# Supporting Online Material for

## Evidence for Ecological Speciation and Its Alternative

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**This PDF file includes:**

**Table S1**. Estimates of the magnitude of reproductive isolation resulting from divergent selection components compared with other components lacking identifiable causes. These are the raw data plotted in Fig. 2. The plant data are calculated from quantities provided in Table 1 in (*S47*), who give original data sources. The animal data are calculated from quantities extracted from Table 3 in (*S48*), who give original data sources. Calculation details are provided in Tables S2 and S3.

| Study system | Divergent selection | Unknown causes | Data source |
|---|---|---|---|
| *Artemisia tridentata* | 0.97 | | (*S47*) |
| *Chamaecrista desvauxii* | 0.30 | 1.00 | (*S47*) |
| *Costus* | 0.95 | 0.88 | (*S47*) |
| *Gelsemium* | 0.96 | 0.80 | (*S47*) |
| *Gilia capitata* | 0.75 | 0.88 | (*S47*) |
| *Helianthus exilis* | 0.97 | 0.00 | (*S47*) |
| *Helianthus* | 0.35 | 1.00 | (*S47*) |
| *Ipomopsis* | 0.99 | -0.09 | (*S47*) |
| *Iris (1)* | 0.94 | -0.56 | (*S47*) |
| *Iris (2)* | 0.18 | 0.31 | (*S47*) |
| *Iris (3)* | 0.79 | 0.89 | (*S47*) |
| *Iris (4)* | 0.79 | -2.66 | (*S47*) |
| *Mimulus (1)* | 1.00 | 0.95 | (*S47*) |
| *Mimulus (2)* | 0.75 | 0.80 | (*S47*) |
| *Mimulus (3)* | 0.95 | 0.96 | (*S47*) |
| *Mimulus guttatus* | 1.00 | 0.00 | (*S47*) |
| *Penstemon* | 0.53 | 0.87 | (*S47*) |
| *Pedicularis* | 0.97 | 0.46 | (*S47*) |
| *Phlox* | 0.52 | 0.98 | (*S47*) |
| *Acyrthosiphon pisum* | 1.00 | | (*S48*) |
| *Agelenopsis aperta* | 0.63 | -0.08 | (*S48*) |
| *Bombina spp.* | 0.81 | 0.19 | (*S48*) |
| *Eurosta solidaginis* | 1.00 | 0.37 | (*S48*) |
| *Galerucella nymphaeae* | 0.98 | 0.00 | (*S48*) |
| *Galerucella spp.* | 0.99 | 0.00 | (*S48*) |
| *Gasterosteus aculeatus* | 0.53 | 0.92 | (*S48*) |
| *Heliconius erato* | 0.74 | 0.00 | (*S48*) |
| *Littorina saxatilis* | 0.90 | 0.52 | (*S48*) |
| *Mitoura spp.* | 0.76 | 0.00 | (*S48*) |
| *Neochlamisus bebbianae* | 1.00 | 0.72 | (*S48*) |
| *Rhagoletis spp.* | 0.89 | | (*S48*) |
| *Timema cristinae* | 0.51 | 0.22 | (*S48*) |

**Table S2.** Calculation details for the plant data given in Table S1. A) Reproductive isolation components calculated from Table 1 in ( *S47*) by averaging the two directional values for each study system for simplicity. B) Absolute contributions of sequential components of reproductive isolation likely attributable to divergent selection. C) Absolute contributions of sequential components of reproductive isolation attributable to unknown causes. Absolute contributions of the sequential components of reproductive isolation were accumulated and totaled using the formulas in (*S49*). Briefly, the absolute contribution of the first component of reproductive isolation in a sequence is, $AC_1 = RI_1$, where $RI_1$ is the strength of the first component of reproductive isolation in the sequence. The absolute contribution of the second component in the sequence is $AC_2 = RI_2*(1-AC_1)$, where $RI_2$ is the strength of the second component of reproductive isolation. And in general, $AC_n = RI_n*(1-(AC_1+AC_2+\ldots+AC_{n-1}))$. Total reproductive isolation for a set of components is the sum of all the $AC_i$. I assumed that the following components of reproductive isolation likely represented divergent selection by active selection or trait-based assortative mating: ecogeographic, immigrant inviability, phenology, pollinators, and extrinsic postzygotic isolation. Remaining components fell into the category of unknown causes.

