Using data provided below, you will be assessing the effects of warming on shifts in arrival time of the migratory ruby throated hummingbird, *Archilochus colubris* and emergence from overwintering of the Spring Azure butterfly, *Celastrina ladon* (data from Ledneva *et al.* 2004). Both species occur in Ohio although this data was collected in Massachusetts. For this study, we will assume that the responses of both the ruby throated hummingbird and the Spring Azure butterfly are uniform throughout their ranges. You will also discuss whether we have evidence for trophic mismatches based on your findings.

|  |  |
| --- | --- |
| Species |  Arrival Time Change (days/oC) |
| *Celastrina ladon* (adults) | 0.55 |
| *Archilochus colubris* | -1.40 |

*1. Based on the data given above for arrival time change, describe the pattern of shifting arrival/emergence time phenology for each pollinator species.*

2. Archilochus colubris *uses* Aquilegia canadensis(*columbine*) *flowers as a nectar food resource, and, in turn, is an important pollinator of this plant (Bertin 1982).* Celastrina ladon *caterpillars feed on* Cornus florida(*flowering dogwood) flowers (University of Florida IFAS Extension), although this interaction is not mutualistic as the dogwood receives no benefit. Given your knowledge of flowering shifts with temperature in* A. canadensis *and* C. florida *as well as arrival time shifts with temperature in* A. colubris *and* C. ladon*, speculate on what effects climate warming might have on survival and reproduction in these species. How would species interactions change with a 1oC temperature increase? With a 3oC temperature increase?*

*3. Forrest and Miller-Rushing (2010) suggest several ecological effects of phenological shifts (see pp. 3105–6). Which of these effects (if any) do you find likely for the columbine-hummingbird mutualism? Which of these effects (if any) do you find likely for the* Celastrina*-dogwood pairing?*