**Title:** Dispersal and migration have contrasting effects on butterfly flight morphology and reproduction

**Authors:** Vaishali Bhaumik1,2,**\***, Krushnamegh Kunte**1,\***

**Affiliations:** 1National Centre for Biological Sciences, Tata Institute of Fundamental Research, GKVK Campus, Bellary Road, Bangalore 560065, India.

2Shanmugha Arts, Science, Technology and Research Academy (SASTRA) Univ., Tirumalaisamudram, Thanjavur 613401, India.

**\*Corresponding author:** Vaishali Bhaumik [vaishalib@ncbs.res.in](mailto:vaishalib@ncbs.res.in), and Krushnamegh Kunte [krushnamegh@ncbs.res.in](mailto:krushnamegh@ncbs.res.in)

**ORCIDs:** Bhaumik: 0000-0002-1504-6269, Kunte: 0000-0002-3860-6118.

**Electronic Supplementary Material**

**Table S1**: Dispersal information for *Catopsilia*. See the submitted file, “2020-05-25\_CatopsiliaMigrationMS\_ESM\_TableS1.xlsx”.

**Table S2**: Sample sizes (n), range, and mean±SD (if normally distributed) or median, IQR (if non-normally distributed) of different morphological parameters (thorax:abdomen ratio, number of ova, and ova:abdomen mass ratio), grouped by species (*Catopsilia pomona*, *C. pyranthe*, *Colias* spp.*, Eurema hecabe, Leptosia nina, Ixias* spp.*, Hebomoia glaucippe, Euploea sylvester*, and *Tirumala septentrionis*), sex, and dispersal behaviour (ND=non-dispersing, D=dispersing, O=ovulating, and RD=reproductive diapause).

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Species** | **Sex** | **State** | **n** | **Thorax:**  **Abdomen**  **ratio** |  |  | **No. of**  **mature**  **ova** |  | **Ova:**  **Abdomen**  **mass** |  |
|  |  |  |  | **Range** | **mean±SD or**  **median,IQR** | **♀ with**  **ova** | **Range**  **(ova)** | **mean±SD or**  **median,IQR** | **Range** | **mean±SD or**  **median,IQR** |
| *pomona* | ♀ | ND | 48 | 0.8–2.33 | 1.37±0.32 | 7 | 0–48 | 0,0 | 0–1.52 | 0,0 |
|  | ♀ | D | 14 | 0.69–1.54 | 1.09±0.23 | 14 | 11–50 | 21.5,8 | 0.22–1.21 | 0.67±0.3 |
|  | ♂ | ND | 65 | 1.01–4.06 | 2.31±0.7 | – |  |  |  |  |
|  | ♂ | D | 20 | 1.73–3.84 | 2.24,0.86 | – |  |  |  |  |
| *pyranthe* | ♀ | ND | 13 | 0.96–2.13 | 1.45±0.35 | 6 | 0–56 | 0,21 | 0–1.22 | 0,0.62 |
|  | ♀ | D | 20 | 0.68–1.54 | 0.98±0.22 | 20 | 2–100 | 45.45±29.81 | 0.05–1.32 | 0.7±0.4 |
|  | ♂ | ND | 12 | 0.99–3.25 | 2.11±0.63 | – |  |  |  |  |
|  | ♂ | D | 20 | 1.32–2.92 | 2.18±0.51 | – |  |  |  |  |
| *Colias* spp. | ♀ | ND | 4 | 0.94–1.08 | 1.01,0.12 | 4 | 22–65 | 39.5,34 | 1.02–3.01 | 1.38,0.79 |
|  | ♂ | ND | 13 | 0.96–3.1 | 2.47,0.52 | – |  |  |  |  |
| *hecabe* | ♀ | ND | 32 | 0.66–1.67 | 0.94,0.26 | 19 | 0–53 | 7,12.5 | 0–2.16 | 0.44,1 |
|  | ♂ | ND | 53 | 0.76–2.2 | 1.46±0.43 | – |  |  |  |  |
| *nina* | ♀ | ND | 7 | 0.62–1.25 | 0.85±0.21 | 6 | 0–11 | 7.57±3.99 | 0–2.2 | 1.38±0.7 |
|  | ♂ | ND | 15 | 0.82–2.21 | 1.46±0.44 | – |  |  |  |  |
| *Ixias* spp. | ♀ | ND | 12 | 0.64–1.18 | 0.86±0.15 | 10 | 0–31 | 17±11.75 | 0–1.1 | 0.48±0.35 |
|  | ♂ | ND | 56 | 0.75–3.56 | 1.77,0.68 | – |  |  |  |  |
| *glaucippe* | ♀ | ND | 9 | 0.65–1.4 | 1.04±0.24 | 7 | 0–50 | 19.56±17.73 | 0–0.22 | 0.12±0.09 |
|  | ♂ | ND | 41 | 1.4–3.05 | 2.2±0.4 | – |  |  |  |  |
| *sylvester* | ♀ | O | 20 | 0.54–1.24 | 0.84±0.19 | 20 | 1–36 | 10,10.5 | 0.02–0.39 | 0.09,0.09 |
|  | ♀ | RD | 27 | 0.87–1.35 | 1.26,0.22 | – | 0–0 | 0,0 | 0–0 | 0,0 |
|  | ♂ | – | – | 1.27–1.83 | 1.38,0.23 | – |  |  |  |  |
| *septentrionis* | ♀ | RD | 9 | 0.6–1.19 | 0.88±0.2 | 9 | 1–42 | 15.56±14.19 | 0.01–0.39 | 0.15±0.13 |
|  | ♀ | O | 23 | 0.94–1.41 | 1.16,0.24 | – | 0–0 | 0,0 | 0–0 | 0,0 |
|  | ♂ | – | 28 | 1.15–1.79 | 1.46±0.16 | – |  |  |  |  |

