Supplementary Information for

**A meta-analysis on global change drivers and the risk of infectious disease**

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**Supplementary Discussion**

**SI Appendix Text S1. Directionality of ‘Enemy Release’ Studies**

The ecological valuation of non-human species based upon their native-status is a conundrum. Discussions surrounding the human valuation of native and non-native organisms have been going on for decades, with a conservationist bias against non-native species possibly rooted in xenophobia*1*. Moreover, given that past natural systems are undergoing transformations caused by anthropogenic global change drivers that will forever alter their landscapes, some scientists argue that the field of ecology needs to move on from the dichotomy between native and non-native species*2*. Nonetheless, the invasion of non-native species presents a threat to native biodiversity, ecosystems as a whole, and human well-being*3*. We recognize the potential ethical problems of valuing native species over non-native species as we have done here, but our treatment of a reduction in disease in non-native species being given the same effect size direction as an increase in disease in native hosts was based solely on the likelihood of non-native species negatively affecting ecosystems and biodiversity*4*.

The value judgment applied to non-native species is not unlike the value judgment applied to infectious diseases and parasites. Parasitism is the most common consumer strategy among organisms. Hence, parasites consume other organisms like every heterotrophic organism on the planet. However, unlike herbivores and many other consumers, parasites and the infectious diseases that they cause are generally regarded as bad or problematic by humans. This is a value judgment just like treating non-native species as adverse.

**SI Appendix Text S2. Tests of Bias and Robustness of Meta-analysis**

Importantly, we found no evidence that effect size patterns among global change drivers could be explained by differences in variances or sample sizes among global change drivers (Extended Data Fig. 4). Further, forest plots showed that extreme observations were uncommon in our dataset and were typically given low weight in our meta-analytical models, suggesting that these data had minimal impacts on patterns among global change drivers (Extended Data Fig. 5A). Egger’s tests indicated significant asymmetries (p < 0.05) in biodiversity change, climate change, and introduced species, but asymmetries for biodiversity change and climate change are likely because of consistent positive effects of these global change drivers on disease, whereas the relatively weak asymmetry for introduced species may be driven by outliers (Extended Data Fig. 5B,C). No significant asymmetries (p > 0.05) were found for chemical pollution or habitat loss/change. Taken together, these results suggest negligible publication bias in reported disease responses across global change drivers. Additionally, there was no indication of a significant time-lag bias (*p* > 0.05). Our results were robust to the iterative exclusion of individual studies (Extended Data Fig. 5D). Finally, fail-safe N analyses indicated that for all global change drivers, the results are likely robust with respect to the file-drawer problem (e.g., a large number of unpublished non-significant results), as almost all estimated number of studies required to shift the significant effect sizes to non-significant were well above the fail-safe N values for each driver (see supplemental R Markdown).

**References in the Supplementary Materials**

1. J. Peretti, Nativism and Nature: Rethinking Biological Invasion. *Environ. Values* **7**, 189-192 (1998).

2. M. Davis *et al.*, Don't judge species on their origins. *Nature* **474**, 153–154 (2011).

3. P. Pyšek *et al.*, Scientists' warning on invasive alien species. *Biol. Rev.* **95**, 1511-1534 (2020).

4. D. Simberloff *et al.*, Impacts of biological invasions: what's what and the way forward. *Trends Ecol. Evol.* **28**, 58-66 (2013).



