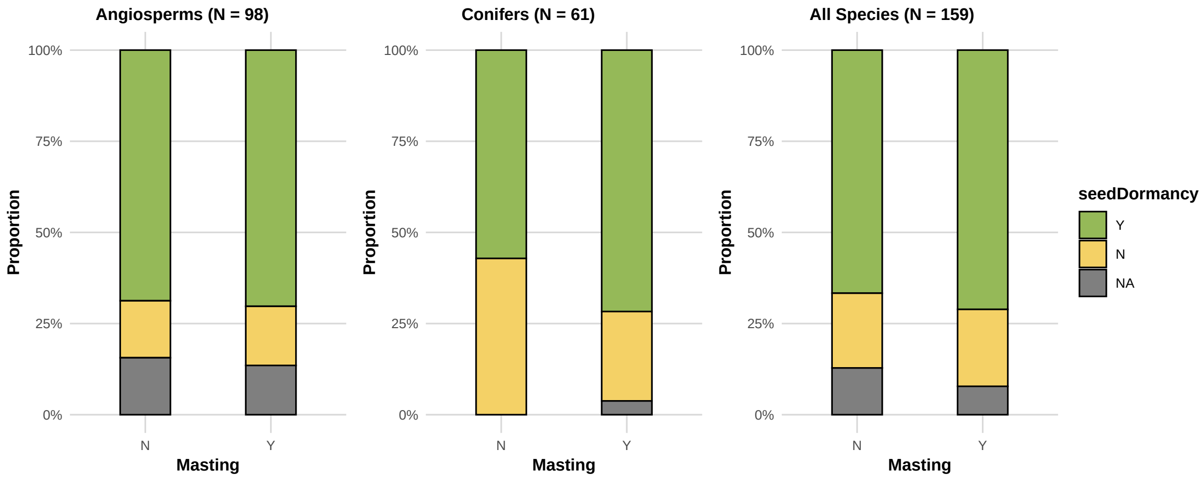
- Dispersal mode: Animal-dispersed species may be more likely to mast, or the mechanisms behind masting could differ depending on dispersal mode.



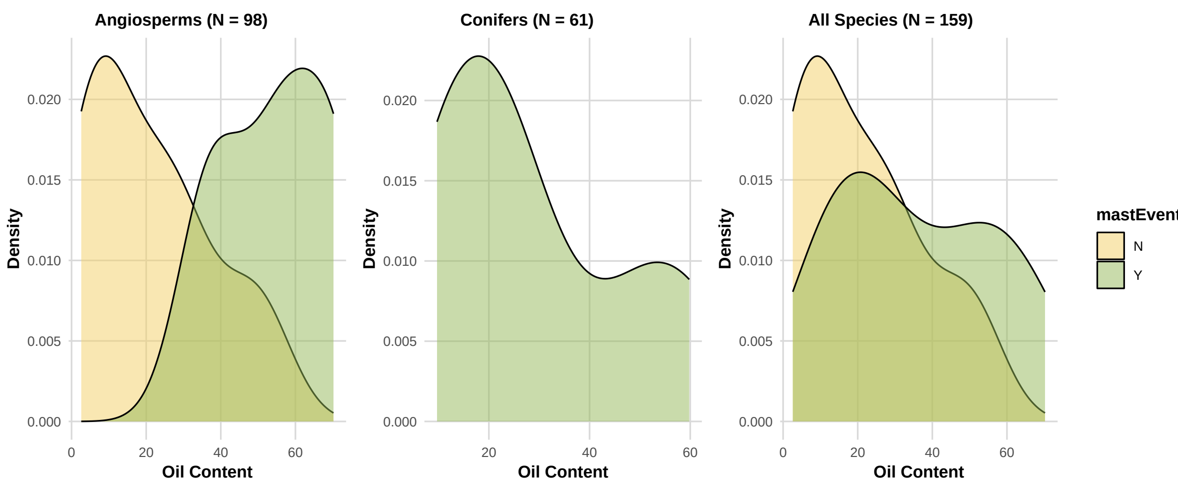
- **Seed size:** Among animal-dispersed species, larger-seeded species might be more prone to masting.



- **Seed dormancy:** Species with dormant seeds are expected to be more likely to mast.

