Impact of Winter Severity and Duration on Wild Bee Abundance in Plymouth County, Massachusetts

A. VanHelene, K. Agbeleye, A. Germaine, P. Sanon, C. Orazine, A. Oguma, M. Bankson

Division of Science and Math, Massasoit Community College, Brockton, Massachusetts, USA

Twitter: @MassasoitSTEM; Email: STEMresearch@massasoit.edu

Introduction

- Bees' keystone role as pollinators make them a critical part of many ecosystems.
- Seasonal temperature may impact bees' metabolism and potentially induce phenological mismatches between bees and plants (Kammerer, et al 2020).
- Understanding how bees respond to temperature may help differentiate between seasonal variation and long-term changes in abundance (Kammerer, et al 2020).
- We investigate the ability of temperature as a predictor of seasonal bee abundance in Southeastern Massachusetts.

Methods

Table 1. Temperature variables and year classifications.

Year	Number of months Below 10℃	Number of months Below 0℃	Warm, cold, or Hot classification	Date of last spring Frost (mm-dd)	Early or late last spring frost classification
2016	6	2	Cold	04-06	Late
2017	6	1	Warm	03-23	Early
2018	6	1	Warm	04-09	Late
2019	6	2	Cold	04-05	Late
2020	6	0	Hot	03-22	Early

- Bees were sampled biweekly from 2016-2020 from six sites in Plymouth County, Massachusetts.
- Spring, summer, fall, and yearly (all seasons combined) bee abundance was compared to weather characteristics.
- Years were categorized as cold, warm, or hot based on the number of months with mean temperatures below 10℃, and with mean temperatures below 0℃.
- The last spring frost was defined as four or more hours below -2℃ (Kammerer, et al 2020).
- Summer floral resource availability was approximated using "growing degree days" above 5℃ (Calovi, et al 2021).
- Temperature data was obtained from The National Center For Environmental Information, and the National Solar Radiation Database (NOAA, 2020; NSRDB, 2020).
- Statistical significance was determined with a one-way ANOVA or a Pearson correlation.