**Table S2. Summary of the number of studies and effect sizes in the infectious disease database across ecological contexts and global change drivers.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Study, Host, and Parasite Factors | | Global Change Driver | Number of Studies | Number of Effect Sizes |
| Parasite Taxa | Arthropod | BC | 9 | 71 |
|  |  | CC | 24 | 36 |
|  |  | CP | 4 | 4 |
|  |  | HLC | 39 | 101 |
|  |  | IS | 8 | 17 |
|  | Bacteria | BC | 12 | 26 |
|  |  | CC | 25 | 36 |
|  |  | CP | 15 | 35 |
|  |  | HLC | 106 | 247 |
|  |  | IS | 10 | 14 |
|  | Fungi | BC | 20 | 156 |
|  |  | CC | 56 | 108 |
|  |  | CP | 70 | 181 |
|  |  | HLC | 16 | 33 |
|  |  | IS | 53 | 208 |
|  | Helminth | BC | 17 | 86 |
|  |  | CC | 34 | 68 |
|  |  | CP | 13 | 69 |
|  |  | HLC | 170 | 534 |
|  |  | IS | 17 | 62 |
|  | Protist | BC | 5 | 14 |
|  |  | CC | 47 | 87 |
|  |  | CP | 14 | 30 |
|  |  | HLC | 212 | 376 |
|  |  | IS | 4 | 8 |
|  | Virus | BC | 19 | 37 |
|  |  | CC | 18 | 30 |
|  |  | CP | 14 | 31 |
|  |  | HLC | 54 | 117 |
|  |  | IS | 22 | 40 |
| Native Host Taxa | Amphibian/Reptile | BC | 5 | 26 |
|  |  | CC | 19 | 32 |
|  |  | CP | 22 | 100 |
|  |  | HLC | 10 | 29 |
|  |  | IS | 10 | 24 |
|  | Arthropod | BC | 4 | 6 |
|  |  | CC | 8 | 15 |
|  |  | CP | 16 | 37 |
|  |  | HLC | 24 | 68 |
|  |  | IS | 10 | 19 |
|  | Bird | BC | 2 | 2 |
|  |  | CC | 5 | 11 |
|  |  | CP | 2 | 4 |
|  |  | HLC | 28 | 47 |
|  |  | IS | 10 | 13 |
|  | Fish | BC | 1 | 2 |
|  |  | CC | 9 | 15 |
|  |  | CP | 6 | 15 |
|  |  | HLC | 0 | 0 |
|  |  | IS | 4 | 9 |
|  | Mammal | BC | 28 | 88 |
|  |  | CC | 70 | 142 |
|  |  | CP | 5 | 18 |
|  |  | HLC | 443 | 1259 |
|  |  | IS | 10 | 15 |
|  | Mollusk | BC | 11 | 55 |
|  |  | CC | 14 | 20 |
|  |  | CP | 12 | 44 |
|  |  | HLC | 2 | 3 |
|  |  | IS | 6 | 39 |
|  | Plant | BC | 28 | 213 |
|  |  | CC | 49 | 100 |
|  |  | CP | 60 | 140 |
|  |  | HLC | 4 | 11 |
|  |  | IS | 46 | 236 |
| Human parasite? | No | BC | 50 | 314 |
|  |  | CC | 134 | 251 |
|  |  | CP | 121 | 351 |
|  |  | HLC | 94 | 232 |
|  |  | IS | 87 | 341 |
|  | Yes | BC | 28 | 78 |
|  |  | CC | 67 | 122 |
|  |  | CP | 3 | 12 |
|  |  | HLC | 444 | 1182 |
|  |  | IS | 9 | 13 |
| Host Thermy | Endotherm | BC | 30 | 90 |
|  |  | CC | 75 | 153 |
|  |  | CP | 7 | 22 |
|  |  | HLC | 468 | 1300 |
|  |  | IS | 19 | 27 |
|  | Ectotherm | BC | 49 | 302 |
|  |  | CC | 126 | 225 |
|  |  | CP | 117 | 342 |
|  |  | HLC | 53 | 148 |
|  |  | IS | 77 | 328 |
| Parasite Size | Microparasite | BC | 58 | 263 |
|  |  | CC | 116 | 203 |
|  |  | CP | 97 | 260 |
|  |  | HLC | 239 | 532 |
|  |  | IS | 66 | 263 |
|  | Macroparasite | BC | 21 | 129 |
|  |  | CC | 83 | 163 |
|  |  | CP | 28 | 92 |
|  |  | HLC | 317 | 914 |
|  |  | IS | 35 | 92 |
| Free Living Stages? | No | BC | 17 | 48 |
|  |  | CC | 56 | 110 |
|  |  | CP | 14 | 31 |
|  |  | HLC | 306 | 617 |
|  |  | IS | 28 | 47 |
|  | Yes | BC | 62 | 343 |
|  |  | CC | 140 | 249 |
|  |  | CP | 106 | 321 |
|  |  | HLC | 250 | 760 |
|  |  | IS | 68 | 269 |
| Endpoint | Host | BC | 7 | 42 |
|  |  | CC | 60 | 117 |
|  |  | CP | 59 | 166 |
|  |  | HLC | 35 | 71 |
|  |  | IS | 14 | 15 |
|  | Parasite | BC | 70 | 350 |
|  |  | CC | 151 | 261 |
|  |  | CP | 80 | 198 |
|  |  | HLC | 484 | 1378 |
|  |  | IS | 85 | 340 |
| Transmission Route | Complex | BC | 32 | 131 |
|  |  | CC | 61 | 122 |
|  |  | CP | 25 | 107 |
|  |  | HLC | 282 | 517 |
|  |  | IS | 23 | 60 |
|  | Direct | BC | 47 | 261 |
|  |  | CC | 126 | 226 |
|  |  | CP | 97 | 244 |
|  |  | HLC | 259 | 853 |
|  |  | IS | 73 | 258 |
| Vector-borne? | No | BC | 46 | 264 |
|  |  | CC | 132 | 233 |
|  |  | CP | 104 | 273 |
|  |  | HLC | 380 | 1170 |
|  |  | IS | 75 | 265 |
|  | Yes | BC | 32 | 127 |
|  |  | CC | 67 | 126 |
|  |  | CP | 19 | 79 |
|  |  | HLC | 163 | 257 |
|  |  | IS | 22 | 53 |
| Parasite Type | Endoparasite | BC | 54 | 215 |
|  |  | CC | 127 | 249 |
|  |  | CP | 61 | 182 |
|  |  | HLC | 484 | 1325 |
|  |  | IS | 64 | 139 |
|  | Ectoparasite | BC | 23 | 177 |
|  |  | CC | 71 | 117 |
|  |  | CP | 60 | 170 |
|  |  | HLC | 48 | 123 |
|  |  | IS | 55 | 216 |
| Venue | Field | BC | 65 | 328 |
|  |  | CC | 115 | 227 |
|  |  | CP | 26 | 67 |
|  |  | HLC | 514 | 1445 |
|  |  | IS | 92 | 346 |
|  | Lab | BC | 12 | 64 |
|  |  | CC | 86 | 151 |
|  |  | CP | 98 | 297 |
|  |  | HLC | 3 | 4 |
|  |  | IS | 5 | 9 |
| Habitat | Freshwater | BC | 15 | 65 |
|  |  | CC | 40 | 72 |
|  |  | CP | 43 | 161 |
|  |  | HLC | 21 | 54 |
|  |  | IS | 15 | 37 |
|  | Marine | BC | 3 | 20 |
|  |  | CC | 27 | 38 |
|  |  | CP | 10 | 28 |
|  |  | HLC | 1 | 1 |
|  |  | IS | 10 | 47 |
|  | Terrestrial | BC | 59 | 307 |
|  |  | CC | 136 | 268 |
|  |  | CP | 71 | 175 |
|  |  | HLC | 501 | 1391 |
|  |  | IS | 71 | 271 |
| Zoonotic? | No | BC | 52 | 323 |
|  |  | CC | 157 | 298 |
|  |  | CP | 121 | 254 |
|  |  | HLC | 243 | 699 |
|  |  | IS | 85 | 338 |
|  | Yes | BC | 28 | 69 |
|  |  | CC | 43 | 68 |
|  |  | CP | 4 | 9 |
|  |  | HLC | 295 | 620 |
|  |  | IS | 7 | 11 |
| Vector | No | BC | 77 | 392 |
|  |  | CC | 175 | 330 |
|  |  | CP | 119 | 349 |
|  |  | HLC | 494 | 1372 |
|  |  | IS | 95 | 351 |
|  | Yes | BC | 0 | 0 |
|  |  | CC | 23 | 36 |
|  |  | CP | 2 | 3 |
|  |  | HLC | 33 | 74 |
|  |  | IS | 3 | 4 |
| Continent | Africa | BC | 10 | 62 |
|  |  | CC | 14 | 30 |
|  |  | CP | 0 | 0 |
|  |  | HLC | 125 | 407 |
|  |  | IS | 3 | 4 |
|  | Asia | BC | 6 | 58 |
|  |  | CC | 11 | 17 |
|  |  | CP | 3 | 5 |
|  |  | HLC | 108 | 307 |
|  |  | IS | 3 | 6 |
|  | Australia | BC | 2 | 12 |
|  |  | CC | 4 | 11 |
|  |  | CP | 1 | 1 |
|  |  | HLC | 14 | 44 |
|  |  | IS | 7 | 16 |
|  | Europe | BC | 13 | 48 |
|  |  | CC | 49 | 108 |
|  |  | CP | 11 | 25 |
|  |  | HLC | 112 | 260 |
|  |  | IS | 16 | 33 |
|  | North America | BC | 27 | 113 |
|  |  | CC | 28 | 49 |
|  |  | CP | 9 | 30 |
|  |  | HLC | 59 | 149 |
|  |  | IS | 21 | 61 |
|  | South America | BC | 7 | 35 |
|  |  | CC | 9 | 12 |
|  |  | CP | 1 | 1 |
|  |  | HLC | 96 | 276 |
|  |  | IS | 3 | 7 |

