Department of Biology

University of Vermont

Undergraduate Research Proposal

BIOL 197 (Fall)/198 (Spring)

PROJECT TITLE: A survey and correlational study of tracheal mites and microsporidians in bumble bee populations of Northern Vermont.

STUDENT INFORMATION

NAME Phillip Alexander Burnham e-mail alexburn17@gmail.com

NETID pburnham STUDENT ID # 955954759 MAJOR Biological Science EXPECTED GRADUATION MONTH/YEAR 2017 ACADEMIC ADVISOR Dr. C. Kilpatrick

FACULTY RESEARCH ADVISOR INFORMATION

NAME Dr. Alison K. Brody e-mail akbrody@uvm.edu

DEPARTMENT Biology

DEADLINE FOR STUDENT TO SUBMIT FINAL PAPER TO ADVISOR\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Note final grade is due to Biology Department Research Coordinator by Wed, Dec 9 2015 (Fall) Wed, May 4, 2016 (Spring)

COURSE INFORMATION: CREDITS (3 or 6): FALL 3 SPRING 3

Each credit requires a minimum of 40 hours. For example, 3 credits require a minimum of 120 hours, or at least 8 hours per week during a 15-week semester or 10 hours per week during 12 weeks in the summer.

Do you plan to use 6 credits of research toward required advanced courses for the BS in Biological Science or Zoology? **Yes** No

ELECTRONIC SIGNATURES

I have read the Instructions to Students sheet and understand the deadlines and duties required for students enrolled in BIOL 197/198.

Student\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

A survey and correlational study of tracheal mites (*Locustacarus buchneri)* and *Nosema bombi* in bumble bees throughout Northern Vermont.

**INTRODUCTION**

The pollination of wild and managed angiosperms is of great importance to both our natural and agricultural systems. It is estimated that around one third of the words food is dependent upon animal-mediated pollination, with the majority being provided by bees (Aizen et al., 2009). Of the 115 most important food crops, 87 are reliant upon pollinators for their success (Klein et al., 2007), which amounted to a global economic benefit of over 218 billion USD in 2009 (Gallai et al., 2009). The importance of honey bees (*Apis mellifera*) in pollination is well documented. The US monetary benefit provided by honey bees was estimated at over 14 billion USD in 2000 (Morse and Calderone, 2000). Our dependence on pollinators has raised grave concerns over documented declines in honey bees (CITE) and has launched research aimed at identifying potential threats to bees (van Engelsdorp et al., 2008). Bee decline cannot be attributed to single cause but instead is the culmination of multiple threats including land use change, pesticide use and pathogens (CITE). Although relatively understudied, these threats are also affecting native bees.

Bumble bees (*Bombus ssp.*) in particular are an important native pollinator Certain plants, most notably of the genus *Solanum* (tomatoes, squash and eggplant), pollinated through “buzz pollination” whereby the bee vibrates, loosening the pollen in the stamens. Certain wild pollinators including bumble bees are capable of this, while honey bees are considered poor buzz pollinators (Buchmann and Hurley, 1978, Strange, 2015). These native bee pollinated plants are of great monetary importance to the agricultural industries of Canada, Mexico and the United states (Thornsbury and Jerardo, 2012).

Native pollinator decline in recent years has the potential to drastically disrupt these industries. It was found that many species of *Bombus* are reduced in abundance when compared to surveys conducted 5 decades ago (Colla and Packer, 2008). Species such as *B. affinis, B. borealis, B. ashtoni, B. fervidus, B. pensylvanicus, and B. sandersoni* (all species that can be found in Vermont) have experienced declines since the 1960s (Colla et al., 2012). In 2015, the state of Vermont listed two species of *Bombus* as threatened (*B. terricola and B. ashtoni*) and one as endangered (*B. affinis*) (Vermont Fish and Wildlife Department, 2015).