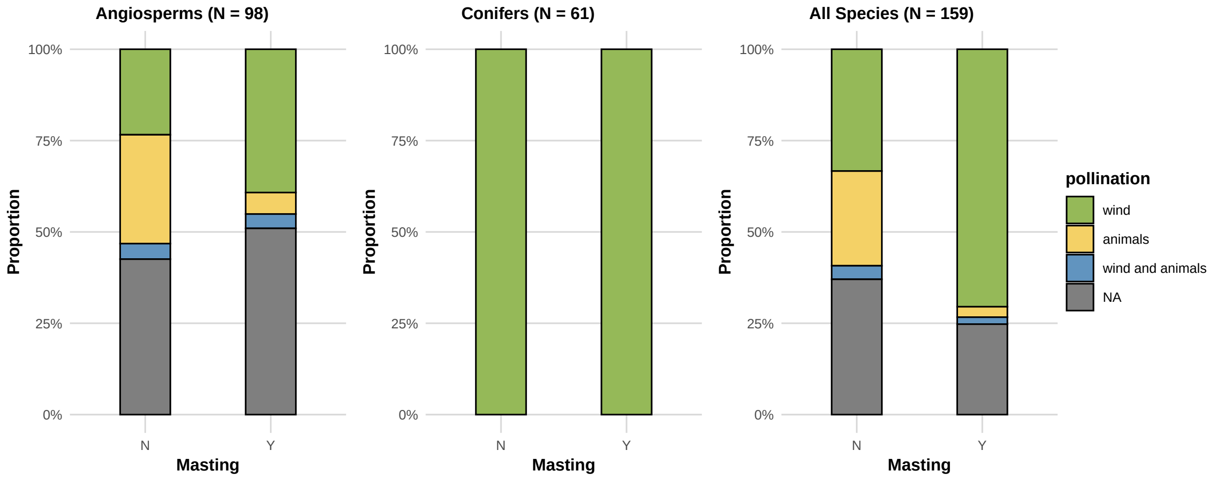


- **Nutrient content:** Species with more nutritious seeds may be more likely to mast.

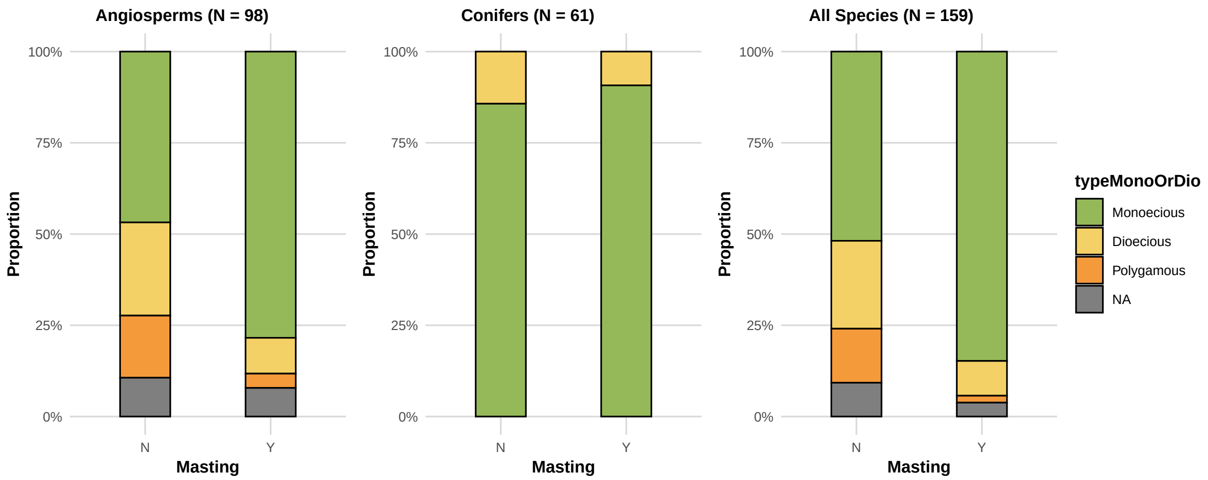


Pollination Coupling

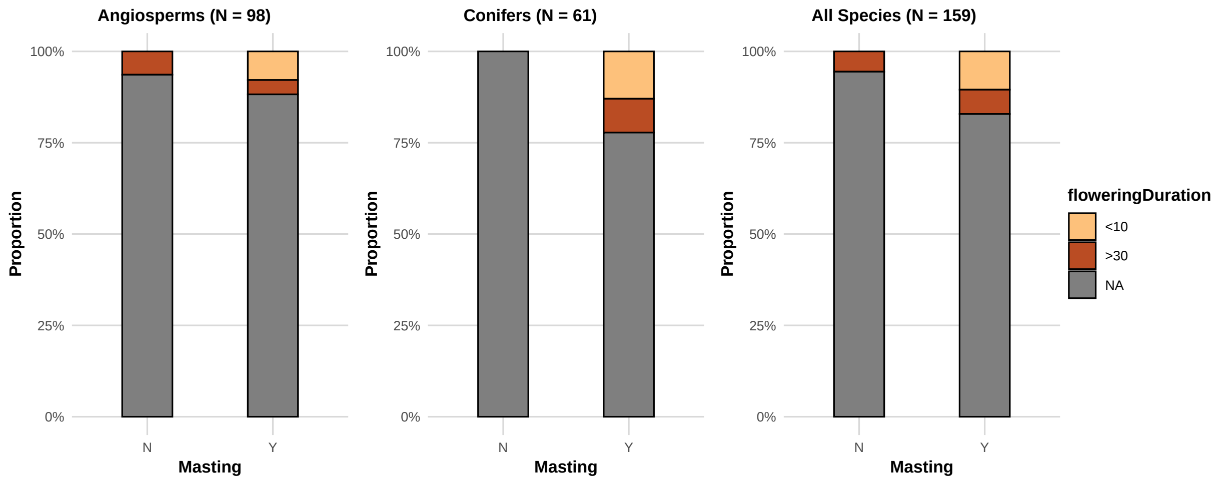
- Wind-pollinated species are expected to mast more frequently.



- Monoecious species may be more likely to mast.