**Table S3. Results of pairwise comparisons from interaction plots presented in Figure 2 and Extended Data Figures (EDF) 4, 8, and 9.** Significant differences (p < 0.05) are highlighted in bold. Pairwise comparisons were conducted among study, host, and parasite endpoints within individual global change drivers to highlight context dependencies.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Study, Host, and Parasite Factors | Global Change Driver | Pairwise Comparison | Estimate | SE | Z-stat | | p-value | |
| Main GCD effect |  | BC – CP | 0.403 | 0.161 | | 2.508 | | 0.089 | |
| Main Text Fig. 2 |  | **BC – CC** | **0.609** | **0.157** | | **3.893** | | **0.001** | |
|  |  | **BC – HLC** | **0.962** | **0.143** | | **6.732** | | **<0.001** | |
|  |  | BC – IS | 0.300 | 0.179 | | 1.677 | | 0.448 | |
|  |  | CP – CC | 0.206 | 0.114 | | 1.809 | | 0.368 | |
|  |  | **CP – HLC** | **0.353** | **0.085** | | **4.140** | | **<0.001** | |
|  |  | CP – IS | -0.309 | 0.137 | | -2.254 | | 0.160 | |
|  |  | **CC – HLC** | **0.559** | **0.091** | | **6.121** | | **<0.001** | |
|  |  | CC – IS | -0.103 | 0.141 | | -0.729 | | 0.950 | |
|  |  | **HLC – IS** | **-0.662** | **0.121** | | **-5.490** | | **<0.001** | |
| LRR GCD effect |  | CP – CC | 0.088 | 0.142 | | 0.622 | | 0.972 | |
| EDF 4A |  | **CP – HLC** | **0.407** | **0.101** | | **4.016** | | **0.001** | |
|  |  | CP – IS | -0.164 | 0.167 | | -0.981 | | 0.864 | |
|  |  | **CC – HLC** | **0.495** | **0.136** | | **3.647** | | **0.003** | |
|  |  | CC – IS | -0.076 | 0.190 | | -0.398 | | 0.995 | |
|  |  | **HLC – IS** | **-0.571** | **0.168** | | **-3.406** | | **0.006** | |
| Continent | BC | Africa - Asia | -0.479 | 0.431 | -1.110 | | 0.878 | |
| EDF 9A | BC | Africa - Australia | -0.276 | 0.443 | -0.622 | | 0.989 | |
|  | BC | Africa - Europe | 0.543 | 0.322 | 1.686 | | 0.541 | |
|  | BC | Africa - North America | 0.293 | 0.340 | 0.861 | | 0.956 | |
|  | BC | Africa - South America | 0.423 | 0.341 | 1.241 | | 0.817 | |
|  | BC | Asia - Australia | 0.203 | 0.460 | 0.442 | | 0.998 | |
|  | **BC** | **Asia - Europe** | **1.022** | **0.344** | **2.967** | | **0.036** | |
|  | BC | Asia - North America | 0.772 | 0.362 | 2.135 | | 0.269 | |
|  | BC | Asia - South America | 0.902 | 0.362 | 2.491 | | 0.127 | |
|  | BC | Australia - Europe | 0.818 | 0.359 | 2.281 | | 0.202 | |
|  | BC | Australia - North America | 0.569 | 0.375 | 1.515 | | 0.655 | |
|  | BC | Australia - South America | 0.699 | 0.376 | 1.859 | | 0.428 | |
|  | BC | Europe - North America | -0.250 | 0.219 | -1.139 | | 0.865 | |
|  | BC | Europe - South America | -0.120 | 0.220 | -0.544 | | 0.994 | |
|  | BC | North America - South America | 0.130 | 0.246 | 0.528 | | 0.995 | |
|  | CC | Africa - Asia | -0.282 | 0.192 | -1.464 | | 0.687 | |
|  | CC | Africa - Australia | -1.207 | 0.447 | -2.701 | | 0.075 | |
|  | CC | Africa - Europe | -0.473 | 0.216 | -2.187 | | 0.244 | |
|  | CC | Africa - North America | -0.143 | 0.145 | -0.985 | | 0.923 | |
|  | CC | Africa - South America | -0.639 | 0.322 | -1.984 | | 0.352 | |
|  | CC | Asia - Australia | -0.925 | 0.483 | -1.915 | | 0.393 | |
|  | CC | Asia - Europe | -0.191 | 0.284 | -0.674 | | 0.985 | |
|  | CC | Asia - North America | 0.139 | 0.234 | 0.594 | | 0.992 | |
|  | CC | Asia - South America | -0.358 | 0.371 | -0.964 | | 0.929 | |
|  | CC | Australia - Europe | 0.734 | 0.493 | 1.488 | | 0.672 | |
|  | CC | Australia - North America | 1.064 | 0.466 | 2.282 | | 0.201 | |
|  | CC | Australia - South America | 0.568 | 0.548 | 1.036 | | 0.906 | |
|  | CC | Europe - North America | 0.330 | 0.254 | 1.301 | | 0.785 | |
|  | CC | Europe - South America | -0.166 | 0.384 | -0.433 | | 0.998 | |
|  | CC | North America - South America | -0.497 | 0.349 | -1.424 | | 0.712 | |
|  | CP | Asia - Europe | -0.625 | 0.407 | -1.533 | | 0.643 | |
|  | CP | Asia - North America | -0.329 | 0.318 | -1.035 | | 0.906 | |
|  | CP | Europe - North America | 0.296 | 0.338 | 0.875 | | 0.953 | |
|  | HLC | Africa - Asia | -0.107 | 0.119 | -0.895 | | 0.948 | |
|  | HLC | Africa - Australia | 0.136 | 0.228 | 0.597 | | 0.991 | |
|  | HLC | Africa - Europe | 0.230 | 0.121 | 1.905 | | 0.399 | |
|  | HLC | Africa - North America | -0.272 | 0.112 | -2.428 | | 0.147 | |
|  | HLC | Africa - South America | -0.056 | 0.103 | -0.548 | | 0.994 | |
|  | HLC | Asia - Australia | 0.243 | 0.246 | 0.984 | | 0.923 | |
|  | HLC | Asia - Europe | 0.336 | 0.152 | 2.206 | | 0.235 | |
|  | HLC | Asia - North America | -0.165 | 0.146 | -1.134 | | 0.867 | |
|  | HLC | Asia - South America | 0.050 | 0.139 | 0.361 | | 0.999 | |
|  | HLC | Australia - Europe | 0.094 | 0.247 | 0.379 | | 0.999 | |
|  | HLC | Australia - North America | -0.408 | 0.243 | -1.677 | | 0.547 | |
|  | HLC | Australia - South America | -0.193 | 0.239 | -0.805 | | 0.967 | |
|  | **HLC** | **Europe - North America** | **-0.501** | **0.147** | **-3.411** | | **0.009** | |
|  | HLC | Europe - South America | -0.286 | 0.140 | -2.039 | | 0.320 | |
|  | HLC | North America - South America | 0.215 | 0.133 | 1.620 | | 0.585 | |
