**Do life-history traits of native bees and their floral resources affect susceptibility to viruses?**

Keywords: native bees, virus, life-history traits, pollination

**Intellectual merit**. Recent European honey bee (*Apis mellifera*) declines from several putative causes underscore the danger of relying on a single introduced pollinator. By providing significant pollination services to crops and wild plants, non-managed native bees can buffer against pollination deficiencies resulting from honey bee declines1. However, as with honey bees, native bees are also affected by global change pressures2, 3, 4, 5. Among these pressures, RNA viruses are emerging as a serious threat 2. Although the transmission of viral pathogens among European honey bees and bumblebees (*Bombus* spp.) has been documented2,the prevalence and probability of transmission to wild bees is largely unknown3, 4. Once viral transmission routes are identified, management recommendations can be made to minimize the exposure of bees to viruses.

Although inter-specific transfer of viruses through pollen can happen, all bees are not equally susceptible, suggesting differences in viral ecology among bee species, and/or differences in pollinator contact with contaminated pollen2. To explore viral transmission among understudied bee taxa, I will examine: **1) How life-history traits of native bees affect their susceptibility to RNA viruses, and 2) Whether pollinator host plants are acting as reservoirs for viral transmission.** No previous study has defined the viral host range across native bees or examined the role of flowering plants in viral transmission. Filling these gaps in present knowledge is important from both an ecological and conservation perspective.

**Life-history traits.**

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| **Table 1. Life-history trait groups** 5 | | | | |
| Trait | States | Definition | Prediction\* | |
| Sociality | Social | Densely populated colonies, one queen, many workers | 🡹 | Viral transmission depends on the frequency of bee to bee contact |
| Solitary | Females nest and provision eggs alone, without worker bees | 🡻 |
| Flower preference | Generalist | Foragers of many flowering species | 🡹 | Viral transmission depends on the range of floral resources visited |
| Specialist | Foragers of few flowering species | 🡻 |
| \*🡹/🡻: A greater/lesser occurrence of viral transmission among bee species | | | | |

Bees differ in life-history traits that may, in turn, affect exposure and susceptibility to viral infection **(Table 1)**. Once infected, traits may also influence how viruses affect bees both as adults and brood.

**Approach.** I will survey viral prevalence among bee species and identify patterns among life-history groups. Bees and their corresponding pollen loads will be collected, identified, and tested for viral infection using reverse transcription-polymerase chain reaction (RT-PCR)6. The RNA viruses I will examine are Deformed wing virus, Sacbrood virus, Black queen cell virus, Israeli acute paralysis virus, and Kashmir bee virus. These viruses cause harmful symptoms in bees and are either newly emerging or common throughout the United States6. Molecular protocols for detecting these viruses have been developed and are highly specific to the target of interest6, 3. By combining prior knowledge of species-specific natural history with field observations, I will group bee species according to life-history traits. Later, I will experimentally test these observed patterns by manipulating floral resources and viral exposure. Viral infection will be tested in bees collected on flowers and in brood from nests of social and solitary bees. To understand how viruses affect bees with different life histories and behavior, I will use social and solitary bee species that readily nest in artificial boxes and examine how viral infection affects brood size and offspring survival.

**Role of flowering host plants.** The role of host plants visited by bees in viral transmission is unclear. Viruses may be found both outside and inside pollen grains2. Thus, viruses may be carried systemically by plants and expressed in nectar and pollen, as well as transferred by floral visitors that carry infected pollen from flower to flower. Understanding how plants affect viral transmission can influence agricultural management decisions. For example, hedgerows are dense areas of flowering plants, managed to provide important floral resources to pollinators. These areas could also serve as viral reservoirs. If particular plants are better at harboring and transmitting viruses, they should be avoided in pollinator conservation recommendations.

**Approach.** To investigate the role of host plants, I will first survey viral prevalence in nectar and pollen among different flowering plants common in hedgerows or fallow areas. I will also test pollen loads carried by bees for the presence of viruses. Once patterns are established, I will experimentally manipulate pollinator host plants to determine how plants are acting as viral reservoirs, and if certain plant or floral traits affect viral transmission.

**Sample size and analysis.** The pollinator communities at my study sites have been surveyed (Ricketts, unpublished). From those surveyed, I will select 5-12 species/site/life history group and collect ca. 50 bees/species. I will use parametric, univariate statistics to examine if life history traits and/or host plants predict viral presence (percent of bees infected) and virulence (effects on brood size and offspring survival) and transmission from parent to offspring.

**Resources.** I will survey bees across several already-identified blueberry farms in Vermont. I am familiar with the field sites and I am currently collaborating with researchers in this system on a long-term monitoring project of native bees. The Vermont Genetics Facility at UVM has all necessary resources and personnel to conduct molecular techniques.

**Broader Impacts.** I will collaborate with several farmers and organize yearly workshops to discuss practices that will help promote native pollinators. Once I am regularly testing bees for viral infection, I will offer testing as a service to beekeepers interested in the health of their hives. I will help educate and spread awareness among farmers about pathogens and suggest practices that may lesson pathogen spillover from honey bee hives to native bees. Results will be published in scientific journals and on a website directed towards agriculturalists interested in pollinator conservation. Lastly, I will recruit and mentor two undergraduate assistants each summer and an additional two students during each academic year. All students will be given the opportunity to develop an independent research project in the field or in the laboratory.

**[1]** Winfree, R *et al.* (2007) Native bees provide insurance against ongoing honey bee losses. *Ecology Letters*.10 (11), 1105-1113. **[2]** Singh, R *et al.* (2010) RNA Viruses in Hymenopteran Pollinators: Evidence of Inter-Taxa Virus Transmission via Pollen and Potential Impact on Non-Apis Hymenopteran Species. *Plos One.* 5 (12).**[3]** González-Varo, JP et al. (2013) Combined effects of global change pressures on animal-mediated pollination. *Trends in Ecology & Evolution*. 28 (9), 524-530. **[4]** Potts, SG *et al.* (2010) Global pollinator declines: trends, impacts and drivers. *Trends in Ecology & Evolution* 25 (6), 345-353. **[5]** Williams, NM *et al.* (2010) Ecological and life-history traits predict bee species responses to environmental disturbances. *Biological Conservation*. 143 (10), 2280-2291. **[6]** Benjeddou, M *et al.* (2001) Detection of acute bee paralysis virus and black queen cell virus from honeybees by reverse transcriptase PCR. *Applied and Environmental Microbiology*. 67 (5), 2384-2387.