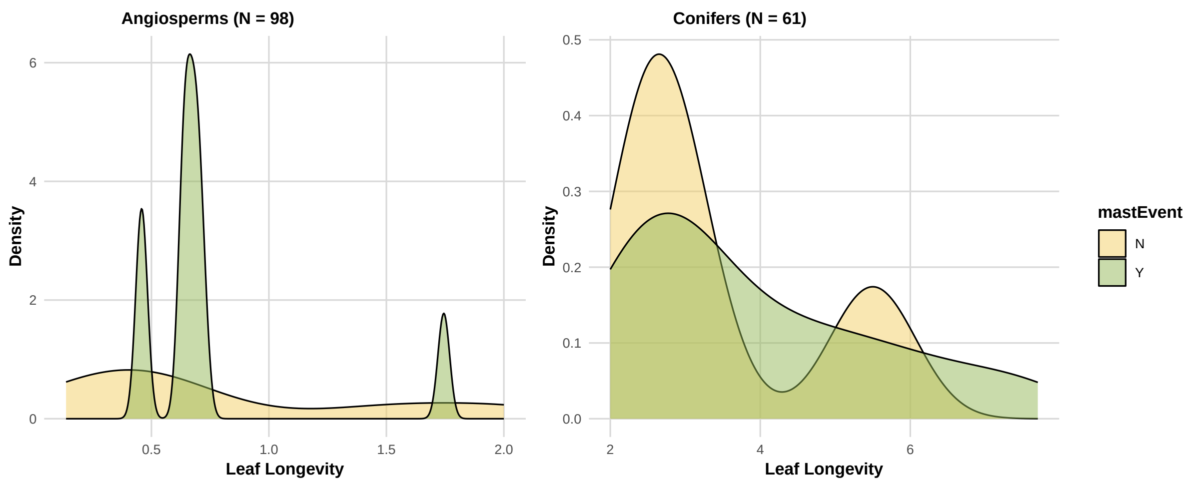


- Species with longer flowering periods may be more likely to mast.

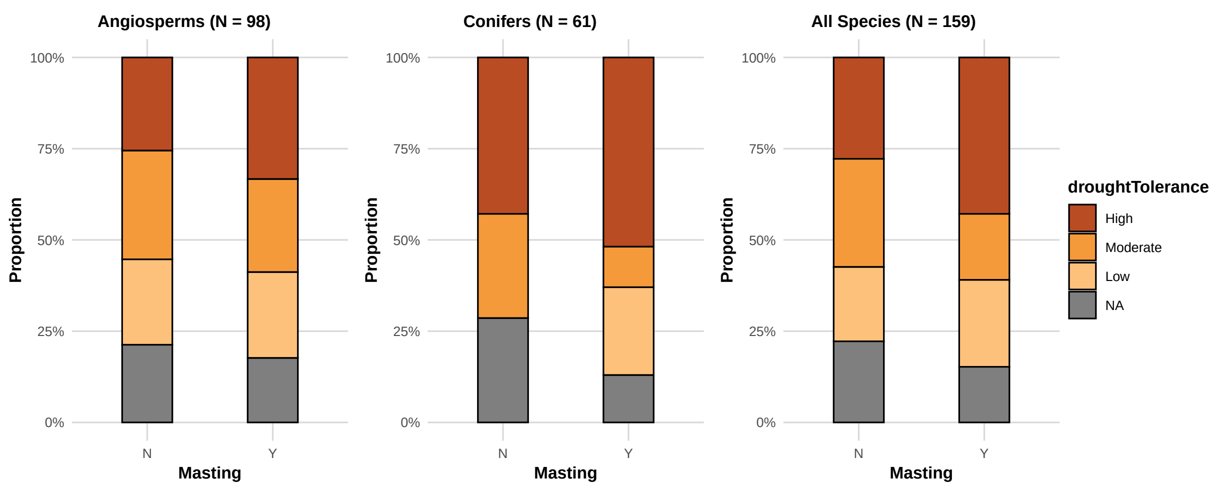

Angiosperms (N = 98)
Conifers (N = 61)
All Species (N = 159)
Proportion
100%
75%
50%
25%
0%
N
Y
Masting
floweringDuration
<10
>30
NA

Resource Matching

- Leaf longevity: Species with long-lived leaves are expected to mast more frequently.



- Drought tolerance: May go either way — tolerant species can accumulate resources; intolerant species respond to resource fluctuations.