|  | IS | Africa - Asia | 1.052 | 1.388 | 0.758 | | 0.974 | |
|  | IS | Africa - Australia | 0.850 | 1.264 | 0.672 | | 0.985 | |
|  | IS | Africa - Europe | 0.177 | 1.354 | 0.130 | | 1.000 | |
|  | IS | Africa - North America | 0.898 | 1.252 | 0.718 | | 0.980 | |
|  | IS | Africa - South America | 0.712 | 1.245 | 0.572 | | 0.993 | |
|  | IS | Asia - Australia | -0.202 | 0.734 | -0.275 | | 1.000 | |
|  | IS | Asia - Europe | -0.875 | 0.880 | -0.994 | | 0.920 | |
|  | IS | Asia - North America | -0.154 | 0.712 | -0.216 | | 1.000 | |
|  | IS | Asia - South America | -0.340 | 0.700 | -0.485 | | 0.997 | |
|  | IS | Australia - Europe | -0.673 | 0.668 | -1.007 | | 0.916 | |
|  | IS | Australia - North America | 0.048 | 0.422 | 0.115 | | 1.000 | |
|  | IS | Australia - South America | -0.138 | 0.403 | -0.342 | | 0.999 | |
|  | IS | Europe - North America | 0.721 | 0.644 | 1.120 | | 0.873 | |
|  | IS | Europe - South America | 0.535 | 0.631 | 0.848 | | 0.958 | |
|  | IS | North America - South America | -0.186 | 0.361 | -0.514 | | 0.996 | |
| Host Taxa | BC | (Amphibian/Reptile) - Arthropod | 0.474 | 0.555 | 0.853 | | 0.957 | |
| EDF 9B | BC | (Amphibian/Reptile) - Bird | -0.012 | 1.527 | -0.008 | | 1.000 | |
|  | BC | (Amphibian/Reptile) - Mammal | 0.873 | 0.477 | 1.832 | | 0.445 | |
|  | BC | (Amphibian/Reptile) - Mollusk | -1.011 | 0.686 | -1.473 | | 0.682 | |
|  | BC | (Amphibian/Reptile) - Plant | 0.366 | 0.481 | 0.761 | | 0.974 | |
|  | BC | Arthropod - Bird | -0.486 | 1.488 | -0.327 | | 1.000 | |
|  | BC | Arthropod - Mammal | 0.399 | 0.328 | 1.215 | | 0.830 | |
|  | BC | Arthropod - Mollusk | -1.484 | 0.594 | -2.498 | | 0.125 | |
|  | BC | Arthropod - Plant | -0.108 | 0.338 | -0.319 | | 1.000 | |
|  | BC | Bird - Mammal | 0.885 | 1.460 | 0.606 | | 0.991 | |
|  | BC | Bird - Mollusk | -0.998 | 1.542 | -0.648 | | 0.987 | |
|  | BC | Bird - Plant | 0.378 | 1.462 | 0.259 | | 1.000 | |
|  | **BC** | **Mammal - Mollusk** | **-1.884** | **0.499** | **-3.777** | | **0.002** | |
|  | BC | Mammal - Plant | -0.507 | 0.181 | -2.799 | | 0.058 | |
|  | BC | Mollusk - Plant | 1.377 | 0.526 | 2.618 | | 0.093 | |
|  | CC | (Amphibian/Reptile) - Arthropod | 0.335 | 0.738 | 0.454 | | 0.998 | |
|  | CC | (Amphibian/Reptile) - Bird | 0.932 | 0.399 | 2.336 | | 0.180 | |
|  | CC | (Amphibian/Reptile) - Mammal | 0.295 | 0.297 | 0.994 | | 0.920 | |
|  | CC | (Amphibian/Reptile) - Mollusk | 0.249 | 0.441 | 0.565 | | 0.993 | |
|  | CC | (Amphibian/Reptile) - Plant | 0.553 | 0.305 | 1.813 | | 0.456 | |
|  | CC | Arthropod - Bird | 0.597 | 0.756 | 0.790 | | 0.969 | |
|  | CC | Arthropod - Mammal | -0.040 | 0.708 | -0.057 | | 1.000 | |
|  | CC | Arthropod - Mollusk | -0.086 | 0.754 | -0.114 | | 1.000 | |
|  | CC | Arthropod - Plant | 0.218 | 0.711 | 0.307 | | 1.000 | |
|  | CC | Bird - Mammal | -0.637 | 0.339 | -1.881 | | 0.414 | |
|  | CC | Bird - Mollusk | -0.683 | 0.427 | -1.601 | | 0.598 | |
|  | CC | Bird - Plant | -0.379 | 0.346 | -1.096 | | 0.883 | |
|  | CC | Mammal - Mollusk | -0.046 | 0.333 | -0.138 | | 1.000 | |
|  | CC | Mammal - Plant | 0.258 | 0.220 | 1.173 | | 0.850 | |
|  | CC | Mollusk - Plant | 0.304 | 0.340 | 0.894 | | 0.948 | |
|  | CP | (Amphibian/Reptile) - Arthropod | -0.037 | 0.316 | -0.116 | | 1.000 | |
|  | CP | (Amphibian/Reptile) - Bird | -0.536 | 1.040 | -0.515 | | 0.996 | |
|  | CP | (Amphibian/Reptile) - Mammal | -0.488 | 0.411 | -1.188 | | 0.843 | |
|  | CP | (Amphibian/Reptile) - Mollusk | 0.043 | 0.297 | 0.144 | | 1.000 | |
|  | CP | (Amphibian/Reptile) - Plant | -0.211 | 0.177 | -1.188 | | 0.843 | |
|  | CP | Arthropod - Bird | -0.500 | 1.067 | -0.469 | | 0.997 | |
|  | CP | Arthropod - Mammal | -0.452 | 0.474 | -0.954 | | 0.932 | |
|  | CP | Arthropod - Mollusk | 0.079 | 0.385 | 0.206 | | 1.000 | |
|  | CP | Arthropod - Plant | -0.174 | 0.294 | -0.591 | | 0.992 | |
|  | CP | Bird - Mammal | 0.048 | 1.099 | 0.044 | | 1.000 | |
|  | CP | Bird - Mollusk | 0.579 | 1.064 | 0.544 | | 0.994 | |
|  | CP | Bird - Plant | 0.326 | 1.034 | 0.315 | | 1.000 | |
|  | CP | Mammal - Mollusk | 0.531 | 0.468 | 1.135 | | 0.867 | |
|  | CP | Mammal - Plant | 0.278 | 0.395 | 0.704 | | 0.982 | |
|  | CP | Mollusk - Plant | -0.253 | 0.285 | -0.888 | | 0.949 | |
|  | HLC | (Amphibian/Reptile) - Arthropod | 1.039 | 0.768 | 1.352 | | 0.756 | |
|  | HLC | (Amphibian/Reptile) - Bird | 1.166 | 0.782 | 1.491 | | 0.670 | |
|  | HLC | (Amphibian/Reptile) - Mammal | 1.062 | 0.760 | 1.398 | | 0.729 | |
|  | HLC | (Amphibian/Reptile) - Mollusk | 0.470 | 0.775 | 0.607 | | 0.991 | |
|  | HLC | (Amphibian/Reptile) - Plant | 1.606 | 0.870 | 1.847 | | 0.436 | |
|  | HLC | Arthropod - Bird | 0.127 | 0.223 | 0.571 | | 0.993 | |
|  | HLC | Arthropod - Mammal | 0.023 | 0.124 | 0.186 | | 1.000 | |
|  | **HLC** | **Arthropod - Mollusk** | **-0.569** | **0.197** | **-2.893** | | **0.044** | |
|  | HLC | Arthropod - Plant | 0.567 | 0.441 | 1.286 | | 0.793 | |
|  | HLC | Bird - Mammal | -0.104 | 0.192 | -0.543 | | 0.994 | |
|  | HLC | Bird - Mollusk | -0.696 | 0.245 | -2.845 | | 0.051 | |
|  | HLC | Bird - Plant | 0.440 | 0.464 | 0.947 | | 0.934 | |
