Harnessing the power of digitized natural history collections to visualize spatiotemporal patterns in native and non-native bee flight phenology

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Introduction

- When and where are bees flying?
- Large, openly available data sets are an inexpensive & efficient way to observe & track phenological trends, but not without bias[1,2]
- Collection efforts (**UCSBees**[3]) – 2016 → passive monthly monitoring (Dec. 2018) & historic collections from Invertebrate Zoology Collection (UCSB-IZC)
- Functional traits affect seasonal shifts[4]
- Flight time could vary on small spatial scales (i.e. coast/inland)

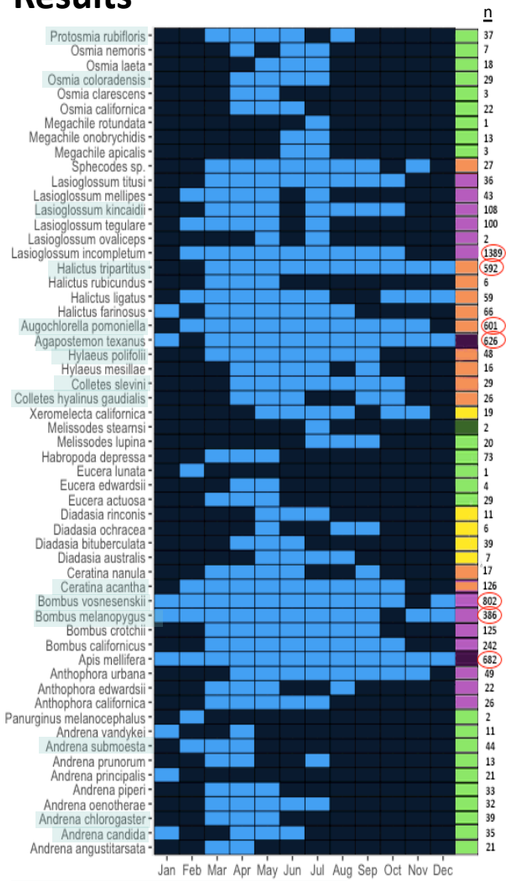
Goals

- Visualize bee flight patterns in coastal Santa Barbara, San Luis Obispo, & Ventura counties
- Identify data gaps
- Create updated species inventories

Methods

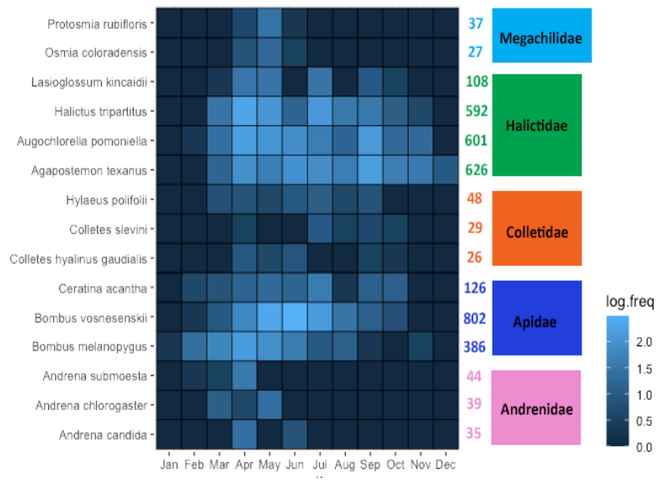
- Chose target 57 species in 5 families based on species present on Santa Cruz Island (Channel Islands National Park)
- Download historical (1907-2020) species occurrence data in 3 coastal CA counties from digitized collection networks
- Figures produced in RStudio 1.3

Results

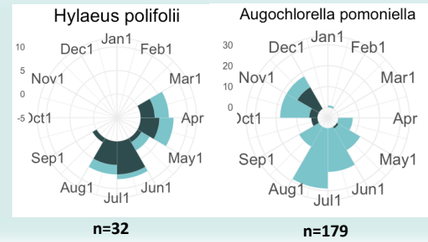


Above (Fig. 1) : Phenological phenogram showing monthly presence-absence data of the 57 bees (present and historically) on the *Checklist of Anthophila of Santa Cruz Island*[5]. Right-most column indicates seasonality of species[6]. Data from SCAN-Bugs occurrences in Santa Barbara, San Luis Obispo, and Ventura counties. Species with n > 300 circled in red.

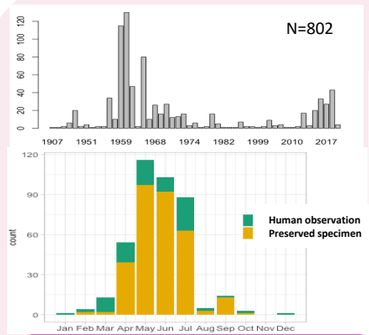
season
spring
spring-summer-fall
summer
fall
winter-fall
year-round



Left (Fig. 2): Monthly occurrence heat-map of log-transformed observations for select species from Fig. 1 based on preserved specimen data downloaded from SCAN-Bugs.

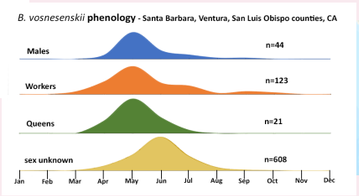


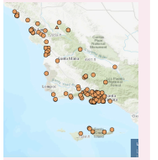
Left (Fig. 6-7): Circular phenograms, another method of representing flight phenology, for *H. polifolii* and *A. pomoniella.*



Above (Fig. 3-4): *B. vosnesenskii* observations from SCAN-Bugs by year, and from UCSB Collection Network separated by Basis of Record (manually-entered human observations from iNaturalist & preserved specimens). **Right (Fig. 5)**: Phenology of *B. vosnesenskii* in 3 coastal CA counties using occurrences from SCAN-Bugs, modeled after figure above of phenology in Tuolumne, CA.

Case study: *Bombus vosnesenskii*





Conclusions & discussion

- Current and historical localized data are temporally and spatially patchy for most species
- Higher degrees of completeness are more likely to be achieved for large species and taxa that can be collected passively
- Male, female & queen flight patterns are regionally variable
- Heat maps appropriate for data sets with higher degrees of completeness

Future areas of focus

- Reproducibility of analyses
- Incorporate GBIF/iDigBio records
- Consistent, organized monitoring efforts to capture target genera and fill gaps: *Melissodes, Andrena, Megachile, Eucera, Diadasia, Halictus*
- Understand consequences of seasonal localized shifts in flight time

Literature **1)** Meiners, J.M., Orr, M.C., Riemer, K., Griswold, T., Simonis, J.P. (2020). The influence of data type and functional traits on native bee phenology metrics: Opportunistic versus inventory records (submitted article). **2)** Shirey, V., Belitz, M.W., Barve, V., Guralnick, R. (2020). Closing gaps but increasing bias In North American butterfly inventory completeness (submitted article). **3)** Seltmann, K.C. UCSBees! Project, 2019 **4)** Stemkovski M. et al. (2020). Bee phenology is predicted by climatic variation and functional traits. Ecology Letters 23(11):1589-1598. **5)** Seltmann, K.C., Dewey, D., and McLaren, L. (2020). Checklist of Anthophila of Santa Cruz Island. **6)** Wilson, J.S. & Carril, O.M (2016). The Bees In Your Backyard. **7)** Koch J., Strange J., & Williams P.: (2012). *Bumble Bees of the Western United States.* USDA Forest Service Research Notes. Publication No. FS-972.

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