Ghazian Progress Report

York University, Toronto, ON

Spring 2019

**Micro to macroclimatic scaling effects on foundation plant species interaction with vertebrate protégé species.**

**Examination Committee:**

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Table 1. MSc research timeline.

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| Chapter | Title | timeline |
| 1 | **A picture is worth a thousand hours: a systematic review of camera trap papers to test for reported sampling effort.** | Full-text articles assessed for eligibility.  Data extraction complete June 2019.  Chapter 1 draft October 2019. |
| 2 | **Plant-animal interactions and microclimate.** | Field season will run 15/05/2019-15/06/2019.  Some statistical analyses have been done for previous year’s macroclimate data.  Camera trap data will be extracted by December 2019.  Draft by May 2020. |
| 3 | **The importance of microclimatic refuges in deserts via shelters.** | Field season 2019.  Shelter design is complete.  Shelters will be built and deployed in the field May 2019.  Shelters will be re-visited August 2019 and data will be extracted.  Analysis and writing should finish July 2020. |

**Background**

The Stress Gradient Hypothesis (SGH) proposes a switch from competition to facilitation with increasingly stressful environmental conditions1. This hypothesis sparked the interest of many2,3 for examining positive interactions. Since, various studies have focused on positive interactions in harsh environments, including arid ecosystems4–6. Facilitation is a type of positive interaction where one interacting species benefits whilst none are harmed7. Thus, positive interactions are studied relatively well when discussing stress; however, many do not measure and report stress effectively. Climate in particular is a stressor typically not explored, nor reported. Thus, to ideally advance the relative importance in stress with global change, we need to measure interactions and climate at different scales.

Foundational plant species or nurse plants are an integral part of facilitation research8. These include shrubs, perennials, trees, or cushion plants that benefit protégé species9 through various mechanistic pathways that include, but are not limited to, seed trapping, abiotic stress amelioration, and soil modification8. There is also capacity for the same interaction pathways to benefit animals in deserts10. An important agent of abiotic stress amelioration is shrub canopy, able to facilitate animals through direct and indirect shelter and refuge effects11,12. This is important because deserts are home to many rare, endemic species of animals and biodiversity is high in drylands. These systems are under threat and many federally listed endangered species are in deserts, including some of the first ever to be listed in the USA13. Hence, it’s crucial to study the diversity of such threatened ecosystems.

Desertification and arid region expansion is a critical global change issue14. The well-being and function of foundation plants species may depend on factors such as in temperature, variability in precipitation, extended drought periods, and radiation15–17. The changes in the above microclimatic parameters are primarily due to anthropogenic climate change18 that significantly modifies physical and biological systems in all continents19. It is important to distinguish between micro- and macroclimate-Microclimate or weather can be defined as short-term (minutes to months) changes in atmospheric conditions in one small study site, while climate is the long-term weather pattern of a particular region (NASA). Over the upcoming decades, microclimate may vary; however, global desertification will generally continue to increase20. Macroclimate-driven behavioural plasticity encourages shifts in habitat so behavioural regimes can continue to function21. Thus, closing this research gap by examining behavioural-ecological domains such as movement and spatial pattern, forging and vigilance, social organization, and reproductive behaviour22 is important. Plants and animals in deserts will not only experience large scale changes such as droughts, but also small scale changes such fluctuations in temperature and light, since for these organisms deserts are extremely heterogeneous at fine scales23,24. Due to this, it’s important to have data at both levels. Climate envelope models are common tools for species to understand how they respond to change and environmental drivers, though one cannot ignore the interactions that buffer their tolerances, as well25.