|  | **HLC** | **Mammal - Mollusk** | **-0.592** | **0.161** | **-3.685** | | **0.003** | |
|  | HLC | Mammal - Plant | 0.544 | 0.426 | 1.276 | | 0.798 | |
|  | HLC | Mollusk - Plant | 1.136 | 0.453 | 2.510 | | 0.121 | |
|  | IS | (Amphibian/Reptile) - Arthropod | -0.457 | 1.052 | -0.434 | | 0.998 | |
|  | IS | (Amphibian/Reptile) - Bird | 0.492 | 0.444 | 1.106 | | 0.879 | |
|  | IS | (Amphibian/Reptile) - Mammal | 0.006 | 0.616 | 0.010 | | 1.000 | |
|  | IS | (Amphibian/Reptile) - Mollusk | -0.005 | 0.429 | -0.011 | | 1.000 | |
|  | IS | (Amphibian/Reptile) - Plant | -0.416 | 0.289 | -1.441 | | 0.702 | |
|  | IS | Arthropod - Bird | 0.948 | 1.075 | 0.882 | | 0.951 | |
|  | IS | Arthropod - Mammal | 0.463 | 1.157 | 0.400 | | 0.999 | |
|  | IS | Arthropod - Mollusk | 0.452 | 1.069 | 0.423 | | 0.998 | |
|  | IS | Arthropod - Plant | 0.041 | 1.021 | 0.040 | | 1.000 | |
|  | IS | Bird - Mammal | -0.485 | 0.655 | -0.740 | | 0.977 | |
|  | IS | Bird - Mollusk | -0.496 | 0.484 | -1.025 | | 0.910 | |
|  | IS | Bird - Plant | -0.908 | 0.365 | -2.486 | | 0.128 | |
|  | IS | Mammal - Mollusk | -0.011 | 0.645 | -0.017 | | 1.000 | |
|  | IS | Mammal - Plant | -0.422 | 0.561 | -0.752 | | 0.975 | |
|  | IS | Mollusk - Plant | -0.411 | 0.346 | -1.188 | | 0.843 | |
| Enemy Taxa | BC | Arthropod - Bacteria | 0.551 | 0.318 | 1.736 | | 0.508 | |
| EDF 9C | BC | Arthropod - Fungi | 0.132 | 0.323 | 0.410 | | 0.999 | |
|  | BC | Arthropod - Helminth | -0.908 | 0.478 | -1.902 | | 0.401 | |
|  | BC | Arthropod - Protist | 0.172 | 0.410 | 0.418 | | 0.998 | |
|  | BC | Arthropod - Virus | 0.287 | 0.314 | 0.915 | | 0.943 | |
|  | BC | Bacteria - Fungi | -0.419 | 0.231 | -1.813 | | 0.457 | |
|  | **BC** | **Bacteria - Helminth** | **-1.460** | **0.398** | **-3.667** | | **0.003** | |
|  | BC | Bacteria - Protist | -0.380 | 0.305 | -1.244 | | 0.815 | |
|  | BC | Bacteria - Virus | -0.264 | 0.213 | -1.240 | | 0.817 | |
|  | BC | Fungi - Helminth | -1.040 | 0.425 | -2.448 | | 0.140 | |
|  | BC | Fungi - Protist | 0.039 | 0.348 | 0.113 | | 1.000 | |
|  | BC | Fungi - Virus | 0.155 | 0.226 | 0.686 | | 0.984 | |
|  | BC | Helminth - Protist | 1.080 | 0.524 | 2.060 | | 0.308 | |
|  | **BC** | **Helminth - Virus** | **1.195** | **0.404** | **2.957** | | **0.037** | |
|  | BC | Protist - Virus | 0.116 | 0.325 | 0.356 | | 0.999 | |
|  | CC | Arthropod - Bacteria | 0.032 | 0.423 | 0.075 | | 1.000 | |
|  | CC | Arthropod - Fungi | 0.437 | 0.280 | 1.561 | | 0.624 | |
|  | CC | Arthropod - Helminth | 0.278 | 0.357 | 0.779 | | 0.971 | |
|  | CC | Arthropod - Protist | 0.530 | 0.252 | 2.105 | | 0.285 | |
|  | CC | Arthropod - Virus | 0.739 | 0.416 | 1.778 | | 0.480 | |
|  | CC | Bacteria - Fungi | 0.405 | 0.381 | 1.065 | | 0.895 | |
|  | CC | Bacteria - Helminth | 0.246 | 0.442 | 0.556 | | 0.994 | |
|  | CC | Bacteria - Protist | 0.498 | 0.357 | 1.394 | | 0.731 | |
|  | CC | Bacteria - Virus | 0.707 | 0.488 | 1.448 | | 0.697 | |
|  | CC | Fungi - Helminth | -0.159 | 0.307 | -0.519 | | 0.996 | |
|  | CC | Fungi - Protist | 0.093 | 0.169 | 0.550 | | 0.994 | |
|  | CC | Fungi - Virus | 0.301 | 0.371 | 0.812 | | 0.966 | |
|  | CC | Helminth - Protist | 0.252 | 0.282 | 0.896 | | 0.948 | |
|  | CC | Helminth - Virus | 0.461 | 0.434 | 1.061 | | 0.897 | |
|  | CC | Protist - Virus | 0.208 | 0.349 | 0.597 | | 0.991 | |
|  | CP | Arthropod - Bacteria | -0.408 | 0.372 | -1.097 | | 0.883 | |
|  | CP | Arthropod - Fungi | -0.261 | 0.314 | -0.832 | | 0.962 | |
|  | CP | Arthropod - Helminth | -0.361 | 0.350 | -1.032 | | 0.907 | |
|  | CP | Arthropod - Protist | -0.466 | 0.524 | -0.889 | | 0.949 | |
|  | CP | Arthropod - Virus | -0.279 | 0.373 | -0.747 | | 0.976 | |
|  | CP | Bacteria - Fungi | 0.147 | 0.256 | 0.573 | | 0.993 | |
|  | CP | Bacteria - Helminth | 0.047 | 0.272 | 0.172 | | 1.000 | |
|  | CP | Bacteria - Protist | -0.058 | 0.497 | -0.117 | | 1.000 | |
|  | CP | Bacteria - Virus | 0.129 | 0.293 | 0.442 | | 0.998 | |
|  | CP | Fungi - Helminth | -0.100 | 0.211 | -0.473 | | 0.997 | |
|  | CP | Fungi - Protist | -0.205 | 0.444 | -0.461 | | 0.997 | |
|  | CP | Fungi - Virus | -0.017 | 0.222 | -0.077 | | 1.000 | |
|  | CP | Helminth - Protist | -0.105 | 0.469 | -0.224 | | 1.000 | |
|  | CP | Helminth - Virus | 0.083 | 0.269 | 0.307 | | 1.000 | |
|  | CP | Protist - Virus | 0.188 | 0.468 | 0.401 | | 0.999 | |
|  | HLC | Arthropod - Bacteria | -0.135 | 0.125 | -1.081 | | 0.889 | |
|  | HLC | Arthropod - Fungi | 0.218 | 0.228 | 0.957 | | 0.931 | |
|  | HLC | Arthropod - Helminth | 0.140 | 0.123 | 1.140 | | 0.865 | |
|  | HLC | Arthropod - Protist | -0.070 | 0.107 | -0.655 | | 0.987 | |
|  | HLC | Arthropod - Virus | -0.294 | 0.115 | -2.570 | | 0.105 | |
|  | HLC | Bacteria - Fungi | 0.353 | 0.220 | 1.602 | | 0.597 | |
|  | HLC | Bacteria - Helminth | 0.275 | 0.107 | 2.566 | | 0.106 | |
|  | HLC | Bacteria - Protist | 0.065 | 0.094 | 0.690 | | 0.983 | |
|  | HLC | Bacteria - Virus | -0.159 | 0.096 | -1.653 | | 0.563 | |
|  | HLC | Fungi - Helminth | -0.078 | 0.222 | -0.350 | | 0.999 | |