**A)**

| Study system | eco-geography | immigrant inviability | phenology | pollinator | mating system | pollen compe-tition | F1 seed forma-tion | F1 seed germi-nation | F1 via-bility | F1 male fertility | F1 seed set | extrinsic post-zygotic |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Artemisia tridentata* | | 0.85 | | | | | | | | | | 0.7725 |
| *Chamaecrista desvauxii* | | | 0.301 | | | | 1 | | | | | |
| *Costus* | 0.413 | | 0.198 | 0.8845 | | | 0.8885 | -0.068 | | 0.0025 | | |
| *Gelsemium* | | | 0.9635 | | | | 0.8015 | | | | | |
| *Gilia capitata* | | 0.749 | | | | | 0.875 | | | | | |
| *Helianthus exilis* | | 0.971 | | | | | 0 | | | | | |
| *Helianthus* | | | 0.3505 | | | 0.983 | -0.0215 | | | 0.949 | 0.991 | |
| *Ipomopsis* | | 0.9615 | | 0.7215 | | -0.0935 | | | | | | 0.2775 |
| *Iris (1)* | | 0.932 | 0.1425 | | | | -0.5635 | | | | | |
| *Iris (2)* | | | 0.1765 | | | | 0.3145 | | | | | |
| *Iris (3)* | | 0.072 | 0.4105 | 0.634 | | 0.8055 | 0.598 | 0.035 | -0.2275 | | -0.1435 | -0.043 |
| *Iris (4)* | | -0.0855 | 0.858 | -0.233 | | -0.305 | | | | | -1.806 | -0.0915 |
| *Mimulus (1)* | 0.587 | 0.934 | | 0.975 | | 0.6195 | 0.447 | 0.125 | -0.668 | 0.645 | 0.573 | |
| *Mimulus (2)* | | | 0.4995 | | 0.4995 | 0.446 | | 0.1285 | 0.074 | 0.436 | 0.196 | |
| *Mimulus (3)* | | | | 0.947 | | | 0.958 | | | | | |
| *Mimulus guttatus* | | 0.9365 | 1 | | | | | | 0.002 | | | -0.7835 |
| *Penstemon* | | | | 0.5295 | | | 0.7435 | | -0.0155 | 0.514 | | |
| *Pedicularis* | | | 0.616 | 0.934 | | | 0.462 | | | | | |
| *Phlox* | | 0.19 | | 0.413 | | 0.204 | 0.209 | | | 0.786 | 0.847 | |

**B)**

| Study system | eco-geography | immigrant inviability | phenology | pollinator | mating system | extrinsic post-zygotic | Total |
|---|---|---|---|---|---|---|---|
| *Artemisia tridentata* | | 0.85 | | | | 0.115875 | 0.965875 |
| *Chamaecrista desvauxii* | | 0 | 0.301 | | | | 0.301 |
| *Costus* | 0.413 | | 0.116226 | 0.4163996 | | | 0.945626 |
| *Gelsemium* | | | 0.9635 | | | | 0.9635 |
| *Gilia capitata* | | 0.749 | | | | | 0.749 |
| *Helianthus exilis* | | 0.971 | | | | | 0.971 |
| *Helianthus* | | | 0.3505 | | | | 0.3505 |
| *Ipomopsis* | | 0.9615 | | 0.0277778 | | 0.002975 | 0.992253 |
| *Iris (1)* | | 0.932 | 0.00969 | | | | 0.94169 |
| *Iris (2)* | | | 0.1765 | | | | 0.1765 |
| *Iris (3)* | | 0.072 | 0.380944 | 0.3468335 | | -0.00861 | 0.791168 |
| *Iris (4)* | | -0.0855 | 0.931359 | -0.035915 | | -0.01739 | 0.792554 |
| *Mimulus (1)* | 0.587 | 0.385742 | | 0.0265766 | | | 0.999319 |
| *Mimulus (2)* | | | 0.4995 | | 0.25 | | 0.7495 |
| *Mimulus (3)* | | | | 0.947 | | | 0.947 |
| *Mimulus guttatus* | | 0.9365 | 0.0635 | | | 0 | 1 |
| *Penstemon* | | | | 0.5295 | | | 0.5295 |
| *Pedicularis* | | | 0.616 | 0.358656 | | | 0.974656 |
| *Phlox* | | 0.19 | | 0.33453 | | | 0.52453 |

