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Supplemental Information

Climate change shifts the timing

of nutritional flux from aquatic insects

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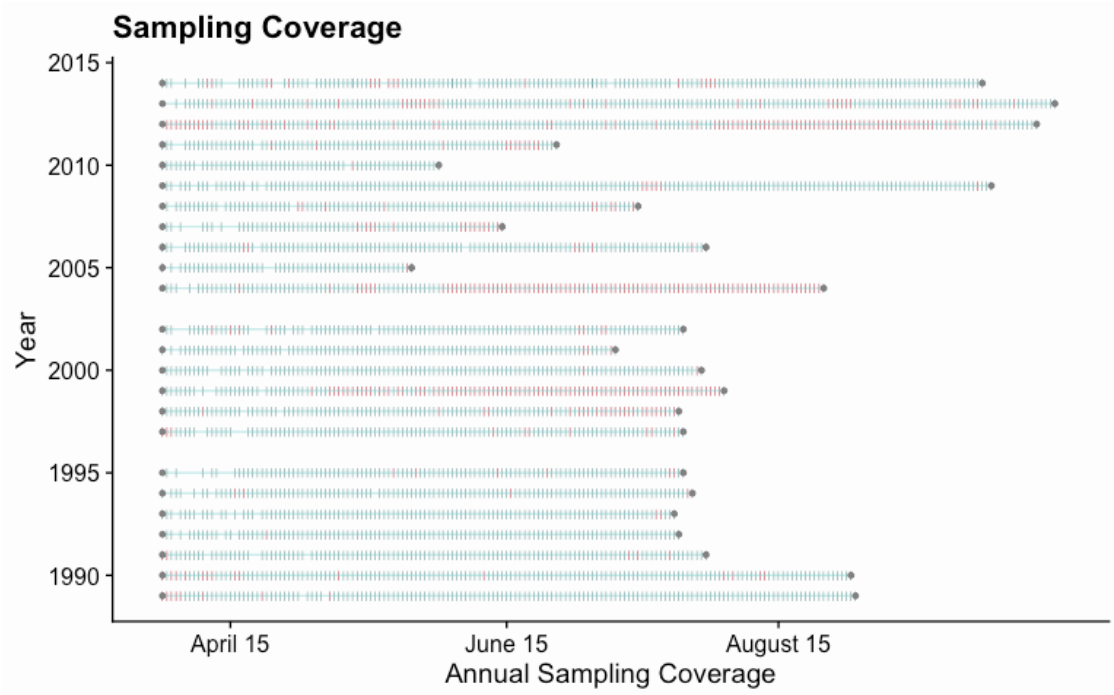

Figure S1: Insect sampling dates from 1989 - 2014. Related to Figures 2-3. The Ithaca vacuum insect sampler was operational from 1989 – 2014 (n = 3,646 unique sampling days). Days where the sampler was operational are coded light green and those where it was non-operational are coded red. Blank regions denote when sampler was operational, but no insects were sampled.

