Climate Effects on Bee Biodiversity in California

**Abstract**

Bees are critical pollinator species for native plants and are fundamental to agricultural prosperity in California. Approximately 1800 unique species of bees are present across California, yet despite their importance and biodiversity, not much is known about patterns of their spatial distribution, endemism, and species richness. Using bee data from museums, collections, and other databases around the world gathered by GBIF as well as climate data from Climate Engine (climateengine.org), we estimated the spatial distribution and average of the expected number of species and endemic species for California. The average number of species in a 15 km grid was 28 and sites ranged from a low of 1 to a high of 402. There was a negative relationship between average spring rainfall (March-October) and species richness. There was also a negative relationship between average spring rainfall (March-October) and corrected weighted endemism (CWE). These results highlight the role of climatic factors, particularly winter rainfall (from March to October), in shaping the distribution and diversity of bee species in California. The insights gained from this study are crucial for developing conservation strategies aimed at protecting these essential pollinators.

Slide 1: Introduction

* We are part of Dr. LeBuhn’s lab for the PINC Summer Program in Conservation Biology, led by our mentor Denzill Loe.
* My name is Ashley, I’m a rising senior in ecology, evolution, and conservation biology here at SF State.
  + Mario, Kap, Isaak, and Mandy
  + Name, year, major
* Today we will be talking to you about our research on Climate Effects on Bee Biodiversity in California

Slide 2: Biodiversity and Climate Change

* California is a biodiversity hotspot that supports over 1600 bee species
  + Which is about 25% of all bees in North America.
  + While most people think of honey when they hear bees, most species are actually solitary and do not produce honey.
  + Bee diversity centers are primarily thought to be in the desert regions of North America.
* This suggests that precipitation patterns may predict both current and future distributions of solitary bees.
* In California, temperatures are expected to rise as much as 7 degrees Celsius by the end of the century due to climate change.
* This will lead to drier seasonal conditions even if precipitation increases.
* For many species, these increases in temperature and dryness may be problematic.
* For bees, this probably means that the plants that they rely on will have shorter flowering seasons.
* To understand what species are most vulnerable, we need to understand the role that climate plays in determining species distributions.

Slide 3: Why conserve bees?

* Bees are critically important as pollinators of native plants and in agricultural systems.
* To give you an idea, bee pollination is responsible for more than $15 billion in crop value each year.
* In fact, one out of every four bites of food people take is courtesy of bee pollination.
* Native bees are estimated to pollinate 80 percent of flowering plants around the world.
* According to the USDA, bees of all sorts pollinate approximately 75 percent of the fruits, nuts and vegetables grown in the United States
* Now I will pass it along to Mario who will talk about endemism, our research question, and methods.

Slide 4: Diversity and Endemism

* Endemism and species richness are widely used indicators of conservation value.
  + Endemic species are found in a single geographic location. Endemism measures how many endemic species are in an area. When used to estimate conservation valueof an area, the greater the number of endemic species in an area, the more biodiversity is lost if that area is lost.
  + Species richness is the number of different species represented in an area.

Slide 5: Research Questions

* Where are the centers of biodiversity of bees?
  + Species Richness
  + Endemism
* What influence does climate have on the bee biodiversity in California?
* Here will be looking at data on precipitation and species of bees

Slide 6: Methods

* We used a geospatial dataset of collected samples of bees from GBIF and iDigBio provided by Dr. Gretchen LeBuhn and graduate student Gilbert Alarcon-Cruz. They generated a grid of 15 km grid cells using the program BioDiverse and estimated species richness and corrected weighted endemism for each cell.
* We found and downloaded 25 years of precipitation data from 1998 to 2023 and estimated average precipitation for each grid cell using the mapping software, ArcGIS.
* We used a linear model to evaluate how precipitation influences species richness and corrected weighted endemism.
  + Could have another slide with a positive versus a negative slope

Slide 7- Research Questions🧡

* Going back to our research questions, we will first be looking at the data to get an idea of the centers of diversity for bees in terms of species richness and see if it aligns with our hypothesis of those centers being more prevalent in areas with lower levels of rainfall.
* Take it away Kap!

Slide 8: Precipitation Map

* Thank you Mario!
* Working with the precipitation data we downloaded, we wanted to spatially analyze the data in addition to statistical analysis
* Here is a map of average winter (October to March) rainfall across California compiled from 25 years of winterffl precipitation data
* Each cell represents a 15 km2 area that contains the amount of average winter rainfall recorded within this region, where darker shades of blue mean higher winter rainfall amounts and lighter shades mean lower.
* From 1998 to 2023, average winter precipitation in California ranged from a minimum of 40 mm to 3521 mm across sites.
* We can see that higher rainfall is concentrated in the northwestern regions of the state as well as the Sierra Nevada Range and low average rainfall in the southeast regions as well as the Central Valley.

