Enemy-Free for Parasitoids

Biology Graduate Research Seminar

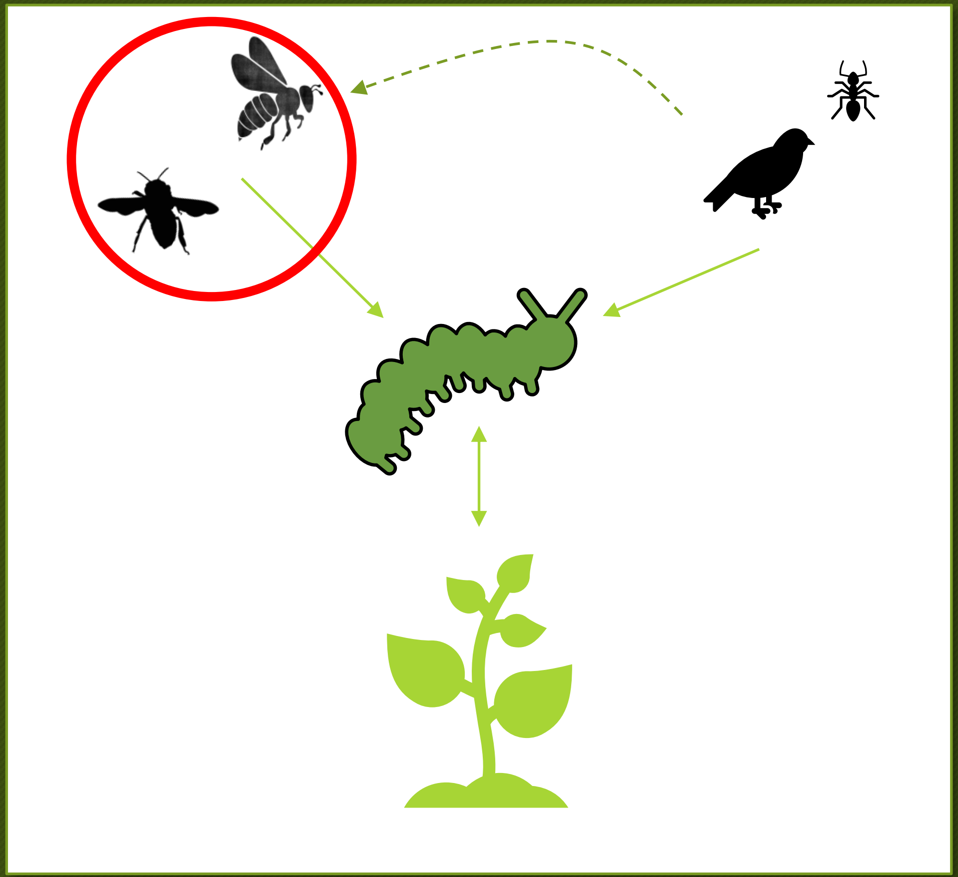
Andrew Hennessy 4-8-2022

Introduction

Tri-trophic interactions centered around caterpillars

My project focuses on insect parasitoids

How do other predators of caterpillars influence parasitoid host choice?



Parasitoid Life History

Adults search out suitable hosts through environmental cues

They oviposit in, or lay eggs on caterpillar host

Parasitoid Life History

Larvae develop within (endoparasite), or on the surface of the host (ectoparasite)

Larva emerge and pupate usually resulting in the death of the host

Parasitoid Life History

Two main taxa: Tachinid flies, Braconid and Ichneumon wasps

Wasps parasitize and emerge while the caterpillars are small

Flies usually stay within caterpillar until after pupation

Enemy-Free Space

An animal's traits are influenced by natural enemies, and they should evolve traits that aid in interactions with these natural enemies

Enemy-Free Space: an explanation for ecological and evolutionary patterns that could not, or only poorly be explained by resource competition.