**Table S3:** Test statistics and *p*-values for pairwise comparisons of thorax:abdomen ratio between different groups of butterflies. Species, sex, and dispersal behaviour are the same as in Table S1. Test statistics are t (with degrees of freedom) and W for one-tailed Student’s t-tests and Wilcoxon rank sum tests between normally and non-normally distributed samples, respectively. Comparisons with *p*<0.05 are marked bold.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Species** | **Sex** | **Dispersal behaviour** | **Test statistic** | **df** | ***p*-value** |
| *pomona* | ♀ | D–ND | -3.6251 | 29 | **0.0005** |
|  | ♂ | D–ND | 784.5 |  | 0.9190 |
|  | ♀–♂ | ND | -9.5682 | 94.879 | **0.0000** |
|  | ♀–♂ | D | 0 |  | **0.0000** |
| *pyranthe* | ♀ | D–ND | -4.3978 | 18.318 | **0.0002** |
|  | ♂ | D–ND | 0.32295 | 19.499 | 0.6249 |
|  | ♀–♂ | ND | -3.1872 | 16.831 | **0.0027** |
|  | ♀–♂ | D | -9.7205 | 25.954 | **0.0000** |
| *Colias* spp. | ♀–♂ | ND | 2 |  | **0.0017** |
| *hecabe* | ♀–♂ | ND | 264.5 |  | **0.0000** |
| *nina* | ♀–♂ | ND | -4.373 | 19.886 | **0.0001** |
| *Ixias* spp. | ♀–♂ | ND | 25.5 |  | **0.0000** |
| *glaucippe* | ♀–♂ | ND | -11.364 | 19.466 | **0.0000** |
| *sylvester* | ♀ | RD–O | 42 |  | **0.0000** |
|  | ♀–♂ | M–O | 0 |  | **0.0001** |
|  | ♀–♂ | M–RD | 63.5 |  | **0.0000** |
| *septentrionis* | ♀ | RD–O | 28 |  | **0.0000** |
|  | ♀–♂ | M–O | -8.0264 | 11.678 | **0.0000** |
|  | ♀–♂ | M–RD | 58 |  | **0.0000** |

**Table S4:** Pairwise comparisons of regression slopes between female *Catopsilia* and danaines. ND=non-dispersing, D=dispersing, O=ovulating, and RD=reproductive diapause. The model used was as follows:

No. of ova ~ thorax:abdomen ratio \* group (*Catopsilia* or danaines) \* dispersal behaviour (dispersing, non-dispersing, ovulating, or diapausing).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Contrast** | **Estimate** | **SE** | **df** | **t ratio** | ***p*-value** |
| *Catopsilia* (D)–*Catopsilia* (ND) | -61.228 | 11.4 | 166 | -5.355 | **<0.0001** |
| *Catopsilia* (D)–Danaine (O) | -60.705 | 16.8 | 166 | -3.61 | **0.0023** |
| *Catopsilia* (D)–Danaine (RD) | -65.116 | 17.1 | 166 | -3.816 | **<0.0001** |
| *Catopsilia* (S)–Danaine (O) | 0.523 | 14.4 | 166 | 0.036 | 1 |
| *Catopsilia* (S)–Danaine (RD) | -3.887 | 14.7 | 166 | -0.264 | 0.9935 |
| Danaine (O)–Danaine (RD) | -4.411 | 19.2 | 166 | -0.23 | 0.9957 |