### Thesis Prospectus 2022-23

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**Student Final Submission (date):**

**Faculty Reader Approval (date):**

**MES Director Approval (date):**

1. **Working title of your thesis[[1]](#endnote-1).**

Effects of temperature and humidity on the phenology and development of Taylor’s Checkerspot Butterflies (*Euphydryas editha taylorii*)

1. **In 250 words or less, summarize the key background information needed to understand your research problem and question.**

Climatic changes including rises in temperature and precipitation have severely altered global ecosystems (Hill et al, 2021). Additionally, growing degree days (GDD) – which measures the total heat accumulation over a growing season – has been shown to have increased 97% since the 1970s, which may benefit some organisms while harming others (Climate Central, 2022). These changes especially impact plant and insect phenology, and because of climate change some insects and plants are at risk of extinction or endangerment. Butterflies are some of the most sensitive organisms to temperature and precipitation changes, and these pollinators also function as indicators of environmental health to the ecosystems they inhabit (Vickery, 2008). This is true for the Taylor’s checkerspot butterfly, which inhabits unique and severely imperiled glacial outwash prairies within the Pacific Northwest. Taylor’s checkerspot butterflies are already federally endangered, and the impacts of increased precipitation and humidity on their phenology and development may push them into extinction (Bachelet et al, 2011; Hill et al, 2019; Weiss et al, 1988). There is a current program at Mission Creek’s Correctional Facility for Women (MCCCW) wherein the Taylor’s checkerspot butterfly is being captively reared through its lifecycle by incarcerated women as a conservation effort with the collaboration of The Sustainability in Prisons Project (SPP), Washington State Department of Fish and Wildlife (WDFW), and the Department of Corrections (DOC). The direct effects of environmental variables such as temperature, GDD, and humidity on the Taylor’s checkerspot butterfly life stage length and development have been overwhelmingly unexplored, yet this information can be pertinent to the species persistence under climate change and could be valuable context for program management, husbandry, and conservation decisions.

1. **State your research question(s).**

How do environmental conditions (temperature, relative humidity, total accumulated heat) affect the length and development of life stages for Taylor's checkerspot butterflies captively reared at the Mission Creek Correctional Center for Women? What growing degree day thresholds are most useful for predicting Taylor’s checkerspot life stages?

1. **Situate your research problem within the relevant literature. What is the theoretical and/or practical framework of your research problem?**

Assumptions throughout research exist which posit that temperature is a driver of butterfly development, and that butterfly development will change under global warming. Additionally, it is presumed that the shift in temperature would result in asynchrony between butterflies and their host plants. Some research has documented the effects of temperature and humidity on the Taylor’s checkerspot butterfly (Ehrlich et al., 1980; Parmesan et al., 2015), but no research to date has conceptualized using these variables and calculations of GDD to analyze how they influence Taylor’s checkerspot life stage length and development. Additionally, GDD is thought to be a reliable way to measure the growth and development of plants and insects. Some research has shown that GDD is a better predictor than date for butterfly emergence (Cayton et al., 2015), however what GDD calculation provides the most explanatory power for the Taylor’s checkerspot butterfly has gone unexplored.

1. **Explain the significance of this research problem. Why is this research important? What are the potential contributions of your work? How might your work advance scholarship?**

This research can be used to help guide decision making processes for the organizations, individuals, and agencies collaborating on the conservation of the Taylor’s checkerspot butterfly at MCCCW. This research would provide a basic scientific foundation for understanding how climate change is impacting the plant-insect phenological cycle of the Taylor’s checkerspot butterfly which other researchers and scholars may build from. By comparing different growing degree day calculations using different baselines, an assessment can be made as to which calculation provides the best explanatory power for TBC research. This work may also be used in reference to help inform the understanding of how climate change is impacting other butterflies and can contribute a piece of information to how a small part of the Joint Base Lewis-McChord prairie ecosystem is being affected by climate change. Finally, understanding how GDD, temperature, and humidity impacts the Taylor’s checkerspot butterfly in a captive-rearing setting may also be used to help inform habitat management and conservation decisions in the field.

