|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | Proportion reproductive costs (%) | | | |  | Proportion seed costs (%) | |
|  |  |  |  | Failure | Success | | |  |  |  |
| species | Seed size (mg) | Seedset | Reproductive costs  (mg) | Failure | Pollen attraction | Packaging and dispersal | Seed | Seed costs (mg) | Pollen attraction | Provisioning |
| *Banksia ericifolia* | 24.064 | 0.031 | 3864.535 | 37.87 | 0.28 | 61.23 | 0.62 | 2401.023 | 0.7 | 99.3 |
| *Boronia ledifolia* | 2.095 | 0.041 | 156.995 | 89.50 | 2.05 | 7.11 | 1.33 | 16.479 | 19.5 | 80.5 |
| *Conospermum ericifolium* | 0.686 | 0.146 | 23.046 | 61.81 | 8.57 | 26.65 | 2.98 | 8.802 | 23.1 | 76.9 |
| *Epacris microphylla* | 0.020 | 0.206 | 0.532 | 73.31 | 17.12 | 5.79 | 3.76 | 0.142 | 64.3 | 35.7 |
| *Grevillea buxifolia* | 26.699 | 0.013 | 844.298 | 81.71 | 1.09 | 14.04 | 3.16 | 154.422 | 6.0 | 94.0 |
| *Grevillea speciosa* | 13.476 | 0.013 | 587.841 | 85.77 | 1.02 | 10.92 | 2.29 | 83.663 | 7.1 | 92.9 |
| *Hakea teretifolia* | 8.176 | 0.005 | 4340.486 | 95.19 | 0.26 | 4.37 | 0.19 | 208.991 | 5.6 | 94.4 |
| *Hemigenia purpurea* | 0.297 | 0.223 | 7.053 | 68.95 | 16.82 | 10.02 | 4.21 | 2.190 | 54.2 | 45.8 |
| *Leucopogon esquamatus* | 0.806 | 0.206 | 24.881 | 78.82 | 4.56 | 13.38 | 3.24 | 5.270 | 21.5 | 78.5 |
| *Persoonia lanceolata* | 14.392 | 0.049 | 1140.445 | 74.36 | 1.58 | 22.80 | 1.26 | 292.418 | 6.2 | 93.8 |
| *Petrophile puchella* | 2.210 | 0.183 | 180.254 | 51.23 | 10.91 | 36.64 | 1.23 | 87.915 | 27.0 | 73.0 |
| *Phyllota phyllicoides* | 1.713 | 0.041 | 306.69 | 97.50 | 1.14 | 0.80 | 0.56 | 7.668 | 45.8 | 54.2 |
| *Pimelea linifolia* | 0.720 | 0.200 | 10.463 | 68.33 | 20.46 | 4.33 | 6.88 | 3.314 | 64.4 | 35.6 |
| *Pultanaea tuberculata* | 1.274 | 0.060 | 121.508 | 94.19 | 3.59 | 1.17 | 1.05 | 7.058 | 61.8 | 38.2 |

# Tables

**Table 1.** Reproductive investment data for each species. Seed size indicates the mass of the embryo and endosperm only (mg). Seedset is mature seeds per ovule initiated. Reproductive costs are the total reproductive investment per seed matured. The proportion of reproductive costs allocated to failed costs, pollen-attraction costs, packaging and dispersal costs and the seed itself are shown. Seed costs are the components of total RE required for the formation of a successful seed, and are divided into two components, pollen attraction costs and provisioning costs. Note that for seed costs, the weight of the seed itself is considered part of provisioning costs. Colored dots indicate plotting colors used for each species in Figures 2, 3.

|  |  |  |  |
| --- | --- | --- | --- |
| Accessory cost component | r2 | Slope  *(confidence interval)* | *p-value*  *(slope* ≠ *1)* |
| Total accessory costs | 0.88 | 1.236 (0.954 - 1.519) | 0.09344 |
| Seed costs | 0.89 | 1.192 (0.922 - 1.461) | 0.14752 |
| Pollen-attraction costs | 0.80 | 0.638 (0.435 - 0.841) | 0.00219\*\* |
| Provisioning costs | 0.88 | 1.348 (1.039 - 1.657) | 0.03044\* |
| Failed tissue costs | 0.87 | 1.220 (0.921 - 1.518) | 0.13481 |
| Failed pollen-attraction costs | 0.85 | 1.211 (0.889 - 1.533) | 0.17939 |
| Failed provisioning costs | 0.83 | 1.258 (0.896 - 1.620) | 0.14658 |

**Table 2.** Scaling of reproductive tissue costs with seed size. All variables were showed a strong correlation with seed size (p < 0.0001). Tables show properties of SMA line fits, between different variables and seed size.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Predictor | | n | | r2 | |
| Total plant weight (mg) | | 357 | | 0.62 | |
| Propagule investment (mg) | | 223 | | 0.52 | |
| Fruit investment (mg) | | 223 | | 0.36 | |
| Flower investment (mg)  (flower weight \* bud count) | | 302 | | 0.93 | |
| Successful investment (mg)  (seed costs \* seed count) | | 223 | | 0.71 | |
| Successful pre-pollination investment (mg) | | 312 | | 0.92 | |
| Provisioning investment (mg) | | 227 | | 0.70 | |
| Failed tissues (mg) | | 356 | | 0.94 | |

**Table 3. Correlation of different estimates of reproductive investment (and total plant weight) against total reproductive investment (mg).** Regressions are done across all individuals of all 14 study species for which both reproductive investment and the *estimate* variable are greater than zero. The total cost of failed tissues or simply the energy expenditure into flowers provides the best approximation of total reproductive investment. All fits were highly significant with p < 0.0001.