Data visualization

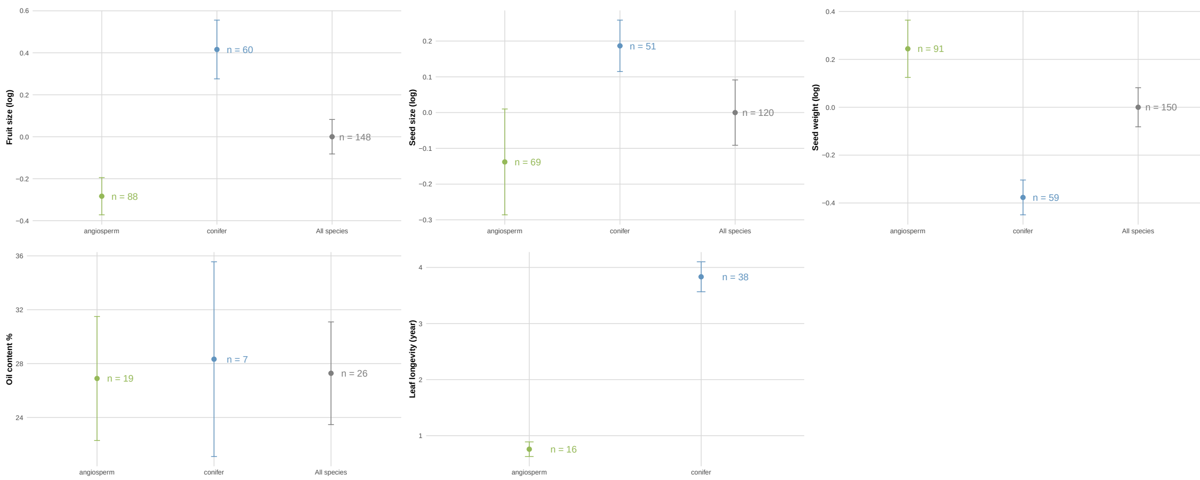


Figure 1: Mean and standard errors for the continuous traits (fruit size, leaf longevity, oil content, seed size, and seed weight) in the original dataset, with number of the data point available.

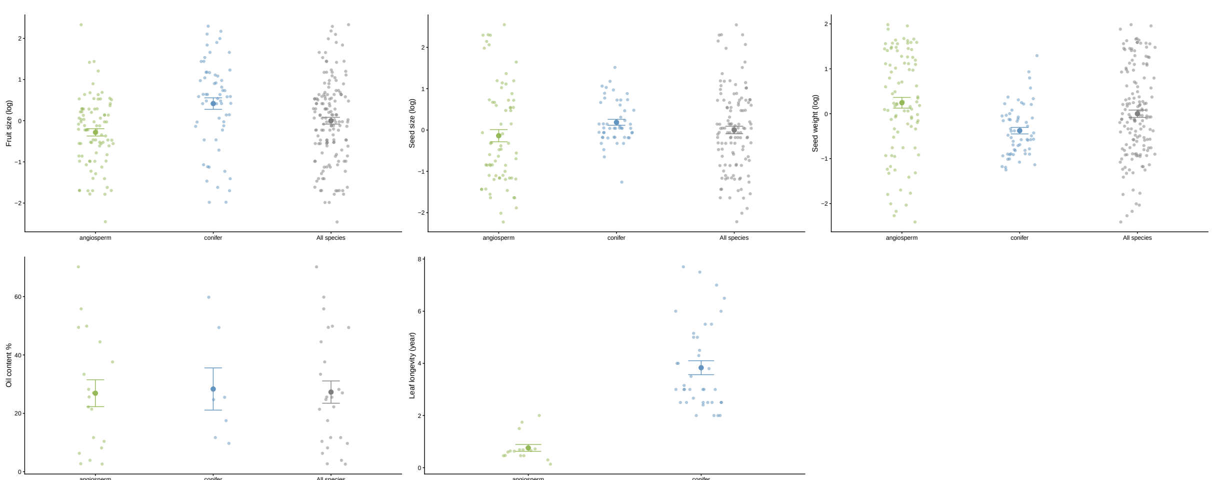


Figure 2: Raw data for the continuous traits (fruit size, leaf longevity, oil content, seed size, and seed weight) in the original dataset, with all the data points scattering.

Results for Binary Response Variable

I ran the phyloglm, including the phylogeny variation.Here I reproted the direct model results in a table:

Table 1: Phyloglm results for conifer species, SE: standard error; P: p-value; N: number of effective sample size

Trait	Predictor	Estimate	SE	P	Phylo a	N
Seed dispersal	Biotic vs abiotic	−0.830	0.807	0.3040	0.015	60
Seed dispersal	Both vs abiotic	−1.106	0.666	0.0968	0.015	60
Seed dormancy	Dormant vs non−dormant	0.706	0.703	0.3150	0.411	59
Reproductive type	Monoecious vs dioecious	−1.135	1.017	0.2640	0.007	61
Seed weight (log)	Seed weight (log, std)	−0.047	0.403	0.9080	0.427	59
Fruit size (log)	Fruit size (log, std)	0.021	0.345	0.9520	0.428	60
Seed size (log)	Seed size (log, std)	−0.108	0.418	0.7960	0.413	51
Leaf longevity (years)	Leaf longevity (years)	0.147	0.345	0.6700	0.430	38
Drought tolerance	Low vs high drought tolerance	0.908	1.645	0.5810	0.429	52
Drought tolerance	Moderate vs high drought tolerance	−1.565	1.065	0.1420	0.429	52

The probability was calculated using the inverse-logit transformation:

$$\Pr(Y = 1) = \frac{1}{1 + e^{-(\alpha+\beta x)}}.$$

0.1 Dispersal mode

Conifers

- Species being abiotic dispersed have an 82% probability of being strong masting species.
- Species being biotic dispersed and both have a lower probability (67% and 61% respectively), but this difference is not statistically.
- **The low alpha (0.02) suggests strong phylogenetic signal in this trait-masting relationship.**
- **Overall, the model provides no evidence that dispersal mode affects whether a conifer species is strong masting or not.**

Angiosperms

- Species being abiotic dispersed have an 32% probability of being strong masting species.
- Species being biotic dispersed and both have a higher probability (45% for both of them), but this difference is not statistically.