|  | HLC | Fungi - Protist | -0.288 | 0.215 | -1.341 | | 0.762 | |
|  | HLC | Fungi - Virus | -0.512 | 0.215 | -2.379 | | 0.163 | |
|  | HLC | Helminth - Protist | -0.210 | 0.084 | -2.509 | | 0.121 | |
|  | **HLC** | **Helminth - Virus** | **-0.434** | **0.098** | **-4.454** | | **<0.001** | |
|  | HLC | Protist - Virus | -0.224 | 0.081 | -2.776 | | 0.061 | |
|  | IS | Arthropod - Bacteria | 0.200 | 0.492 | 0.405 | | 0.999 | |
|  | IS | Arthropod - Fungi | -0.471 | 0.331 | -1.425 | | 0.712 | |
|  | IS | Arthropod - Helminth | 0.405 | 0.383 | 1.057 | | 0.898 | |
|  | IS | Arthropod - Protist | 0.249 | 0.695 | 0.358 | | 0.999 | |
|  | IS | Arthropod - Virus | 0.249 | 0.301 | 0.830 | | 0.962 | |
|  | IS | Bacteria - Fungi | -0.671 | 0.435 | -1.543 | | 0.637 | |
|  | IS | Bacteria - Helminth | 0.206 | 0.481 | 0.427 | | 0.998 | |
|  | IS | Bacteria - Protist | 0.049 | 0.753 | 0.065 | | 1.000 | |
|  | IS | Bacteria - Virus | 0.050 | 0.418 | 0.119 | | 1.000 | |
|  | IS | **Fungi - Helminth** | **0.876** | **0.303** | **2.894** | | **0.044** | |
|  | IS | Fungi - Protist | 0.720 | 0.655 | 1.099 | | 0.882 | |
|  | IS | **Fungi - Virus** | **0.721** | **0.147** | **4.915** | | **<0.001** | |
|  | IS | Helminth - Protist | -0.157 | 0.687 | -0.228 | | 1.000 | |
|  | IS | Helminth - Virus | -0.156 | 0.280 | -0.556 | | 0.994 | |
|  | IS | Protist - Virus | 0.001 | 0.644 | 0.001 | | 1.000 | |
| Endpoint | **BC** | **Host - Parasite** | **-0.939** | **0.259** | **-3.632** | | **<0.001** | |
| EDF 8A | CC | Host - Parasite | 0.176 | 0.202 | 0.871 | | 0.384 | |
|  | CP | Host - Parasite | -0.103 | 0.149 | -0.710 | | 0.478 | |
|  | HLC | Host - Parasite | 0.097 | 0.120 | 0.808 | | 0.419 | |
|  | IS | Host - Parasite | -0.170 | 0.380 | -0.448 | | 0.654 | |
| Vector-borne | **BC** | **No - Yes** | **-0.596** | **0.271** | **-2.201** | | **0.028** | |
| EDF 8B | CC | No - Yes | 0.247 | 0.156 | 1.589 | | 0.112 | |
|  | CP | No - Yes | -0.210 | 0.180 | -1.165 | | 0.244 | |
|  | HLC | No - Yes | 0.008 | 0.094 | 0.086 | | 0.932 | |
|  | **IS** | **No - Yes** | **0.809** | **0.315** | **2.580** | | **0.010** | |
| Route | BC | **Complex - Direct** | **0.590** | **0.285** | **2.074** | | **0.038** | |
| EDF 8C | CC | Complex - Direct | 0.016 | 0.179 | 0.090 | | 0.929 | |
|  | CP | Complex - Direct | -0.007 | 0.177 | -0.040 | | 0.968 | |
|  | HLC | Complex - Direct | -0.068 | 0.136 | -0.502 | | 0.616 | |
|  | IS | **Complex - Direct** | **-0.815** | **0.288** | **-2.834** | | **0.005** | |
| Macroparasite | **BC** | **No - Yes** | **-0.943** | **0.303** | **-3.116** | | **0.002** | |
| EDF 8D | CC | No - Yes | -0.221 | 0.167 | -1.321 | | 0.187 | |
|  | CP | No - Yes | -0.056 | 0.160 | -0.347 | | 0.729 | |
|  | **HLC** | **No - Yes** | **0.169** | **0.065** | **2.592** | | **0.010** | |
|  | IS | No - Yes | 0.731 | 0.414 | 1.767 | | 0.077 | |
| Venue | **BC** | **Field - Lab** | **-1.547** | **0.436** | **-3.548** | | **<0.001** | |
| EDF 8E | CC | Field - Lab | 0.025 | 0.174 | 0.144 | | 0.886 | |
|  | CP | Field - Lab | 0.162 | 0.173 | 0.936 | | 0.349 | |
|  | **HLC** | **Field - Lab** | **-0.204** | **0.041** | **-5.002** | | **<0.001** | |
|  | IS | Field - Lab | 0.544 | 0.597 | 0.910 | | 0.363 | |
| Habitat | **BC** | **Freshwater - Marine** | **-2.228** | **0.384** | **-5.800** | | **<0.001** | |
| EDF 8F | **BC** | **Freshwater - Terrestrial** | **0.772** | **0.313** | **2.469** | | **0.036** | |
|  | **BC** | **Marine - Terrestrial** | **3.000** | **0.276** | **10.866** | | **<0.001** | |
|  | CC | Freshwater - Marine | 0.002 | 0.304 | 0.007 | | 1.000 | |
|  | CC | Freshwater - Terrestrial | 0.082 | 0.160 | 0.511 | | 0.816 | |
|  | CC | Marine - Terrestrial | 0.080 | 0.299 | 0.267 | | 0.962 | |
|  | CP | Freshwater - Marine | 0.142 | 0.466 | 0.303 | | 0.951 | |
|  | CP | Freshwater - Terrestrial | 0.091 | 0.149 | 0.608 | | 0.816 | |
|  | CP | Marine - Terrestrial | -0.051 | 0.459 | -0.111 | | 0.993 | |
|  | HLC | Freshwater - Marine | 0.611 | 0.416 | 1.468 | | 0.306 | |
|  | **HLC** | **Freshwater - Terrestrial** | **0.996** | **0.417** | **2.391** | | **0.044** | |
|  | **HLC** | **Marine - Terrestrial** | **0.385** | **0.034** | **11.241** | | **<0.001** | |
|  | IS | Freshwater - Marine | -1.002 | 0.652 | -1.537 | | 0.274 | |
|  | IS | Freshwater - Terrestrial | -0.625 | 0.347 | -1.801 | | 0.170 | |
|  | IS | Marine - Terrestrial | 0.377 | 0.570 | 0.661 | | 0.786 | |
| Ectothermic Host | **BC** | **No - Yes** | **-0.794** | **0.198** | **-4.011** | | **<0.001** | |
| EDF 8G | CC | No - Yes | 0.031 | 0.171 | 0.180 | | 0.857 | |
|  | CP | No - Yes | 0.371 | 0.365 | 1.015 | | 0.310 | |
|  | HLC | No - Yes | -0.331 | 0.197 | -1.675 | | 0.094 | |
|  | IS | No - Yes | -0.463 | 0.332 | -1.393 | | 0.164 | |
| Ectoparasite | BC | No - Yes | 0.397 | 0.253 | 1.569 | | 0.117 | |
| EDF 8H | CC | No - Yes | -0.003 | 0.174 | -0.015 | | 0.988 | |
|  | CP | No - Yes | 0.234 | 0.152 | 1.547 | | 0.122 | |
|  | HLC | No - Yes | -0.072 | 0.197 | -0.366 | | 0.714 | |
|  | **IS** | **No - Yes** | **-0.670** | **0.184** | **-3.649** | | **<0.001** | |