Results

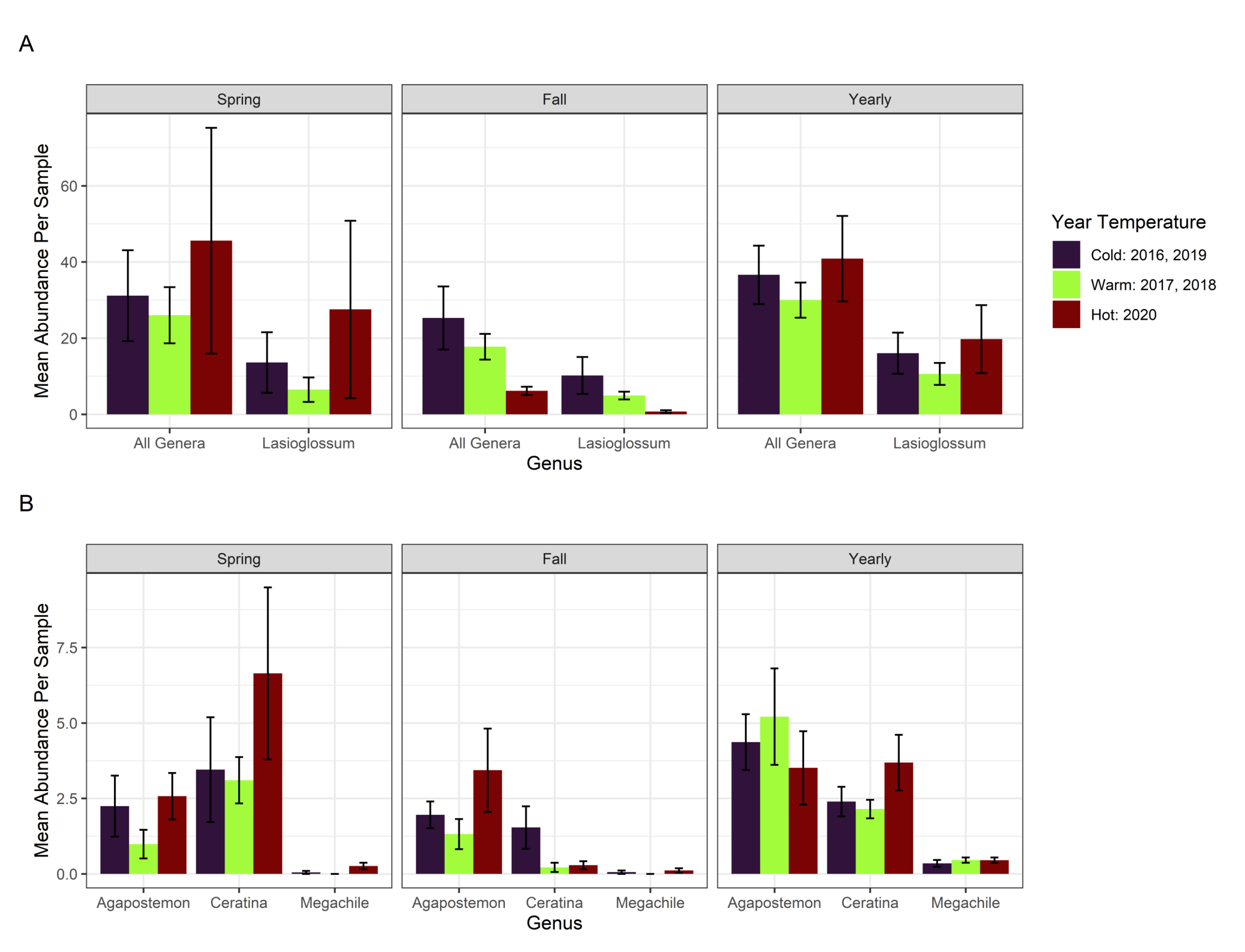

Figure 1. Mean seasonal abundance during categorically cold, warm, and hot years. (A) Single-factor ANOVA revealed the significant effect of temperature category on fall abundance for all genera ($p = 0.042$) and *Lasioglossum* ($p = 0.011$). All genera and *Lasioglossum* show the same general pattern of responses to temperature for spring, fall and yearly. **(B)** Single-factor ANOVA revealed a significant effect of temperature category on *Megachile* spring abundance ($p = 0.005$). *Agapostemon, Ceratina*, and *Megachile* showed different patterns of seasonal abundance amongst themselves, as well as to all genera and *Lasioglossum*.