Table 2: Phyloglm results for angiosperm species, SE: standard error; P: p-value; N: number of effective sample size

Trait	Predictor	Estimate	SE	P	Phylo a	N
Dispersal mode	Biotic vs abiotic	0.549	0.533	0.3030	0.059	93
Dispersal mode	Both vs abiotic	0.552	0.567	0.3300	0.059	93
Pollination mode	Wind vs animal pollination	1.719	0.723	0.0174	0.346	52
Pollination mode	Wind vs animal pollination and animals	1.225	1.148	0.2860	0.346	52
Seed dormancy	Dormant vs non−dormant	0.034	0.497	0.9460	0.096	85
Reproductive type	Monoecious vs dioecious	0.904	0.680	0.1840	0.110	89
Reproductive type	Monoecious vs polygamous	−0.129	0.956	0.8920	0.110	89
Seed weight (log)	Seed weight (log, std)	0.707	0.306	0.0210	0.063	91
Fruit size (log)	Fruit size (log, std)	0.058	0.232	0.8020	0.171	88
Seed size (log)	Seed size (log, std)	0.269	0.330	0.4150	0.081	69
Oil content (%)	Oil content (%)	0.034	0.027	0.2110	0.139	19
Leaf longevity (years)	Leaf longevity (years)	0.262	0.948	0.7820	0.007	16
Drought tolerance	Low vs high drought tolerance	0.045	0.476	0.9250	0.110	79
Drought tolerance	Moderate vs high drought tolerance	−0.126	0.465	0.7870	0.110	79

- **The low alpha (0.06) suggests strong phylogenetic signal in this trait-masting relationship.**
- **Overall, the model provides no evidence that dispersal mode affects whether an angiosperm species is strong masting or not.**

0.2 Pollination mode

Conifers

- All the conifers in our dataset are wind pollinated, and they are mostly strong masting species.

Angiosperm

- Animal pollinated species only have a relatively low probability (20%) of being strong masting species.
- Wind pollinated species have a significantly higher probability (59%) of being strong masting species.
- Species pollinated by both animal and wind have an intermediate change (47%) of being strong masting species, but is not significantly different from animal pollinated ones.
- **The relatively moderate alpha (0.35) suggests moderate phylogenetic signal in this trait-masting relationship.**
- **Overall, pollination mode is an important predictor of whether an angiosperm species has strong masting pattern, because wind pollination increases the odds of strong masting compared to animal pollination.**

0.3 Seed dormancy

Conifers

- Species without dormant seeds have 80% probability of being strong masting species.
- Species with dormant seeds have higher probability (89%), but this difference is not significant.
- **The moderate alpha (0.35) suggests moderate phylogenetic signal in this trait-masting relationship.**
- **Overall, the model provides no evidence that seed dormancy affects whether a conifer species is strong masting or not.**

Angiosperm

- Species without dormant seeds have 39% probability of being strong masting species.
- Species with domrmant seeds have a very similar probability (40%) of being strong masting species, but the difference is not significant.
- **The relatively low alpha (0.10) suggests strong phylogenetic signal in this trait-masting relationship.**
- **Overall, the model provides no evidence that seed dormancy affects whether an angiosperm species is strong masting or not.**

0.4 Reproductive type

Conifers

- Dioecious species have a higher probability (70%) of being strong masting species compared to monoecious species (44%), but the difference is not significant.
- **The very low alpha (0.007) suggests very strong phylogenetic signal in this trait-masting relationship.**
- **Overall, the model provides no evidence that reproductive type affects whether a conifer species is strong masting or not.**

Angiosperm

- Dioecious species have 28% probability of being strong masting species.
- Monoecious species have higher probability (49%), but this difference is not significant. Polygamous species have similar probability (26%), but the difference is not significant.
- **The relatively low alpha (0.11) suggests strong phylogenetic signal in this trait-masting relationship.**
- **Overall, the model provides no evidence that reproductive type affects whether an angiosperm species is strong masting or not.**

0.5 Drought tolerance

Conifers

- High drought tolerance species have a high probability (91%) of being strong masting species.
- Moderate and low drought tolerance species have lower or higher probabilities (68% and 96% respectively), but differences are not significant.
- **The moderate alpha (0.43) suggests moderate phylogenetic signal in this trait-masting relationship.**
- **Overall, the model provides no evidence that drought tolerance affects whether a conifer species is strong masting or not.**

Angiosperm

- High drought tolerance species have a low probability (44%) of being strong masting species.
- Moderate and low drought tolerance species both have lower probabilities (40% and 44% respectively), but differences are not significant.
- **The relatively low alpha (0.11) suggests strong phylogenetic signal in this trait-masting relationship.**
- **Overall, the model provides no evidence that drought tolerance affects whether an angiosperm species is strong masting or not.**

0.6 Seed weight

Conifers

- **Seed weight has no significant effect on strong masting pattern for conifer species.**
- **The moderate alpha (0.43) suggests moderate phylogenetic signal in this trait-masting relationship.**

Angiosperm

- **Higher seed weight significantly increases chance of being strong masting species for angiosperms, seed weight is a strong predictor of masting.**
- **The relatively low alpha (0.063) suggests strong phylogenetic signal in this trait-masting relationship.**

0.7 Fruit size

Conifers

- **Fruit size has no significant effect on strong masting pattern for conifer species.**
- **The moderate alpha (0.43) suggests moderate phylogenetic signal in this trait-masting relationship.**

Angiosperm

- **Fruit size has no significant effect on strong masting pattern for angiosperm species.**
- **The relatively low alpha (0.17) suggests strong phylogenetic signal in this trait-masting relationship.**

0.8 Seed size

Conifers

- **Seed size has no significant effect on strong masting pattern for conifer species.**
- **The moderate alpha (0.41) suggests moderate phylogenetic signal in this trait-masting relationship.**

Angiosperm

- **Seed size has no significant effect on strong masting pattern for angiosperm species.**
- **The relatively low alpha (0.08) suggests strong phylogenetic signal in this trait-masting relationship.**

0.9 Oil content

Conifers

- Not enough data available for conifers.