Various parasites and pathogens have been identified as threats to native bumble bee species. Two parasitic organism that are prevalent in *Bombus spp.* are the tracheal mite, *Locustacarus buchneri* and the microsporidian, *Nosema bombi.* Such infestations are detrimental to bumble bee health and can adversely affect pollinator efficiency and foraging behavior (Otterstatter et al., 2005). Surveys have been conducted that look at the parasite loads across *Bombus* species (Kissinger et al., 2011). However, such surveys have never been conducted in Vermont and tend to focus on the invasion of parasitic species separately. However, the interplay between multiple parasitic organisms and the host species may create a more dynamic relationship. I will conduct a survey of *L. buchneri* and *N. bombi* across bumble bee species in Northern Vermont to examine:

**1.** What patterns exist in tracheal mite and *Nosema* prevalence across different *Bombus* species throughout Northern Vermont.

**2**. Are there patterns in co-infection that would predict interactive effects between these two parasitic organisms.

I hypothesize thatcertainspecies of *Bombus* will tend to be more susceptible to *L. buchneri* and that there will be a correlation between high mite loads and the presence of *Nosema*.

I predict both mite and *Nosema* prevalence will be highest in *Bombus* speciesthat build larger colonies compared to *Bombus* species that tend to build smaller colonies containing fewer workers. In infected individuals, I expect a positive correlation between the two pathogens.

**METHODS**

**Preliminary Work:**

In 2014, over 300 bumble bees were collected from 13 different field sites throughout Northern Vermont (fig.1). The bees were netted randomly from flowers. At some sites, queens and males were also captured. The bees were put on dry ice in the field and were transferred to a -80oC freezer within 12 hours of being captured. At each site, bee abundance and flowering vegetation surveys were conducted. In sites with honey bees present, forging honey bees were also collected from flowers and/or directly from hives.

**Work to be Conducted:**

The 300+ bees will be dissected using a standardized protocol (fig. 2) under a dissection scope and screened for both, *L. buchneri* and *N. bombi.* Standardized counts will be made for both parasites. Percentages of *Bombus* infected by *L. buchneri* and/or *N. bombi* will be calculated for both species and location captured. These data will be analyzed in R using ANOVA. We will look for patterns in the data looking closely for certain species or locations that exhibit higher mite loads. We will use ANOVA to look for a correlation between the presence of *N. bombi* in conjunction with high *L. buchneri* loads. Using the data collected from pollinator abundance surveys, I will test if pollinator abundance is a good predictor of pathogen prevalence across sites.

**EXPECTED RESULTS**

I predict *L. buchneri* prevalence will significantly differ between bumble bee species. I believe that species that tend to build larger colonies and/or were caught in sites with high pollinator density will tend to have higher mite loads. Because of the relationship between host density and parasite prevalence, it makes sense to see higher infestations in areas with higher *Bombus* population (Arneberg et al., 1998). (“As predicted by the HOST DENSITY HYPOTHESIS with posits…….”

I also expect to see a positive relationship between bumblebees with high tracheal mite loads and bees that are infected with *Nosema.* Correlations between macroparasites and pathogens in honey bee have been detected. In honeybees, *Varroa destructor,* an ectoparasistic mite, suppresses bee immunity and may create conditions necessary for increased RNA virus replication. Therefore, honeybee colonies with high *Varroa* loads also tend to have high viral loads (CITE). A similar dynamic relationship might be at play between *L. buchneri* and *N. bombi.*whereby immune suppression by the mites could make bumble bee hosts more susceptible to *Nosema.*

If the above patterns are not found, it might give evidence that infestations of *L. buchneri* and *N. bombi* are widespread and indiscriminate. If patterns in mite/Nosema prevalence are not driven by host species difference I may find site specific differences. Differences across sites may be driven by climatic differences associated with elevation or latitude as well as differences in honey bee abundance EXPLAIN COMPETITION ALTERNATIVE HYPOTHESIS HERE. Competition with honeybees could also be weakening bumble bees, making them more susceptible to pathogens (Elbgami et al., 2014). Differences in the phenologies of wild flower and *Bombus* species, or delays in growth caused by weather in certain locations might also skew the expected results. (Need citation for nutrition deficit- more susceptible to disease.)