| C) Study system | pollen competition | F1 seed formation | F1 seed germination | F1 viability | F1 male fertility | F1 seed set | Total |
|---|---|---|---|---|---|---|---|
| *Artemisia tridentata* | | | | | | | |
| *Chamaecrista desvauxii* | | 1 | 0 | | | | 1 |
| *Costus* | | 0.8885 | -0.007582 | | 0.000298 | | 0.881216 |
| *Gelsemium* | | 0.8015 | | | | | 0.8015 |
| *Gilia capitata* | | 0.875 | | | | | 0.875 |
| *Helianthus exilis* | | 0 | | | | | 0 |
| *Helianthus* | 0.983 | -0.0003655 | | | 0.01648 | 0.000878 | 0.999992 |
| *Ipomopsis* | -0.0935 | 0 | | | | | -0.0935 |
| *Iris (1)* | | -0.5635 | | | | | -0.5635 |
| *Iris (2)* | | 0.3145 | | | | | 0.3145 |
| *Iris (3)* | 0.8055 | 0.116311 | 0.00273662 | -0.017165 | | -0.01329 | 0.894092 |
| *Iris (4)* | -0.305 | | | | | -2.35683 | -2.66183 |
| *Mimulus (1)* | 0.6195 | 0.1700835 | 0.02630206 | -0.122988 | 0.198081 | 0.062469 | 0.953448 |
| *Mimulus (2)* | 0.446 | | 0.071189 | 0.035728 | 0.194928 | 0.049422 | 0.797268 |
| *Mimulus (3)* | | 0.958 | | | | | 0.958 |
| *Mimulus guttatus* | | | | 0.002 | | | 0.002 |
| *Penstemon* | | 0.7435 | | -0.003976 | 0.133885 | | 0.873409 |
| *Pedicularis* | | 0.462 | | | | | 0.462 |
| *Phlox* | 0.204 | 0.166364 | | | 0.494894 | 0.114127 | 0.979384 |

**Table S3.** Calculation details for the animal data given in Table S1. A) Numbers extracted from Table 3 in (*S48*). B) Absolute contributions of sequential components of reproductive isolation likely attributable to divergent selection. C) Absolute contributions of sequential components of reproductive isolation attributable to unknown causes. Absolute contributions of the sequential components of reproductive isolation were accumulated and totaled using the formulass in (*S49*), as described in the legend of Table S2. I assumed that the following components of reproductive isolation likely represented divergent selection by active selection or trait-based assortative mating: ecogeographic, immigrant inviability, phenology, pollinators, and extrinsic postzygotic isolation. Remaining components fell into the category of unknown causes.