Slide 9: Bee Species Richness Map

* Using that climate variable, we wanted to compare it to the bee data that we have collected from Gilbert
* So here we have a spatial distribution in species richness of bees in California
* In the same cell size as the precipitation map, this map shows the number of unique bee species recorded in each box and in California they range from 1 species per cell up to 402
* We have concentrations of higher species richness in areas such as the Bay Area, the Sierra Nevada Range again, and in the greater Los Angeles region.

Slide 10: Precipitation and Species Richness Comparison

* Bringing both of these maps together we can start to see spatial patterns between these two variables
* We can see that higher levels of bee species diversity can be found in areas where precipitation is lower such as the Bay Area, SoCal, and the Eastern Sierra Nevadas
* Not to mention higher bee diversity can be found in more wet places like the greater Sierra Nevadas or the little region in northern California, but for the most part bee diversity tends to be found more in drier areas.

Slide 11: Richness and Precipitation Graph

* And here is a graphical representation of the comparison of both rainfall and species richness where each dot on the graph represents one of the 15km2 grid cells shown in the previous maps.
* And according to the trendline, there seems to be a negative relationship between average winter precipitation and bee species richness, suggesting that higher bee diversity can be found in areas of lower precipitation.
* And now Ashley is going to talk to you about our code and bee endemism

Slide 12: Code for Species Richness and Precipitation Graph

* Thank you, Kap!
* This is our code for the previous graph on species richness and precipitation, we used ggplot and took the species richness data and precipitation data.

Slide 13: Transition Slide

* So now we want to look at these centers of diversity in terms of corrected weighted endemism which is the measurement of the amount of endemic species in a given area and see how that corresponds to our hypothesis of finding them in areas with lower levels of rainfall.

Slide 14: Corrected Weighted Endemism (CWE) Map

* On this map, we have our corrected weighted endemism of bee species with the darker green cells representing higher concentrations of endemic species and the lighter cells representing lower levels of endemic species. Similar to the species richness data Kap went over, each cell is based on a 15 square kilometer grid.

Slide 15: Precipitation and CWE Comparison

* Here we have a side-to-side comparison of our precipitation data map and we can see more endemic species in areas with lower levels of precipitation.
* And now I will pass it on to Isaak who will go over our graph, discussion, and next steps.

Slide 16: CWE and Precipitation Graph

* So to further build upon what Ashley said, here we have a graphical representation of average winter precipitation vs corrected weighted endemism (point at axes pertaining to their titles), and as you can see there is a much higher concentration of corrected weighted endemism in areas that experience lower precipitation.

Slide 17: Code for Endemism and Precipitation Graph

* Moving onto the code we used for formulating our Endemism and Precipitation graph. It is almost exactly the same as the code that Ashley explained not too long ago, with the title being the only thing that is different.

Slide 18: All Maps Comparison

* So now looking at all of the maps we have generated regarding the average precipitation over 25 years, richness of bee species across California, and the corrected weighted endemisms of bee species in california. As you can see in areas that exhibit higher concentrations of precipitation there is less of a concentration of bee species richness and corrected weighted endemism in California.

Slide 19: Discussion

* From all of this, we can conclude that drier areas tend to be better for bees, but there is still a threshold in this, meaning that they still require some level of rainfall.
* In the future, we will need to take necessary steps for the protection of our bees which include:
  + Influences of climate change especially for bee species in drier areas
  + Land management to conserve dry lands in order to support bees
  + And range shift which is how bees may move to new habitats as climate change continues.
* As we do conservation, we’ll want to think about the future of these sites to predict range shift and think about where the new climate envelopes will be for bees and other species

Slide 20: Next Steps

* This study points our focus to do more investigating into bee species that live in drier areas
  + Better data from desert regions of California
* As well as comparing our species richness data and corrected weighted endemism data with other climate variables like temperature, humidity, wind speed, etc. to better understand the climate needs of species

Slide 21: Acknowledgements

* We want to thank our Professor, Dr. Gretchen LeBuhn for all her guidance and support.
* We also want to thank our mentor Denzill
* Chloe Martin from the school of the environment
* The PINC summer program funded by Genentech