Angiosperm

- **Oil content has no significant effect on strong masting pattern for angiosperm species.**
- **The relatively low alpha (0.14) suggests relatively strong phylogenetic signal in this trait-masting relationship.**

0.10 Leaf longevity

Conifers

- **Leaf longevity has no significant effect on strong masting pattern for conifer species.**
- **The moderate alpha (0.42) suggests moderate phylogenetic signal in this trait-masting relationship.**

Angiosperm

- **Leaf longevity has no significant effect on strong masting pattern for angiosperm species.**
- **The relatively low alpha (0.006) suggests strong phylogenetic signal in this trait-masting relationship.**

I also ran the common glm, using conifer and angiosperm as a fixed effect in the model, and I modified the results for better visualization:

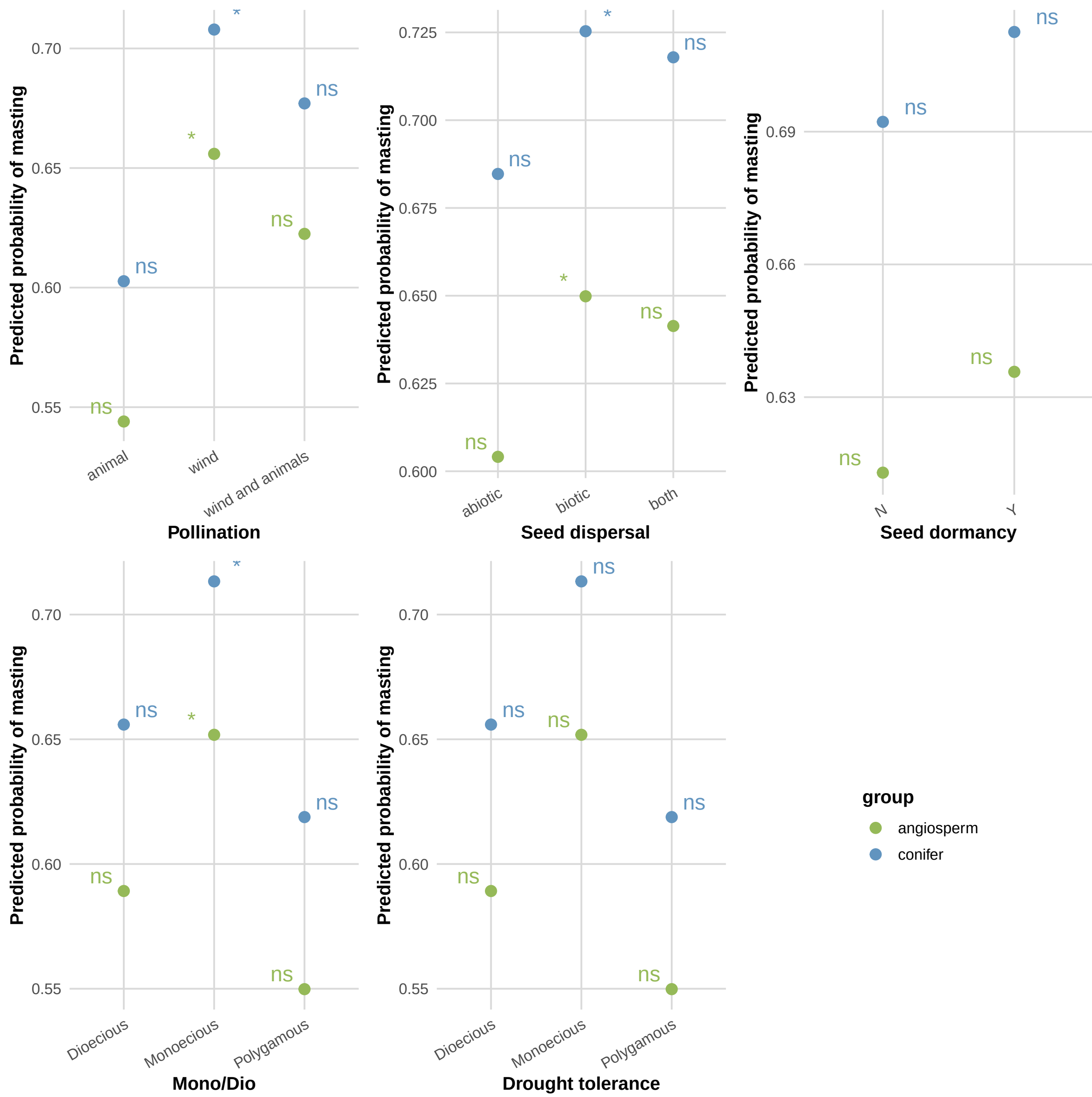


Figure 3: Predicted probability of being a strong masting species across categorical traits (pollination mode, seed dispersal, seed dormancy, mono/dio, and drought tolerance). Significance levels are indicated as follows: ns = not significant; * = $p < 0.05$.