1. **Summarize your study design[[2]](#endnote-2). If applicable, identify the key variables in your study. What is their relationship to each other? For example, which variables are you considering as independent (explanatory) and dependent (response)?**

This study will be conducted on Taylor’s checkerspot butterflies captively reared in the two laboratory greenhouses in Mission Creek Correctional Facility in Belfair, Washington. Research questions will be answered by analyzing previously collected data retrieved from HOBO loggers for minimum temperature, maximum temperature, maximum humidity, and minimum humidity data through the years of 2013 – 2022, in addition to data collected during this coming year of 2023. For every year the beginning and end of every life stage that takes place within the facility will be recorded, which will include: oviposition, egg through pre-diapause, diapause, and post-diapause. These numbers may be compared with other data incarcerated technicians at Mission Creek Correctional Facility and biologists with WDFW already collect for each development period regarding fecundity and total survivorship throughout each development period. Prior to statistical analysis, three different GDD calculations incorporating different baselines will be calculated for every matriline during every year. Thus, different growing degree day categories would be considered as independent variables, used to explain variation in responses. Temperature and relative humidity will also be separately considered as independent variables. Length of life stage will be a response variable, in addition to survivorship per life stage and fecundity during oviposition.

1. **Describe the data that will be the foundation of your thesis. Will you use existing data, or gather new data (or both)? Describe the process of acquiring or collecting data[[3]](#endnote-3).**

Existing data collected by the Sustainability in Prisons Project will be primarily used, but some data from the 2023 year will be collected following SPP’s guidelines. SPP’s procedures for collecting environmental data involve the deployment of HOBO loggers kept in conditions mimicking that of the butterflies or larvae, with several placed on different points around the greenhouse in which the animals are kept. Acquiring existing data would involve downloading previous year’s data from SPP servers, who I am currently employed with.

1. **Summarize your methods of data analysis. If applicable, discuss any specific techniques, tests, or approaches that you will use to answer your research question.**

Correlation and regression analyses will be used to answer my research question, potentially multiple linear regression. The dependent variables being tested include larval survivorship per matriline, fecundity per butterfly, length of life stage per matriline, and potentially percent movement. The independent variable would be the GDD calculation used. Different correlation and regression analyses tests would be performed to also analyze temperature and humidity as independent variables for the above listed dependent variables.

1. **Address the ethical issues[[4]](#endnote-4) raised by your thesis work. Include issues such as risks to anyone involved in the research, as well as specific people or groups that might benefit from or be harmed by your thesis work, perhaps depending on your results. List any specific reviews you must complete first (e.g., Human Subjects Review or Animal Use Protocol Form).**

While my research contains no human subjects, this research relies on environmental and developmental data collected from Mission Creek Corrections Center for Women. There are some ethical issues or risks connected to this research. Developmental data throughout the years has overwhelmingly been collected by incarcerated individuals, who work to run the Taylor’s checkerspot butterfly program. Incarcerated individuals are paid for their work by DOC but receive lower compensation than Washington State minimum wage and have a maximum cap of income they are able to make per month, regardless of actual hours worked. Therefore, much of the actual hours they put into the program on a seasonal basis may not be compensated for. Incarcerated individuals collecting data in past years and in the present also may be exposed to hazardous conditions such as bees, bug bites, and working in extreme heat or cold without PPE such as sunscreen. Regardless of the results of this research, publishing this research will hopefully provide the benefit of helping to inform husbandry decisions for incarcerated women working to help rase the Taylor’s checkerspot butterfly. SPP and WDFW may also benefit from this research regarding meeting husbandry and program management goals, and DOC may also benefit from results indirectly as a supportive partner.

1. **List specific research permits[[5]](#endnote-5) or permissions you need to obtain before you begin collecting data (e.g. landowner permissions, agency permits).**

No research permits need to be obtained.

1. **Reflect on how your positionality as a researcher could affect your results and how you will account for this in the research process[[6]](#endnote-6).**

I am currently employed with SPP and work as the Butterfly Program Coordinator for MCCCW. I also have no personal experience with being incarcerated. Since I am employed by SPP, there may be an unconscious bias in hoping to see a definitive pattern or trend in my statistical analysis which supports husbandry decisions and environmental targets as already listed in the procedures. Throughout my research process, I will account for this by working closely with my thesis reader as a neutral third party and maintain transparency and clarity in communicating my study design and statistical analysis.