Carrizo Plain National Monument (35.1914° N, 119.7929° W) is the largest remnant ecosystem of the San Joaquin Desert located in the south-eastern San Louis Obispo Country26. The plain is home to various dominant shrub species such as *Ephedra californica* (Mormon tea) and *Atriplex polycarpa* (saltbush)27. *Ephedra californica* is a well-adapted, slow-growing shrub which spreads colonially in hot deserts28, generally growing in elevations of 200-1200 m. Although severe fires can kill the plant29, it is fairly resistant to moderate fires with the ability to sprout. Ephedra’s high abundance and resilience in arid ecosystem make it the perfect plant for facilitation research.

**Chapter 1:** **A picture is worth a thousand hours: a systematic review of camera trap papers to test for reported sampling effort.**

**Purpose:** Identify the relevant literature using camera trapping to examine species richness and diversity as an index of sampling effort.

**Questions:** How many hours, days, or months are needed to estimate the species richness and diversity of a given ecosystem using a camera trapping tool? What taxa are usually recorded (i.e. mammals, Aves etc.)? Does the temperature of the study period function as a covariate when predicting species richness?

**Methods:** The PRISMA diagram (Figure 1) workflow describes the process of this meta-analysis. A citation alert set up on Web of Science with key terms ensures that the review is up to date. Studies were selected from a scientific database (Web of Science) using the keywords: Camera Trap\* AND Richness\*, Camera\* Trap\* AND Diversity\*, and Camera Trap\* AND Rarefaction\* Curve\*. This search was done on January 27th, 2019. An entire paper was selected for the analysis if it contained the species richness/diversity and at least some sort of a measurement of time spam (hours, days, months, and/or camera trapping days), in addition to the number of records. If the study reported a measure of temperature, this was recorded; however, most studies did not. Thus, external research needs to be done in order to obtain climate data. Exclusion criteria included non-English, reviews or idea papers, non-quantitative studies, or focussed on a single species.

**Preliminary Results:** A total of 515 studies were selected, which resulted in 397 studies when duplicates were removed. Many of the papers were either long-term, wildlife monitoring studies or agricultural. However, infrequently there were some studies involving aquatic ecosystems and coral reefs.

**Future Direction:** Currently data are being extracted from 252 full text studies. The aim is to finish this process in June 2019 and start the statistical analysis. I hope to write the paper by October 2019.

Papers obtained through database searching (Web of Science) Keywords:

Camera\* Trap\* AND Richness\*, Diversity\*, and Rarefaction\* Curve\*

(n= 515)

(n = 1090)

Full-text articles assessed for eligibility (n = 252)

(n = )

Records after duplicates removed   
(n = 397)

## Identification

Papers obtained from other sources, such as book chapter bibliographies

(n= 0)

## Eligibility

Records excluded for: relevance, review, opinion or idea paper, focus on one spices, qualitative, not English.

Records screened by abstract (n = 397)

## Screening

Full-text articles excluded:

Not reporting richness or diversity, number of records, and any measure of duration.

Include in synthesis

(n = )

Extracted data:

Location (lat, long), duration.hours, duration.months, camera trap days, number of records, animal richness, scientific name, year, number of cameras, number of sites, month of study, type of ecosystem, study design, and some measure of temperature for study period

## Included

Figure 1: PRISMA diagram used for camera trapping effort systematic review30. Search done with keywords: Camera\* Trap\* AND Richness\*, Diversity\*, and Rarefaction\* Curve\* on January 27th, 2019.

**Chapter 2: Plant-animal interactions and microclimate.**

**Purpose:** To examine whether animal association patterns with shrubs are explained by microsite level fluctuations in temperature and light.

**Question:** To what extent do radiation intensity, air and soil temperature influence the association of vertebrates with foundational plants? How does the strength of this association change as the above microclimatic parameters increase or decrease? Is this association species-specific and does it depend on the animal’s lifestyle?

**Hypotheses:** Shrubs act as thermal refuges for many desert animals by reducing temperature, reducing the amplitude of variation in mircoclimate, and reducing solar radiation.