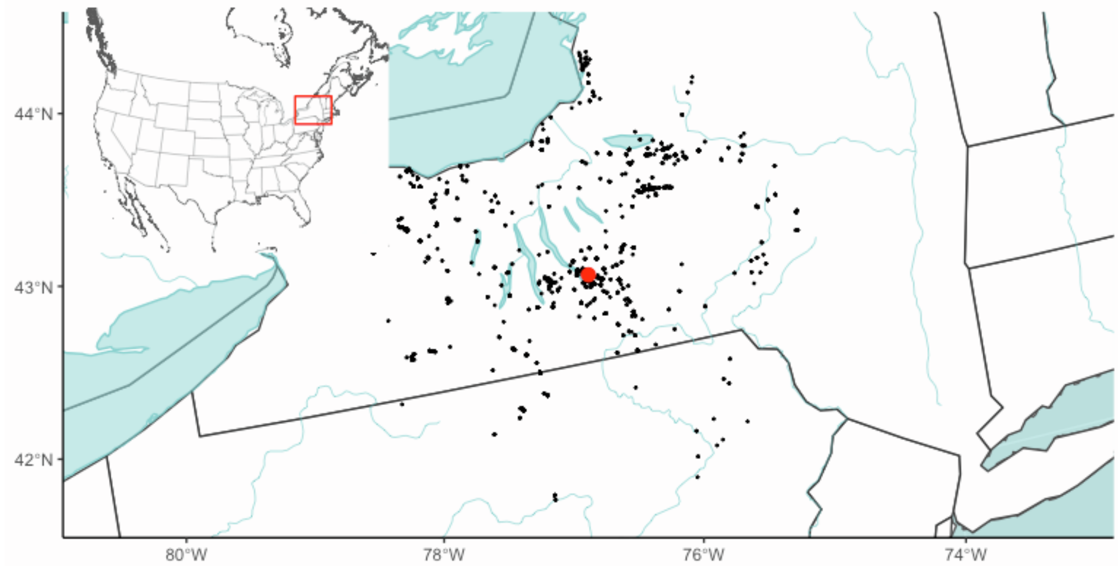

Figure S2: Location of nest records within 150 km of Ithaca, New York from the Nestwatch and Martinwatch databases. Related to Figures 2-3. Black points are the location of the reported breeding sites for the 7 focal species and the red point in the main figure is the location of the vacuum insect sampler.

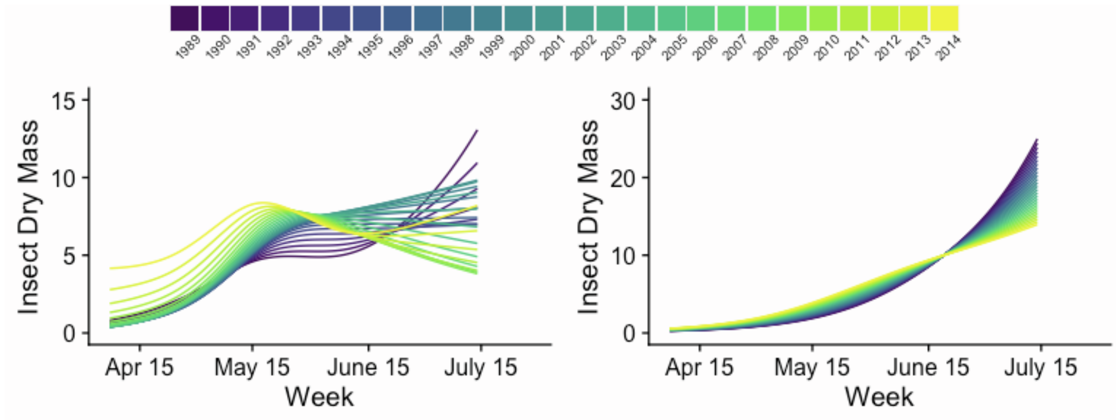

Figure S3: Changes in the seasonal emergence of aquatic and terrestrial insects from 1989 - 2014. Related to Figure 3. Results from modeling aquatic and terrestrial insect emergence present evidence of earlier emergence in both groups, with shifts in the timing of peak abundance. Aquatic emergence suggests a trend towards an earlier peak with a decline in overall abundance after mid-May, whereas terrestrial insect emergence suggests an earlier but more gradual seasonal accumulation of biomass. Some of the trend towards early emergence in the aquatic data before 15 April appears to be driven primarily by exceptionally early emergence behavior from 2012 - 2014.