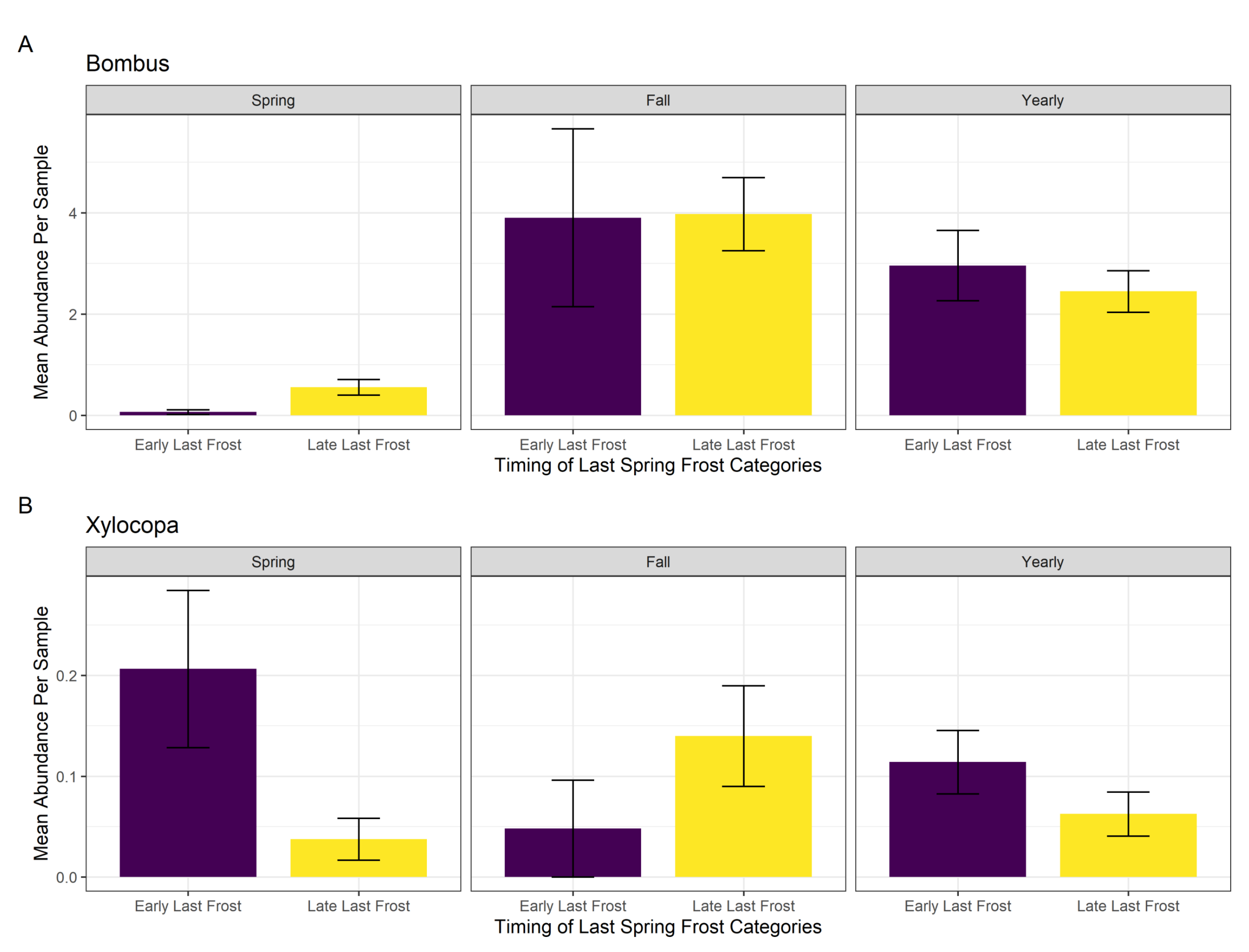

Figure 2. Mean seasonal abundance during years with early and late last spring frosts. Single-factor ANOVA revealed a significant effect of the timing of last spring frost on *Bombus* ($p = 0.009$) and *Xylocopa* ($p = 0.049$) spring abundance. **(A)** *Bombus* experienced lower spring abundance during years with an early last spring frost. **(B)** *Xylocopa* experienced higher spring abundance during years with an early last spring frost.

Table 2. Growing degree days of previous summer compared to spring bee abundance. Pearson correlation revealed no relationship between summer growing degree days and spring abundance ($r^2 = 4.11 \times 10^{-5}$, $p = 0.973$)

	2016	2017	2018	2019	2020
Mean Spring Abundance	27.626	31.539	20.528	34.712	45.596
Growing Degree Days	2671	2626	2470.	2872	2627

Table 3. Results of single-factor ANOVA comparing cold, warm, and hot years for select genera.