**Predictions:**

1. There are more animals associated with shrubs relative to open, non-canopy sites and the strength of this relationship increases with micro-environmental stress.
2. Shrub size predicts the strength of association between shrubs and protégé animals.
3. The facilitation refuge effect may be enhanced between abundance and richness of animal populations.
4. Microclimatic (ones site) and mesoclimatic (multiple sites) measures are more significant predictors of fine-scale animal abundances relative to the macroclimate of the region.

**Methods:**

Climate at two scales and presence of animals will be measure for one season at two sites in the Carrizo National Monument. A total of 2 sets of temperature pendant loggers (one soil and one air) will be placed below the canopy for shrub microsite and 3 meters away from the camera in the open for the open microsite to log temperature and light intensity data in 30-minute intervals. The air pendants will be secured to pegs using zip ties and placed 2-3 cm above ground. Camera trapping will be done in the Spring-Summer of 2019 in the Carrizo National Monument at 2 different sites. Cameras will be re-deployed at a new shrub on a weekly basis to avoid repeated-measures sampling. New shrubs will be randomly selected, however a comparison of previous coordinates with new coordinates will ensure than no shrub is selected more than once. Each camera will be deployed facing a shrub 3 meters away from shrub canopy. The open microsite equivalent will be placed back-to-back with the shrub camera, but recording the open/non-canopy area. Shrub height, length, and width (x, y, and z) dimensions will also be recorded once before and after the study is finished. Cameras will be placed exactly at ground level at any given coordinate and secured using pegs. Additionally, Soil moisture measurements will be recorded from under the canopy and the open area (directly beside the camera) on a daily basis. Images collected will be saved as Joint Photographic Expert Group (JPEG) format where data such as presence/absence of an animal will be extracted as a binary variable (0’s and 1’s). Video trap data from another lab member’s research (Mario Zuliani) will also be used to further explore and confirm the activity of these vertebrates.

**Progress to Date:**

* Carrizo macroclimatic monthly 2018 weather data was retrieved from a nearby weather station located in Cuyama (<https://cimis.water.ca.gov/WSNReportCriteria.aspx>) to explore climate patterns of the region. Analysis showed that July, followed by August were the hottest months. February was the most humid month with the maximum humidity percentage reaching 99%, whilst July was the least humid. Total precipitation was the highest in January totalling 23.3 mm. May to September experienced no precipitation.
* Downscaled climate data for each of the two sites was extracted from WorldClim.
* HOBO cable-sensor loggers and pendants (ITM Instruments INC.) were tested. Pendants were a better choice over cable loggers because, whilst data were similar in estimating micro-climate, they were more compact and had lower chance of being chewed by animals. In addition, pendants were able to measure radiation, while loggers were not.
* Field preparations for the survey proposed in Chapter 2 were completed.

**Chapter 3: The importance of microclimatic refuges in deserts via shelters.**

**Purpose:** To explore how different shelters influence the temperature and light underneath their canopies.

**Questions:** How does the canopy coverage of various shelters differ? To what extent does the shelter material and design affect temperature and light fluctuations? What are the implication of this study for various climate change scenarios? Do solar farms alter the microclimate of their respective microsite?

**Hypotheses and predictions:** Foundation species, shelters, and relatively large objects in desert ecosystems influence the microclimate of their canopies.

**Methods:** Shelters will be built and deployed in a Bureau of Land Management secured lot in Hollister, California. One set of temperature/light pendant will be placed into the soil under the shelter canopy and one will be secured to a peg using zip ties and placed 2-3 cm above ground, still under the canopy. The same will be repeated outside in the open directly beside the shelter to serve as control. Pendants will log data in 1 hour intervals. Shelters will be re-visited in August where temperature/light data will be downloaded. Originally 4 types of shelters were proposed: opaque and clear umbrella, Perspex OTC, mesh, and solar panel. However, this may be subject to change.

**Progress to Date:**

* Hollister was visited in January and rain-out Perspex shelter prototype was built and deployed with loggers.

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