**Table S4. EcoEvo PRISMA Checklist.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Checklist item** | **Sub-item number** | **Sub-item** | **Reported by authors?** | **Notes** |
| Title and abstract | 1.1 | Identify the review as a systematic review, meta-analysis, or both | Yes | Title |
| 1.2 | Summarise the aims and scope of the review | Yes | Intro |
| 1.3 | Describe the data set | Yes | Main paper and methods |
| 1.4 | State the results of the primary outcome | Yes | Results |
| 1.5 | State conclusions | Yes | Results and discussion |
| 1.6 | State limitations |  | Discussion |
| Aims and questions | 2.1 | Provide a rationale for the review | Yes | Intro |
| 2.2 | Reference any previous reviews or meta-analyses on the topic | Yes | Intro |
| 2.3 | State the aims and scope of the review (including its generality) | Yes | Intro |
| 2.4 | State the primary questions the review addresses (e.g. which moderators were tested) | Yes | Intro |
| 2.5 | Describe whether effect sizes were derived from experimental and/or observational comparisons | Yes | We indicated if the studies were lab or field based |
| Review registration | 3.1 | Register review aims, hypotheses (if applicable), and methods in a time-stamped and publicly accessible archive and provide a link to the registration in the methods section of the manuscript. Ideally registration occurs before the search, but it can be done at any stage before data analysis. | No | We did not register the review |
| 3.2 | Describe deviations from the registered aims and methods | NA | We did not register the review |
| 3.3 | Justify deviations from the registered aims and methods | NA | We did not register the review |
| Eligibility criteria | 4.1 | Report the specific criteria used for including or excluding studies when screening titles and/or abstracts, and full texts, according to the aims of the systematic review (e.g. study design, taxa, data availability) | Yes | Methods |
| 4.2 | Justify criteria, if necessary (i.e. not obvious from aims and scope) | NA |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Checklist item** | **Sub-item number** | **Sub-item** | **Reported by authors?** | **Notes** |
| Finding studies | 5.1 | Define the type of search (e.g. comprehensive search, representative sample) | Yes | Methods |
| 5.2 | State what sources of information were sought (e.g. published and unpublished studies, personal communications) | Yes | Methods |
| 5.3 | Include, for each database searched, the exact search strings used, with keyword combinations and Boolean operators | Yes | Supplemental Table 1 |
| 5.4 | Provide enough information to repeat the equivalent search (if possible), including the timespan covered (start and end dates) | Yes | Supplemental Table 1 |
| Study selection | 6.1 | Describe how studies were selected for inclusion at each stage of the screening process (e.g. use of decision trees, screening software) | Yes | Methods |
| 6.2 | Report the number of people involved and how they contributed (e.g. independent parallel screening) | Yes | Methods (by name) |
| Data collection process | 7.1 | Describe where in the reports data were collected from (e.g. text or figures) | Yes | Both – but not described by paper but methods for both described |
| 7.2 | Describe how data were collected (e.g. software used to digitize figures, external data sources) | Yes | Methods |
| 7.3 | Describe moderator variables that were constructed from collected data (e.g. number of generations calculated from years and average generation time) | Yes | Methods |
| 7.4 | Report how missing or ambiguous information was dealt with during data collection (e.g. authors of original studies were contacted for missing descriptive statistics, and/or effect sizes were calculated from test statistics) | Yes | Methods on effect sizes |
| 7.5 | Report who collected data | Yes | Methods |
| 7.6 | State the number of extractions that were checked for accuracy by co-authors | Yes | Methods |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Checklist item** | **Sub-item number** | | | **Sub-item** | | | **Reported by authors?** | | **Notes** | |
| Data items | 8.1 | | | Describe the key data sought from each study | | | Yes | | Methods | |
| 8.2 | | | Describe items that do not appear in the main results, or which could not be extracted due to insufficient information | | | Yes | | *Data extraction and effect size calculations* section | |
| 8.3 | | | Describe main assumptions or simplifications that were made (e.g. categorising both ‘length’ and ‘mass’ as ‘morphology’) | | | Yes | | Methods | |
| 8.4 | | | Describe the type of replication unit (e.g. individuals, broods, study sites) | | | No | | Not recorded at study level in the paper | |
| Assessment of individual study quality | 9.1 | | | Describe whether the quality of studies included in the systematic review or meta-analysis was assessed (e.g. blinded data collection, reporting quality, experimental *versus* observational) | | | No | | We did not assess study quality, aside from SE and sample size from each study | |
| 9.2 | | | Describe how information about study quality was incorporated into analyses (e.g. meta-regression and/or sensitivity analysis) | | | Yes | | Sensitivity analysis; Extended Data Figures 5 & 6 | |
| Effect size measures | 10.1 | | | Describe effect size(s) used | | | Yes | | Methods | |
| 10.2 | | | Provide a reference to the equation of each calculated effect size (e.g. standardised mean difference, log response ratio) and (if applicable) its sampling variance | | | Yes | | Methods | |
| 10.3 | | | If no reference exists, derive the equations for each effect size and state the assumed sampling distribution(s) | | | Yes | | Provided both references and explicit equations used, when possible | |
| Missing data | 11.1 | | | Describe any steps taken to deal with missing data during analysis (e.g. imputation, complete case, subset analysis) | | | Yes | | Methods, discussion on missing cells | |
| 11.2 | | | Justify the decisions made to deal with missing data | | | Yes | | Discussion on missing cells | |
| Meta-analytic model description | 12.1 | | | Describe the models used for synthesis of effect sizes | | | Yes | | Methods | |
| 12.2 | | | The most common approach in ecology and evolution will be a random-effects model, often with a hierarchical/multilevel structure. If other types of models are chosen (e.g. common/fixed effects model, unweighted model), provide justification for this choice | | | NA | | Hierarchical/multilevel model was used | |
| **Checklist item** | | **Sub-item number** | | | **Sub-item** | | | **Reported by authors?** | | **Notes** | |
| Software | | 13.1 | | | Describe the statistical platform used for inference (e.g. *R*) | | | Yes | | Methods | |
| 13.2 | | | Describe the packages used to run models | | | Yes | | Methods, code, and R markdown output | |
| 13.3 | | | Describe the functions used to run models | | | Yes | | Methods, code, and R markdown output | |
| 13.4 | | | Describe any arguments that differed from the default settings | | | NA | | Defaults used | |
| 13.5 | | | Describe the version numbers of all software used | | | Yes | | Methods | |
| Non-independence | | 14.1 | | | Describe the types of non-independence encountered (e.g. phylogenetic, spatial, multiple measurements over time) | | | Yes | | Methods, multiple effect sizes from the same study | |
| 14.2 | | | Describe how non-independence has been handled | | | Yes | | Methods, random effect of study | |
| 14.3 | | | Justify decisions made | | | Yes | | Methods | |
| Meta-regression and model selection | | 15.1 | | | Provide a rationale for the inclusion of moderators (covariates) that were evaluated in meta-regression models | | | Yes | | Methods | |
| 15.2 | | | Justify the number of parameters estimated in models, in relation to the number of effect sizes and studies (e.g. interaction terms were not included due to insufficient sample sizes) | | | Yes | | Methods | |
| 15.3 | | | Describe any process of model selection | | | Yes | | Methods | |
| Publication bias and sensitivity analyses | | 16.1 | | | Describe assessments of the risk of bias due to missing results (e.g. publication, time-lag, and taxonomic biases) | | | Yes | | Methods and Extended Data Figure 6 | |
| 16.2 | | | Describe any steps taken to investigate the effects of such biases (if present) | | | Yes | | Methods and Extended Data Figure 6 | |
| 16.3 | | | Describe any other analyses of robustness of the results, e.g. due to effect size choice, weighting or analytical model assumptions, inclusion or exclusion of subsets of the data, or the inclusion of alternative moderator variables in meta-regressions | | | Yes | | Methods and Extended Data Figure 6 | |
| Clarification of *post hoc* analyses | | 17.1 | | | When hypotheses were formulated after data analysis, this should be acknowledged. | | | NA | | No post hoc analyses to report | |
| **Checklist item** | | | **Sub-item number** | | | **Sub-item** | | **Reported by authors?** | | **Notes** | |
| Metadata, data, and code | | | 18.1 | | | Share metadata (i.e. data descriptions) | | Yes | | In data file available on Figshare and Github | |
| 18.2 | | | Share data required to reproduce the results presented in the manuscript | | Yes | | In Supplementary R Markdown output and data + code available on Figshare and Github | |
| 18.3 | | | Share additional data, including information that was not presented in the manuscript (e.g. raw data used to calculate effect sizes, descriptions of where data were located in papers) | | Yes | | Data + code available on Figshare and Github | |
| 18.4 | | | Share analysis scripts (or, if a software package with graphical user interface (GUI) was used, then describe full model specification and fully specify choices) | | Yes | | In Supplementary R Markdown output and data + code available on Figshare and Github | |
| Results of study selection process | | | 19.1 | | | Report the number of studies screened | | Yes | | Extended Data Figure 1, PRISMA plot | |
| 19.2 | | | Report the number of studies excluded at each stage of screening | | Yes | | Extended Data Figure 1, PRISMA plot | |
| 19.3 | | | Report brief reasons for exclusion from the full text stage | | Yes | | Extended Data Figure 1, PRISMA plot | |
| 19.4 | | | Present a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)-like flowchart (www.prisma-statement.org). | | Yes | | Extended Data Figure 1, PRISMA plot | |
| Sample sizes and study characteristics | | | 20.1 | | | Report the number of studies and effect sizes for data included in meta-analyses | | Yes | | Main Text Figure 1, Extended Data Figures 2-5 | |
| 20.2 | | | Report the number of studies and effect sizes for subsets of data included in meta-regressions | | Yes | | Main Text Figure 1, Extended Data Figures 2-5 | |
| 20.3 | | | Provide a summary of key characteristics for reported outcomes (either in text or figures; e.g. one quarter of effect sizes reported for vertebrates and the rest invertebrates) | | Yes | | Main Text Figure 1, Extended Data Figures 2-5 | |
| 20.4 | | | Provide a summary of limitations of included moderators (e.g. collinearity and overlap between moderators) | | Yes | |  | |
| 20.5 | | | Provide a summary of characteristics related to individual study quality (risk of bias) | | Yes | | Extended Data Figure 5 – average SE and sample size per effect size across GCDs | |