1. **Provide at least a rough estimate of the costs associated with conducting your research, if any.  Provide details about each budget item so that the breakdown of the final cost is clear.**

I am working with overwhelmingly pre-existing data, aside from data collected during the 2022 year which I collected myself. Costs may include:

* An all in one scanner/printer/copier [(~109.99](https://www.bestbuy.com/site/epson-workforce-wf-2930-all-in-one-inkjet-printer/6516130.p?skuId=6516130&ref=212&loc=1&ref=212&loc=1&ds_rl=1262656&gclid=CjwKCAiAhKycBhAQEiwAgf19el_QfTOWOLdiD1WPXNsBmQW8A5-4wNXbx0yOgSmYiYDJjd-zfQh5CRoCERUQAvD_BwE&gclsrc=aw.ds))

1. **Provide a detailed working outline of your thesis.**

Acknowledgements

Acronyms

Introduction

Literature Review

*Introduction*

*Growing Degree Days – General Uses*

*General overview of E. e. taylori*

*Insect phenology*

*Phenological mismatch*

*Current Conservation Measures & Captive Rearing*

*Conclusion*

Methods

Study sites

Data management

Oviposition procedures

Eggs and larvae procedures

Diapause procedures

Wake Up procedures

Statistical analysis

Results

Discussion

1. **Provide a specific work plan and a timeline for each of the major tasks in the work plan. Be as realistic and specific as you can at this point, including the deadlines for Spring quarter.**

**Winter Quarter:**

* Start of winter quarter January 9th
* Compile data and complete designing excel spreadsheet containing all years of environmental data for data analysis by January 13th.
* Complete statistical analysis by January 20th (consider writing draft of statistical analysis section?)
* Complete draft of Literature Review by the 27th.
* Complete Acknowledgements, Introduction, and Acronyms by February 3rd.
* Draft of Methods, Study Sites, and Data management by February 10th.
* Draft of procedures (Oviposition, eggs and larvae, diapause, and wake up) by February 17th.
* Draft of Statistical analysis by February 24th.
* Draft of Results & Discussion by March 17th.
* End of winter quarter, March 23rd.

**Spring Quarter**

* Beginning of Spring Quarter on April 3rd
* Send **complete draft of thesis** to Thesis Reader by the Spring quarter, end of Week 2 (April 10th).
* Submit one of two forms, signed by Thesis Reader, to MES Director during Spring quarter by Friday of Week 5:
  + “**Request to Present** Thesis Research” to complete your thesis during Spring 2023, OR
  + “**Request to Extend** Thesis Research” if you plan on/need to extend your work into another quarter[[7]](#footnote-1)
* Spring Quarter **Thesis Presentations** during Weeks 8-9 of Spring 2023.
* Send **final draft of thesis** to Thesis Reader by Friday of Week 9 in Spring 2023.
* Submit **signed, final version** of thesis—electronic copy required—to MES Office by Friday, June 9, 2023.
* End of Winter quarter, March 23rd

1. **Who (if anyone), beyond your MES thesis reader, will support your thesis (in or outside of Evergreen)? Be specific about who they are and in what capacity they will support your thesis. If you are working with an outside agency or expert, be specific about their expectations for your data analysis or publication of results.**

Kelli Bush with SPP may help support access to pre-existing data and be a point of contact for consulting. WDFW biologists Andy Dechaine and Mary Linders, who are overseeing the Taylor’s checkerspot butterfly program at MCCCW, will also be points of contact for consultation. Incarcerated women at MCCCW maintained proper temperature/humidity conditions of HOBO loggers to help mimic the microclimate of the butterflies during my absence of the 2022 year and throughout previous years under the guidance of past coordinators. None of these groups or individuals hold any expectations of my analysis or publication of results.

1. **Provide the 5 most important references you have used to identify the specific questions and context of your topic, help with issues of research design and analysis,** **and/or provide a basis for interpretation. Annotate these references with notes on how they relate to/will be helpful for your thesis. For any other sources cited in your prospectus in other answers, provide a complete bibliographic citation here as well**.

**Bachelet, D., Johnson, B. R., Bridgham, S. D., Dunn, P. V., Anderson, H. E., & Rogers, B. M. (2011). Climate change impacts on western Pacific Northwest prairies and savannas. *Northwest Science*, *85*(2), 411-429.**

Provides relevant background information on prairie systems and the effects on them by climate change factors such as temperature and precipitation. Since prairie ecosystems are the preferred habitat for Taylor’s Checkerspot and my research will be focusing on climate change effect, this paper will be helpful to draw information from.

Buckingham, D. A., Linders, M., Landa, C., Mullen, L., & LeRoy, C. (2016). Oviposition Preference of Endangered Taylor's Checkerspot Butterflies (Euphydryas editha taylori) Using Native and Non-Native Hosts. *Northwest Science*, *90*(4), 491-497.