Genus	Season	Mean abundance cold years	Mean abundance warm years	Mean abundance hot years	*p* Value
All Genera	Spring	31.17	26.03	45.60	*p*= 0.997
	Summer	42.91	38.79	42.00	*p*= 0.979
	Fall	25.31	17.74	6.16	*p*= 0.042*
	Yearly	36.62	29.99	40.89	*p*= 0.923
Agapostemon	Spring	2.25	2.58	0.99	*p*= 0.116
	Summer	6.30	4.95	8.61	*p*= 0.507
	Fall	1.96	3.44	1.32	*p*= 0.23
	Yearly	4.37	3.52	5.21	*p*= 0.57
Bombus	Spring	0.22	0.46	0.13	*p*= 0.462
	Summer	2.61	4.01	3.65	*p*= 0.472
	Fall	3.62	4.19	2.00	*p*= 0.737
	Yearly	2.10	3.00	2.27	*p*= 0.511
Ceratina	Spring	3.45	6.65	3.10	*p*= 0.376
	Summer	1.94	2.80	1.83	*p*= 0.37
	Fall	1.54	0.290	0.220	*p*= 0.068
	Yearly	2.40	3.69	2.15	*p*= 0.42
Lasioglossum	Spring	13.62	6.48	7.55	*p*= 0.431
	Summer	19.37	16.36	16.74	*p*= 0.963
	Fall	10.21	4.93	0.72	*p*= 0.011*
	Yearly	16.06	10.61	19.76	*p*= 0.797
Megachile	Spring	0.051	0.26	0	*p*= 0.005*
	Summer	0.62	0.76	0.81	*p*= 0.649
	Fall	0	0	0	*p*= 0.488
	Yearly	0.35	0.46	0.46	*p*= 0.544
Xylocopa	Spring	0.08	0.12	0.21	*p*= 0.499
	Summer	0.04	0.04	0.10	*p*= 0.542
	Fall	0.04	0.15	0	*p*= 0.162
	Yearly	0.05	0.09	0.14	*p*= 0.242

Discussion

- *Lasioglossum's* dominant abundance may obscure patterns in other genera when looking at all genera abundance vs the timing or intensity of seasonal temperature.
- The impact of cold, warm, and hot years on wild bee abundance varied, suggesting genera-specific effects.
- *Bombus* and *Xylocopa's* different responses to the timing of the last spring frost also suggests genera-specific effects.

Conclusion

- The impact of weather on seasonal abundance varies by genus.
- Understanding the impact of weather on bees can help differentiate between seasonal variation and long-term changes in abundance.

Acknowledgements

This research was supported by the state of Massachusetts STEM Starter Academy grant and the National Science Foundation. Additional thanks go to Douglas Brown, Nico Hayes_Huer, Rachel Franciosi, Belunda Moise, Alieza Inam, Emilie Oberg, Jordan Palmer Matthew Healy, Nathanaelle Brignol, and Tatyanna Moreland-Junior.

Literature Cited

"Climate Data Online." *Climate Data Online (CDO) - The National Climatic Data Center's (NCDC) Climate Data Online (CDO) Provides Free Access to NCDC's Archive of Historical Weather and Climate Data in Addition to Station History Information. | National Climatic Data Center (NCDC)*, www.ncdc.noaa.gov/cdo-web/.

Calovi, M., Grozinger, C.M., Miller, D.A. *et al.* Summer weather conditions influence winter survival of honey bees (*Apis mellifera*) in the northeastern United States. *Sci Rep* 11, 1553 (2021). https://doi.org/10.1038/s41598-021-81051-8

Downing, Jason, et al. "Differential Impacts from an Extreme Cold Spell on Subtropical vs. Tropical Specialist Bees in Southern Florida." *Ecosphere*, vol. 7, no. 5, 2016, doi:10.1002/ecs2.1302.

Kammerer, Melanie, et al. "Wild Bees as Winners and Losers: Relative Impacts of Landscape Composition, Quality, and Climate." *Global Change Biology*, vol. 27, no. 6, 2021, pp. 1250–1265., doi:10.1111/gcb.15485.

"NSRDB." *NSRDB: National Solar Radiation Database*, nsrdb.nrel.gov/.