Host plant dependent disease progression of the microsporidian parasite *Nosema tyriae* on Cinnabar moth larvae

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Introduction

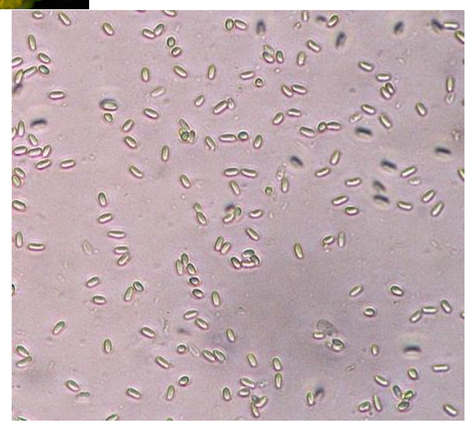
Tyria jacobaeae was introduced as a **biological control agent** to control the noxious weed *Jacobaea vulgaris*. Eventually introduced to the Cascade mountain range of Oregon, *T. jacobaeae* has been found to feed on *Senecio triangularis,* a native plant closely related to *J. vulgaris*.

Nosema tyriae is a parasitic fungus under the phylum Microspora (Microsporidians) and *T. jacobaeae* is the main host of the parasite (Canning et Al. 1999). Microsporidia infections of insect larvae exhibit slowed development, and increased mortality in both the larval and pupal stages.

Nutritional content of the host plant has been shown to increase the effect of the pathogen *N. tyriae* on *T. jacobaeae*. This increase can lead to greater mortality and decreased insect performance of *T. jacobaeae* on its non-target host *S. triangularis* (McEvoy et Al. 2008).

The **objective** of this study was to **determine the difference between pathogen infection levels on the two host plants** *T. jacobaeae* and *S. triangularis*.
Based on previously documented higher mortality rates on *S. triangularis* (McEvoy et al. 2008), our **hypothesis** was that **pathogens** would **multiply faster on *S. triangularis*** than *J. vulgaris* and that the **infection levels would increase in later stages** with more time post-inoculation, and **with greater spore dosages**.

Image by Neil Smith



Similar species: *Nosema fumiferanae postvittana*
http://nature.berkeley.edu/millslab/Julie.html

Methods and Materials

Methods for infecting larvae were adapted from (Karacetin, 2007).

- Larvae were randomly assigned to low (10^2), medium (10^3), and high (10^5) doses of microsporidia.
- Spore solutions were created by crushing 4th and 5th instar larvae found to be already infected, centrifuging the solution and mixing with appropriate amounts of water to obtain pellets with concentrated amounts of spores.
- Each spore dose was deposited onto the appropriate leaf, and larvae were given 24 hours to eat. Any larvae that did not eat the entire leaf disk were not used in the experiment.
- After 4, 8 and 12 days a subset of larvae were taken and homogenized in a solution with a controlled amount of water, and were analyzed for spore contents. Several larvae were not infected at all and used as control.
- Larvae were reared at 22°C during the day, and 10°C at night.

Statistical Analysis:

- Generalized linear model with Poisson error
- Response variable: spore concentration at time of dissection
- Explanatory variable: Days since infection (continuous), spore dose (continuous), and host plant (categorical)

Results

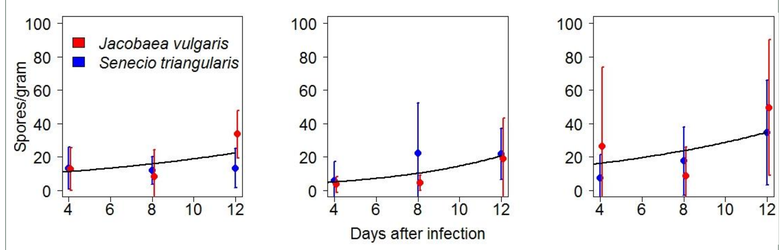


Fig1: Relationship between spore concentration at time of dissection and initial spore dose, host plant and time since infection. Most left figure represents dosage of 10^2 spores (low dose), middle represents 10^3 spores (medium), and most right represents 10^5 spores (high).