- Pollination mode is a significant predictor of strong masting with wind-pollinated species have a significantly higher probability of being strong masting species and this pattern is consistent for both angiosperms and conifers.
- Seed dispersal mode is a significant predictor of strong masting with species with biotic dispersed seeds have a significantly higher probability of being strong masting species and this pattern is consistent for both angiosperms and conifers

- Reproductive type is a significant predictor of strong masting with monoecious species have a significantly higher probability of being strong masting species and this pattern is consistent for both angiosperms and conifers.

- Seed dormancy and drought tolerance are not strong predictors of strong masting pattern for our studied species.

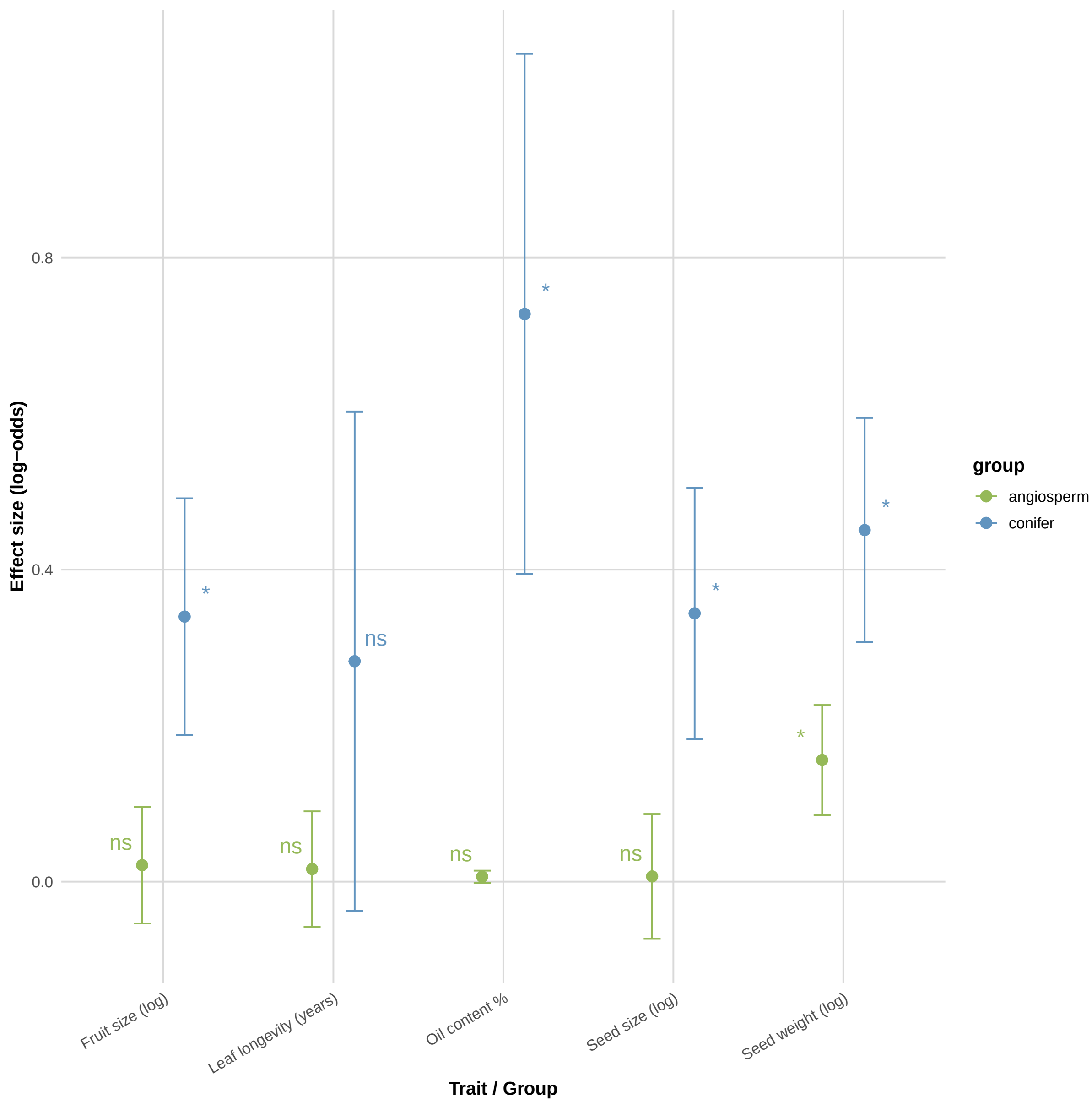


Figure 4: Effect sizes (log-odds) of continuous traits (fruit size, leaf longevity, oil content, seed size, and seed weight) on the probability of being a strong masting species. Points represent estimated coefficients, with error bars showing standard errors. Significance levels are indicated as follows: ns = not significant; * = $p < 0.05$.

- Fruit size is a significant predictor of strong masting for conifers, with log-odds of masting increaseing with increasing fruit size.
- Oil content is a significant predictor of strong masting for conifers, with log-odds of masting increasing with higher oil content.
- Seed size is a significant predictor of strong masting for conifers, with log-odds of masting increasing with bigger seeds.
- Seed weight is a significant predictor of strong masting for both angiosperm and conifers, with log-odds of masting increasing with bigger seed weight.

- Leaf longevity is not a strong predictor of strong masting pattern for either conifer or angiosperm.