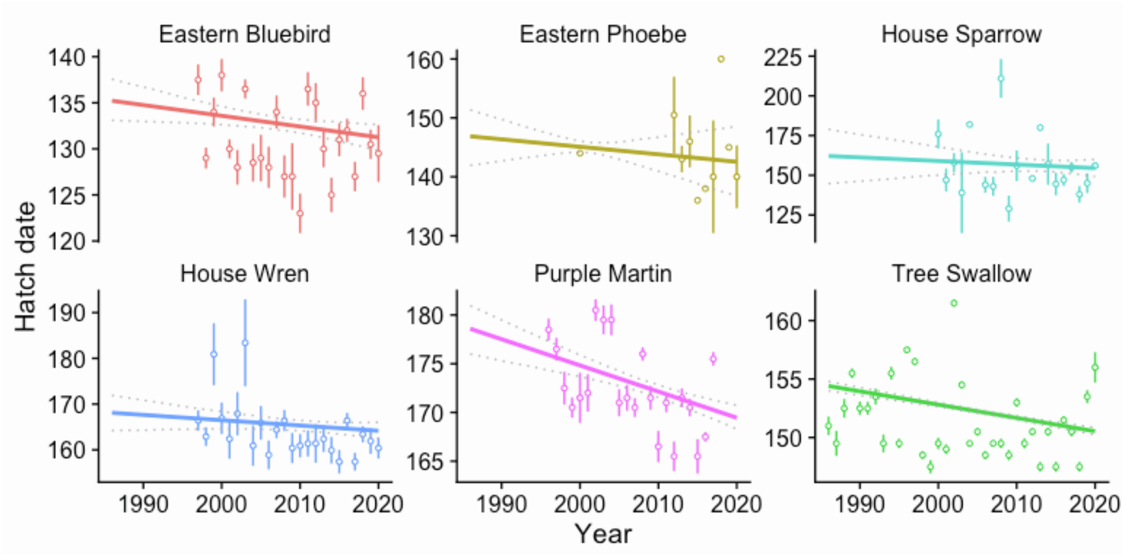

Figure S4: Trends in observe hatch dates. Related to Figure 3. We collected records for Eastern Bluebird, Eastern Phoebe, House Sparrow, House Wren, Purple Martin, and Tree Swallows within 150 km of the Ithaca, NY field site. There were insufficient records to robustly estimate a trend in Barn Swallows. In all species, there is a trend towards reproduction and specifically egg hatching to occur earlier in the spring. The medians and standard errors for each year are presented for each species and the confidence interval was calculated by using a non-parametric bootstrap 1000 times.

Taxon	Equation	R^2	Juvenile Habitat
Ephemeroptera [S2]	$0.014 * L^{2.49}$	0.89	Aquatic
Nematocera [S2]	$0.1 * L^{1.57}$	0.90	Aquatic
Odonata [S2]	$0.14 * L^{2.27}$	0.90	Aquatic
Trichoptera [S2]	$0.01 * L^{2.9}$	0.92	Aquatic
Arachnida [S2]	$0.05 * L^{2.74}$	0.98	Terrestrial
Coleoptera [S2]	$0.04 * L^{2.64}$	0.96	Terrestrial
Hemiptera[S1]	$0.01 * L^{2.73}$	n/a	Terrestrial
Homoptera [S2]	$0.005 * L^{3.33}$	0.93	Terrestrial
Hymenoptera [S2]	$0.56 * L^{1.56}$	0.75	Terrestrial
Other Diptera [S2]	$0.04 * L^{2.26}$	0.67	Terrestrial

Table S1: Allometric relationships between insect dry mass and body length. Related to Figures 2-4. Reported allometric relationships from the literature were used to convert the sampled daily average size of different insect taxonomic groups into estimates of emergent biomass.

		Dependent variable	
Predictors	*Estimates*	*CI*	*p*
(Intercept)	1.00	1.00 – 1.00	**<0.001**
Smooth term (Year) * Nematocera (small < 3 mm)			0.414
Smooth term (Year) * Nematocera (medium 3 – 7 mm)			0.280
Smooth term (Year) * Nematocera (large > 7 mm)			0.504
Smooth term (Year) * Other Diptera			0.785
Smooth term (Year) * Coleoptera			0.667
Smooth term (Year) * Hemiptera			0.583
Smooth term (Year) * Hymenoptera			0.305
Observations	168		

Table S2: Changes in total annual insect abundance from 1989 – 2014. Related to Figure 2. There was no evidence of a clear trend of decreasing insect biomass in any of our taxonomic groups using a GAMM.

		Dependent variable	
Predictors	*Estimates*	*CI*	*p*
(Intercept)	3.67	3.10 – 4.35	**<0.001**
te(Week,Year)			**<0.001**
Observations	270		

Table S3: Changes in phenology of weekly abundance from 1989 – 2014. Related to Figure 3.

	Eastern Bluebird		Eastern Phoebe		House Sparrow		House Wren		Purple Martin		Tree Swallow	
Predictors	*Est*	*p*	*Est*	*p*	*Est*	*p*	*Est*	*p*	*Est*	*p*	*Est*	*p*
(Intercept)	366.9	**<0.001**	417.7	0.070	608.9	0.329	398.3	**0.016**	712.2	**<0.001**	380.5	**<0.001**
Year	-0.12	**0.019**	-0.14	0.231	-0.22	0.467	-0.12	0.157	-0.27	**<0.001**	-0.11	**<0.001**
Obs.	684		57		178		580		806		9198	
R^2 adj	0.007		0.008		-0.003		0.002		0.030		0.014	

Table S4: Changes in timing of reproduction from 1989 – 2020. Related to Figure 3.

Supplemental References

S1. Benke, A. C., Huryn, A. D., Smock, L. A., & Wallace, J. B. (1999). Length-mass relationships for freshwater macroinvertebrates in North America with particular reference to the southeastern United States. *Journal of the North American Benthological Society*, *18*(3), 308-343.

S2. Sabo, J. L., Bastow, J. L., & Power, M. E. (2002). Length–mass relationships for adult aquatic and terrestrial invertebrates in a California watershed. *Journal of the North American Benthological Society*, *21*(2), 336-343.