Suggestions:

To avoid overfitting, we should probably check predictive capacity using leave-one out testing.

# Figures

***a. Investment categories***

***Pollen-attraction costs***

***Provisioning costs***

***Seed costs***

***Failed tissue costs****, including both pollen-attraction and provisioning tissues*

***Reproductive costs***

*Seed size*

*Reproductive costs*

*Or*

*Accessory costs*

*Or*

*Seed costs*

*Seed size*

*Scaled*

*seed*

*count*

*Relatively higher*

*provisioning costs*

*Slope =-1*

*Seed size*

*Seed set*

*(seed:ovule)*

*Seeds (slope =-1)*

*Ovules (slope > -1)*

*Seed size*

*Seed size*

*Seed cost*

*components*

***b. Seed size-number trade-off***

*Provisioning (Slope > 1)*

***c. Big-seed species are choosier about which embryos to provision***

***d. Investment in seed cost components shifts with seed set and seed size***

*Slope = 1*

*Pollen attraction (Slope < 1)*

*Relatively higher*

*pollen-attraction costs*

*Scaled*

*count*

*Seed set*

*(seed:ovule)*

***Packaging and dispersal costs***

***Seed size***

Figure 1. a) Categories of reproductive costs. Categories in red are components of total accessory costs. b) Total reproductive, accessory costs and seed costs all scale isometrically with seed size. This leaves a fixed pool of energy to invest in seeds, which plants can divide into fewer big seeds or more small seeds ***(Seed size-number trade-off)***. c) Plants with a smaller quantity of bigger seeds need to ensure each seed has “good” genes, achieved through selective post-pollination zygote abortion. This can only occur if there are surplus ovules, leading to the hypothesis, that larger-seeded species will have a higher ovule : seed ratio, expressed as seed set. d) This links with parental optimist-parental pessimist theory: Parental optimists are those species which produce disproportionate ovules relative to what they are able to provision (low seed set). In turn, these species have evolved to minimize pollen-attraction costs and invest more heavily in provisioning tissues ***(Pollen attraction-seed provisioning trade-off)***. Linking these trade-off together, we hypothesize that big-seeded species invest disproportionately in provisioning tissues.

****

**Figure 2.** Species show concerted shifts in traits with seed size, including a decrease in seed set illustrated both as a) a stronger decrease in seed camp than ovule camp and b) an overall decrease in seed set with increasing seed size. In addition, with increasing seed size, c) pollen attraction costs increase less steeply than 1:1, while d) provisioning costs increasing more steeply than 1:1. Species with smaller seeds have traits identifying them as “parental pessimists” and those with larger seeds fall on the “parental optimist” end of the spectrum. In each plot, different colored points represent the 14 study species; see Table 1 for the key. The black line is the best fit through the data and the red line indicates a slope of 1.



**Figure 3.** Propagule investment is much more poorly correlated with total reproductive investment, than is a composite variable, the product of a count of the buds initiated multiplied by average flower weight. In each plot, different colored points represent the 14 study species; see Table 1 for the key. The colored lines are best fit lines through each species’ points. There are more points in panel b, as some individuals produce buds, but no seeds. In this plot, propagule weight, the weight of the dispersed unit, not embryo and endosperm weight are used, as the purpose is to plot the commonly used currency.

# Supplemental figures and tables

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | *Total reproductive investment*  *vs*  *propagule investment* | | | *Total reproductive investment*  *vs*  *“flower weight\*bud count”* | | |
| species | n | r2 | *p-value* | n | r2 | *p-value* |
| *Banksia ericifolia* | 6 | 0.69 | 0.0398 | 13 | 0.83 | <0.0001 |
| *Boronia ledifolia* | 24 | 0.56 | <0.0001 | 35 | 0.87 | <0.0001 |
| *Conospermum ericifolium* | 14 | 0.90 | <0.0001 | 14 | 0.97 | <0.0001 |
| *Epacris microphylla* | 28 | 0.74 | <0.0001 | 28 | 0.99 | <0.0001 |
| *Grevillea buxifolia* | 12 | 0.50 | 0.0097 | 20 | 0.91 | <0.0001 |
| *Grevillea speciosa* | 12 | 0.55 | 0.0058 | 22 | 0.52 | <0.0001 |
| *Hakea teretifolia* | 12 | 0.78 | 0.0001 | 24 | 0.97 | <0.0001 |
| *Hemigenia purpurea* | 17 | 0.70 | <0.0001 | 27 | 0.98 | <0.0001 |
| *Leucopogon esquamatus* | 23 | 0.71 | <0.0001 | 25 | 0.99 | <0.0001 |
| *Persoonia lanceolata* | 6 | 0.84 | 0.0102 | 10 | 0.91 | <0.0001 |
| *Petrophile puchella* | 9 | 0.30 | 0.1290 | 12 | 0.92 | <0.0001 |
| *Phyllota phyllicoides* | 19 | 0.31 | 0.0128 | 24 | 0.99 | <0.0001 |
| *Pimelea linifolia* | 13 | 0.78 | 0.0001 | 16 | 0.97 | <0.0001 |
| *Pultanaea tuberculata* | 28 | 0.49 | <0.0001 | 32 | 1.00 | <0.0001 |

**Supplementary Table XX.** Correlations, within each of the 14 study species, between total reproductive investment (mg) and investment in propagules (mg) and between reproductive investment (mg) and investment as defined by the composite variable, flower weight \* bud count. Regressions against propagule investment include only those individuals that produced at least 1 seed and regressions against the composite variable include those individuals that produced at least 1 bud, resulting in different *n* values for each species and between the two tests.