Results for Continous Response Variable

For the continuous response variable, I used the mean mast cycle obtained from Silvics and analyzed the data using PGLS. The results indicate that none of the traits is significantly related to mast cycle for either conifer or angiosperm species. There is no phylogenetic signal detected for any of the conifer traits, whereas weak phylogenetic signal is observed for seed dispersal, seed dormancy, reproductive type, drought tolerance, fruit size, and seed weight among angiosperm traits.

Table 3: PGLS results for conifer species, SE: standard error; P: p-value; N: number of effective sample size

Trait	Predictor	Estimate	Std_Error	P_value	Lambda	N
Dispersal mode	Biotic vs abiotic	−0.112	0.167	0.506	0	50
Dispersal mode	Both vs abiotic	0.009	0.124	0.945	0	50
Seed dormancy	Dormant vs non−dormant	−0.027	0.126	0.830	0	48
Reproductive type	Monoecious vs dioecious	0.196	0.172	0.260	0	50
Drought tolerance	Low vs high drought tolerance	−0.035	0.137	0.801	0	44
Drought tolerance	Moderate vs high drought tolerance	0.120	0.178	0.502	0	44
Leaf longevity (years)	Leaf longevity (years)	−0.010	0.041	0.811	0	32
Oil content (%)	Oil content (%)	−0.004	0.007	0.623	0	7
Fruit size (log)	Fruit size (log)	0.009	0.052	0.861	0	50
Seed size (log)	Seed size (log)	0.034	0.051	0.502	0	41
Seed weight (log)	Seed weight (log)	−0.017	0.049	0.739	0	48

Table 4: PGLS results for angiosperm species, SE: standard error; P: p-value; N: number of effective sample size

Trait	Predictor	Estimate	Std_Error	P_value	Lambda	N
Dispersal mode	Biotic vs abiotic	−0.077	0.140	0.584	0.253	43
Dispersal mode	Both vs abiotic	0.015	0.149	0.920	0.253	43
Seed dormancy	Dormant vs non−dormant	−0.015	0.124	0.907	0.147	41
Reproductive type	Monoecious vs dioecious	0.129	0.187	0.494	0.264	40
Reproductive type	Polygamous vs dioecious	−0.320	0.385	0.412	0.264	40
Drought tolerance	Low vs high drought tolerance	0.263	0.139	0.067	0.350	37
Drought tolerance	Moderate vs high drought tolerance	0.239	0.121	0.057	0.350	37
Pollination mode	Wind vs animal pollination	−0.293	0.195	0.148	0.034	24
Pollination mode	Wind+animal vs animal pollination	0.029	0.284	0.919	0.034	24
Leaf longevity (years)	Leaf longevity (years)	0.109	0.200	0.615	0.000	6
Fruit size (log)	Fruit size (log)	−0.022	0.066	0.737	0.208	42
Seed size (log)	Seed size (log)	−0.061	0.050	0.229	0.000	31
Seed weight (log)	Seed weight (log)	0.004	0.066	0.955	0.161	41

Just to be consistant with the binary trait response variable, I also ran lm using conifer and angiosperm as a fixed effect in the model. Nothing is significant except for conifer vs angiosperm:

Table 5: lm results, SE: standard error; P: p-value; N: number of effective sample size

Trait	Predictor	Estimate	SE	P	N
Dispersal mode	Biotic vs abiotic	−0.066	0.101	0.517	93
Dispersal mode	Both vs abiotic	0.030	0.092	0.748	93
Dispersal mode	Conifer compared to angiosperm	0.229	0.079	0.005	93
Pollination mode	Wind vs animal pollination	−0.299	0.217	0.173	74
Pollination mode	Wind vs animal pollination and animals	0.034	0.319	0.915	74
Pollination mode	Conifer compared to angiosperm	0.380	0.094	0.000	74
Seed dormancy	Dormant vs non−dormant	−0.042	0.088	0.633	89
Seed dormancy	Conifer compared to angiosperm	0.278	0.076	0.000	89
Reproductive type	Monoecious vs dioecious	0.142	0.119	0.237	90
Reproductive type	Monoecious vs polygamous	−0.284	0.374	0.450	90
Reproductive type	Conifer compared to angiosperm	0.261	0.076	0.001	90
Seed weight (log)	Seed weight (log, std)	−0.003	0.043	0.940	89
Seed weight (log)	Conifer compared to angiosperm	0.250	0.085	0.004	89
Fruit size (log)	Fruit size (log, std)	−0.009	0.039	0.820	92
Fruit size (log)	Conifer compared to angiosperm	0.258	0.077	0.001	92
Seed size (log)	Seed size (log, std)	−0.031	0.038	0.416	72
Seed size (log)	Conifer compared to angiosperm	0.127	0.073	0.087	72
Oil content (%)	Oil content (%)	−0.003	0.005	0.576	11
Oil content (%)	Conifer compared to angiosperm	0.296	0.202	0.181	11
Leaf longevity (years)	Leaf longevity (years)	−0.008	0.039	0.827	38
Leaf longevity (years)	Conifer compared to angiosperm	0.262	0.204	0.207	38
Drought tolerance	Low vs high drought tolerance	0.063	0.099	0.526	81
Drought tolerance	Moderate vs high drought tolerance	0.140	0.108	0.200	81
Drought tolerance	Conifer compared to angiosperm	0.322	0.086	0.000	81