Statistical Analysis:
Host plant had no significant effect on levels of *N. tyriae* (intercept: $\chi2=30.2$, df=1, P = 0.52) or disease progression (slope: $\chi2=1.09$, df=1, P = 0.9). The **effect of dose on disease progression was not significant** (slope: $\chi2=3.4$, df=1, P = 0.82), while the **effect of dose on disease levels was marginally significant** (intercept: $\chi2=212.6$, df=1, P = 0.09).

Discussion

We hypothesized that host plant would have an impact on the progression on disease and that infection levels would increase faster with higher doses of infection. We believed that *S. triangularis* infection levels would increase faster than those on *J. vulgaris* because of previous studies that showed evidence of Nosema causing higher mortality on *S. triangularis* (Karacetin et al. 2007) .
A comparable study was done where bees (*Apis mellifera*) were fed *Nosema apis* and two different diets in a subgroup, one with exclusively sugar/pollen and the other with a proteinaceous pollen (Rinderer et al. 1977). Contrary to our results of no difference, Rinderer et al. (1977) found *Nosema* spores increased at a faster rate on the higher quality food source.
In our study we observed that the larvae on *S. triangularis* grew slower than those on *J. vulgaris*. If they had weighed less than larvae on *J. vulgaris* at the time of infection that could have affected the outcome; a possibility for accounting for differences in size would be to infect at a specific weight, instead of using instars as a measurement. Additionally, after infection is was noted that the larvae on *S. triangularis* continued to grow at a slowed rate in comparison to those on *J. vulgaris* so the spores per weight of larvae could influence the results.
It is also known that temperature can affect the development of disease. The larvae in this study were reared in incubators at 22°C during the day and 10°C at night. This varies greatly between the temperatures in the Willamette valley in Oregon during the summer, when they are still in the larvae stage. In the field it is often between 30 to 38 degrees Celsius, which could give a different result when comparing field and lab studies.
Among other similar studies, the results differed greatly, especially mortality rates. The highest dose in this study was 10^5, whereas Down et al. (2003) used a spore concentration double the amount (2*10^5), which increased the rate of mortality greatly. Additional studies could consider a greater span between the different doses, similar to what other studies have done with different species.

References

Canning, E. U., A. Curry, S. A. Cheney, N. J. Lafranchi-Tristem, Y. Kawakami, Y. Hatakeyama, H. Iwano, and R. Ishihara. 1999. Nosema tyriae n.sp and Nosema sp., microsporidian parasites of cinnabar moth Tyria jacobaeae. Journal of Invertebrate Pathology 74:29-38.
Down, R., Bell, H., Kirkbride-Smith, A., Edwards, J. The pathogenicity of *Vairimorpha necatrix* (Microspora: Microsporidia) against the tomato moth, *Lacanobia oleracea* (Lepidoptera: Noctuidae) and its potential use for the control of lepidopteran glasshouse. Central Science Laboratory, Sand Hutton, York, UK. Pest Management Science Volume 60, Issue 8, pages 755–764.
Karacetin, E. (2007). Biotic Barriers to Colonizing New Hosts by the Cinnabar Moth *Tyria jacobaeae* (L.) (Lepidoptera: Arctiidae).
Lewis, L., Bruck, D., Prasifkaa, J., Raunc, E. *Nosema pyrausta*: Its biology, history, and potential role in a landscape of transgenic insecticidal crops. Biological Control Volume 48, Issue 3, March 2009, Pages 223–231.
McEvoy, P., Higgs, K., Coombs, E., Karaçetin, E., Starcevich, L. Evolving while invading: rapid adaptive evolution in juvenile development time for a biological control organism colonizing a high-elevation environment. Evolutionary Applications Special Issue: Evolution and Biological Control Volume 5, Issue 5, pages 524–536, July 2012.
Rinderer, T., Elliot, K. Worker Honey bee respose to infection with *Nosema apis*: Influence of Diet. Journal of Economic Entomology Volume 70, Issue 4, Pages 431-433.