**A)**

| Study system | Habitat isolation | Immigrant inviability | Sexual isolation | Pollen competition | Hybrid inviability (genetic) | Hybrid inviability (ecological) | Sexual selection on hybrids |
|---|---|---|---|---|---|---|---|
| *Acyrthosiphon pisum* | 0.927 | 0.97 | | | 0 | 0.47 | |
| *Agelenopsis aperta* | | 0.632 | 0.06 | | -0.15 | | |
| *Bombina spp.* | 0.66 | 0.437 | | | 0.19 | | |
| *Eurosta solidaginis* | 0.962 | 0.877 | 0.365 | | 0 | 0.344 | |
| *Galerucella nymphaeae* | 0.855 | 0.772 | 0 | | 0 | 0.322 | |
| *Galerucella spp.* | 0.904 | 0.938 | | | 0 | -0.71 | |
| *Gasterosteus aculeatus* | | 0.363 | 0.633 | | 0 | 0.255 | 0.777 |
| *Heliconius erato* | 0 | 0.52 | 0 | | 0 | 0.45 | |
| *Littorina saxatilis* | 0.742 | 0.691 | 0.518 | | 0 | -0.259 | 0 |
| *Mitoura spp.* | 0.696 | 0.208 | | | 0 | | |
| *Neochlamisus bebbianae* | 0.947 | 0.99 | 0.72 | | | | |
| *Rhagoletis spp.* | 0.555 | 0.368 | | | | 0.606 | |
| *Timema cristinae* | 0.252 | 0.34 | 0.222 | | | | |

**B)**

| Study system | Habitat isolation | Immigrant inviability | Hybrid inviability (ecological) | Total |
|---|---|---|---|---|
| *Acyrthosiphon pisum* | 0.927 | 0.07081 | 0.0010293 | 0.9988393 |
| *Agelenopsis aperta* | | 0.632 | 0 | 0.632 |
| *Bombina spp.* | 0.66 | 0.14858 | 0 | 0.80858 |
| *Eurosta solidaginis* | 0.962 | 0.033326 | 0.001607856 | 0.99693386 |
| *Galerucella nymphaeae* | 0.855 | 0.11194 | 0.01064532 | 0.97758532 |
| *Galerucella spp.* | 0.904 | 0.090048 | -0.00422592 | 0.98982208 |
| *Gasterosteus aculeatus* | | 0.363 | 0.162435 | 0.525435 |
| *Heliconius erato* | 0 | 0.52 | 0.216 | 0.736 |
| *Littorina saxatilis* | 0.742 | 0.178278 | -0.020648 | 0.89963 |
| *Mitoura spp.* | 0.696 | 0.063232 | 0 | 0.759232 |
| *Neochlamisus bebbianae* | 0.947 | 0.05247 | 0 | 0.99947 |
| *Rhagoletis spp.* | 0.555 | 0.16376 | 0.17043144 | 0.88919144 |
| *Timema cristinae* | 0.252 | 0.25432 | 0 | 0.50632 |

**C)**

| Study system | Sexual isolation | Hybrid inviability (genetic) | Sexual selection on hybrids | Total |
|---|---|---|---|---|
| *Acyrthosiphon pisum* | | | | |
| *Agelenopsis aperta* | 0.06 | -0.141 | 0 | -0.081 |
| *Bombina spp.* | 0 | 0.19 | 0 | 0.19 |
| *Eurosta solidaginis* | 0.365 | 0 | 0 | 0.365 |
| *Galerucella nymphaeae* | 0 | 0 | 0 | 0 |
| *Galerucella spp.* | 0 | 0 | 0 | 0 |
| *Gasterosteus aculeatus* | 0.633 | 0 | 0.285159 | 0.918159 |
| *Heliconius erato* | 0 | 0 | 0 | 0 |
| *Littorina saxatilis* | 0.518 | 0 | 0 | 0.518 |
| *Mitoura spp.* | 0 | 0 | 0 | 0 |
| *Neochlamisus bebbianae* | 0.72 | 0 | 0 | 0.72 |
| *Rhagoletis spp.* | | | | |
| *Timema cristinae* | 0.222 | 0 | 0 | 0.222 |

**Supporting Online Material for**

**Evidence for ecological speciation and its alternative**

**by Dolph Schluter**

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