**REFERENCES**

Aizen, M. a., Garibaldi, L. a., Cunningham, S. a., & Klein, A. M. (2009). How much does agriculture depend on pollinators? Lessons from long-term trends in crop production. *Annals of Botany*, *103*(9), 1579–1588. http://doi.org/10.1093/aob/mcp076

Arneberg, P., Skorping, A., Grenfell, B., & Read, A. F. (1998). Host densities as determinants of abundance in parasite communities. *Proceedings of the Royal Society B: Biological Sciences*, *265*(1403), 1283–1289. http://doi.org/10.1098/rspb.1998.0431

Colla, S. R., Gadallah, F., Richardson, L., Wagner, D., & Gall, L. (2012). Assessing declines of North American bumble bees (Bombus spp.) using museum specimens. *Biodiversity and Conservation*, *21*(14), 3585–3595. http://doi.org/10.1007/s10531-012-0383-2

Colla, S. R., & Packer, L. (2008). Evidence for decline in eastern North American bumblebees (Hymenoptera: Apidae), with special focus on Bombus affinis Cresson. *Biodiversity and Conservation*, *17*(6), 1379–1391. http://doi.org/10.1007/s10531-008-9340-5

Kissinger, C. N., Cameron, S. a., Thorp, R. W., White, B., & Solter, L. F. (2011). Survey of bumble bee (Bombus) pathogens and parasites in Illinois and selected areas of northern California and southern Oregon. *Journal of Invertebrate Pathology*, *107*(3), 220–224. http://doi.org/10.1016/j.jip.2011.04.008

Klein, A.-M., Vaissière, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. a, Kremen, C., & Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. *Proceedings. Biological Sciences / The Royal Society*, *274*(1608), 303–313. http://doi.org/10.1098/rspb.2006.3721

Kuster, R. D., Boncristiani, H. F., & Rueppell, O. (2014). Immunogene and viral transcript dynamics during parasitic Varroa destructor mite infection of developing honey bee (Apis mellifera) pupae. *The Journal of Experimental Biology*, *217*(Pt 10), 1710–8. http://doi.org/10.1242/jeb.097766

Morse, R. a, & Calderone, N. W. (2000). The value of honey bees as pollinators of US crops in 2000. *Bee Culture*, *128*(March 2000), 1–15. Retrieved from http://www.beeculture.com/content/pollinationreprint07.pdf\npapers2://publication/uuid/480F22F5-2367-4853-AD20-88441298BE0B

Otterstatter, M. C., Gegear, R. J., Colla, S. R., & Thomson, J. D. (2005). Effects of parasitic mites and protozoa on the flower constancy and foraging rate of bumble bees. *Behavioral Ecology and Sociobiology*, *58*(4), 383–389. http://doi.org/10.1007/s00265-005-0945-3

Strange, J. P. (2015). Bombus huntii, Bombus impatiens, and Bombus vosnesenskii (Hymenoptera: Apidae) Pollinate Greenhouse-Grown Tomatoes in Western North America. *Journal of Economic Entomology*. http://doi.org/10.1093/jee/tov078

Thornberry, S., and A. Jerardo. 2012. Vegetables and Pulses Outlook. USDA, Economic Research Service, p. 52. (http://www.ers.usda.gov/media/826842/vgs350.pdf)

Van Engelsdorp, D., Hayes, J., Underwood, R. M., & Pettis, J. (2008). A survey of honey bee colony losses in the U.S., Fall 2007 to Spring 2008. *PLoS ONE*, *3*(12), 8–13. http://doi.org/10.1371/journal.pone.0004071

Vermont adds nine species to threatened and endangered list. (2015) Vermont Fish

and Wildlife Department. Retrieved 9/5/15 from http://www.vtfishandwildlife.com

/cms/One.aspx?portalId=73163&pageId=269142