**Cayton, H. L., Haddad, N. M., Gross, K., Diamond, S. E., & Ries, L. (2015). Do growing degree days predict phenology across butterfly species? *Ecology*, *96*(6), 1473–1479.**

This source describes how GDD is a better predictor of phenology, emergence, and abundance of butterfly species in Ohio than date, and supports GDD as an effective tool to assess butterfly response to climate change. Though this source is not focused in Washington State or on the Taylor’s Checkerspot, it does provide some sense as to how GDD has been used pertaining to butterflies and climate change.

Climate Central. (2022, March 9). *Growing Degree Days*. https://www.climatecentral.org/climate-matters/growing-degree-days

Ehrlich, P. R., Murphy, D. D., Singer, M. C., Sherwood, C. B., White, R. R., & Brown, I. L. (1980). Extinction, reduction, stability and increase: The responses of checkerspot butterfly (Euphydryas) populations to the California drought. *Oecologia*, *46*(1), 101–105.

**Hill, G. M., Kawahara, A. Y., Daniels, J. C., Bateman, C. C., & Scheffers, B. R. (2021). Climate change effects on animal ecology: butterflies and moths as a case study. *Biological Reviews*.**

This source essentially reviews studies on butterflies and moths (Lepidoptera) and how climate change is impacting these species as a whole. Since the relevance of my prospectus topic focuses on how climate change will impact the Taylor’s checkerspot, I’ll be referring to this source heavily in order to better understand climate change impacts on my species of focus from a broader perspective.

Linders, M., & Lewis, K. (2013). Captive rearing and translocation of Taylor’s checkerspot butterfly (Euphydryas editha taylori): South Puget Sound, Washington, 2012–2013. *Annual Report to the US Fish and Wildlife Service, Joint Base Lewis-McChord Fish and Wildlife Program and JBLM-ACUB Technical Review Committee*, 17.

Parmesan, C., Williams-Anderson, A., Moskwik, M., Mikheyev, A. S., & Singer, M. C. (2015). Endangered Quino checkerspot butterfly and climate change: Short-term success but long-term vulnerability? *Journal of Insect Conservation*, *19*(2), 185–204.

**Weiss, S. B., Murphy, D. D., & White, R. R. (1988). Sun, slope, and butterflies: topographic determinants of habitat quality for *Euphydryas editha*. *Ecology*, *69*(5), 1486-1496.**

A study that describes insect-plant phenology and how butterflies use slope in order to mitigate the effects of temperature during larvae and oviposition lifecycles. The authors have found that there is a north/south slope dichotomy with butterflies in that larvae hatched on one side of the slope have higher survival rates due to temperature effects on host plants (shading vs. more exposure to sunlight). I will be using this to further describe the effects of temperature and heat on butterflies in my literature review.

**Vickery, M. (2008). Butterflies as indicators of climate change. *Science Progress (1933)*, *91*(2), 193–201.** [**http://www.jstor.org/stable/43425780**](http://www.jstor.org/stable/43425780)

This is a source I likely will not be relying heavily on but is mentioned above. It describes how butterflies are used as indicator species to assess the overall health of the environments they occupy.

1. You are not locked into this title; we want you to identify the main point or topic of your thesis. [↑](#endnote-ref-1)
2. You might discuss selection of case studies, sampling methods, experimental design, and/or specific hypotheses you will test. You should also address any specialized knowledge or skills that are necessary to complete the research. [↑](#endnote-ref-2)
3. If you are planning to use existing data, explain the specific source, contact information, arrangement with collaborating agencies, and expectations about use of data and final products of your research. If you are planning to gather new data, describe specific methods, time, place, and equipment that will be required. [↑](#endnote-ref-3)
4. If you’re not sure where to start, consult a ‘Code of Ethics’ or other similar document from an academic society in an applicable field of study. [↑](#endnote-ref-4)
5. If you are collecting ANY samples or data, even observational data, on public lands (city, county, state and/or federal) it is your responsibility to find out the permit requirements BEFORE you collect data. Conducting research with tribal members/on tribal lands will have different and additional requirements. [↑](#endnote-ref-5)
6. Your *positionality as a researcher* refers to the fact that one’s “…beliefs, values systems, and moral stances are as fundamentally present and inseparable from the research process as [one]’s physical, virtual, or metaphorical presence when facilitating, participating and/or leading the research project…” (The Weingarten Blog 2017). [↑](#endnote-ref-6)
7. You must show progress on your thesis and get your reader’s approval to extend. Talk to your reader, before the deadline, about extending into Summer vs. Fall. Faculty are not on contract during Summer Quarter. [↑](#footnote-ref-1)