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| **Checklist item** | **Sub-item number** | **Sub-item** | **Reported by authors?** | **Notes** |
| Meta-analysis | 21.1 | Provide a quantitative synthesis of results across studies, including estimates for the mean effect size, with confidence/credible intervals | Yes |  |
| Heterogeneity | 22.1 | Report indicators of heterogeneity in the estimated effect (e.g. *I*2, *tau*2 and other variance components) | Yes |  |
| Meta-regression | 23.1 | Provide estimates of meta-regression slopes (i.e. regression coefficients) and confidence/credible intervals | Yes | In Supplementary R Markdown output |
| 23.2 | Include estimates and confidence/credible intervals for all moderator variables that were assessed (i.e. complete reporting) | Yes | In Supplementary R Markdown output |
| 23.3 | Report interactions, if they were included | Yes | In Supplementary R Markdown output |
| 23.4 | Describe outcomes from model selection, if done (e.g. R2 and AIC) | Yes | In Supplementary R Markdown output |
| Outcomes of publication bias and sensitivity analyses | 24.1 | Provide results for the assessments of the risks of bias (e.g. Egger's regression, funnel plots) | Yes | Methods and Extended Data Figure 6 |
| 24.2 | Provide results for the robustness of the review's results (e.g. subgroup analyses, meta-regression of study quality, results from alternative methods of analysis, and temporal trends) | Yes | Methods and Extended Data Figure 6 |
| Discussion | 25.1 | Summarise the main findings in terms of the magnitude of effect | yes |  |
| 25.2 | Summarise the main findings in terms of the precision of effects (e.g. size of confidence intervals, statistical significance) | Yes |  |
| 25.3 | Summarise the main findings in terms of their heterogeneity | Yes |  |
| 25.4 | Summarise the main findings in terms of their biological/practical relevance | Yes |  |
| 25.5 | Compare results with previous reviews on the topic, if available | Yes |  |
| 25.6 | Consider limitations and their influence on the generality of conclusions, such as gaps in the available evidence (e.g. taxonomic and geographical research biases) | Yes |  |

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| **Checklist item** | **Sub-item number** | **Sub-item** | **Reported by authors?** | **Notes** |
| Contributions and funding | 26.1 | Provide names, affiliations, and funding sources of all co-authors | Yes |  |
| 26.2 | List the contributions of each co-author | Yes |  |
| 26.3 | Provide contact details for the corresponding author | Yes |  |
| 26.4 | Disclose any conflicts of interest | Yes |  |
| References | 27.1 | Provide a reference list of all studies included in the systematic review or meta-analysis | Yes | Included as column in database |
| 27.2 | List included studies as referenced sources (e.g. rather than listing them in a table or supplement) | No | Nearly 1000 studies included in meta-analysis, would be excessive to include them all as referenced sources. |

**Data S1. (separate file)**

Supplementary Data S1: R Markdown code and output associated with this publication