Enemy free space and the structure of ecological communities

M. J. JEFFRIES AND J. H. LAWTON

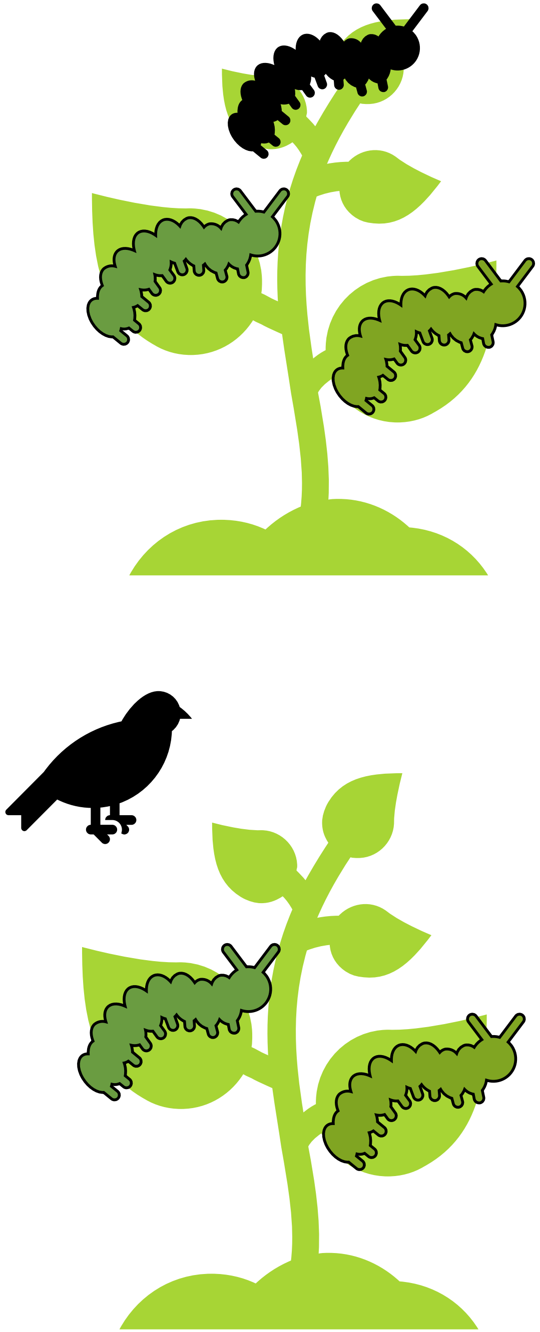
Department of Biology, University of York, Heslington, York YO1 5DD

Accepted for publication May 1983

Enemy-Free Space for Caterpillars

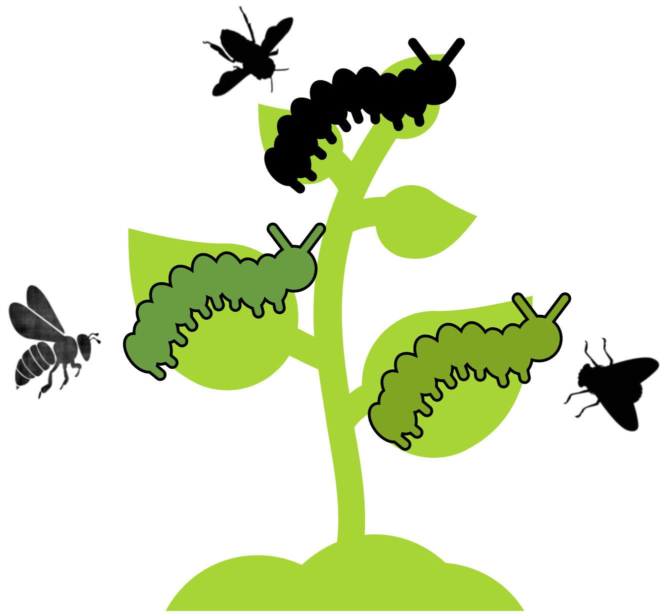
Defensive traits like spines or sequestered chemicals provide herbivores with enemy-free space

The herbivore community can be structured by the predator effects



Enemy-Free Space for Parasitoids

Insect Parasitoids are exposed to the same risks of predation as their hosts



Enemy-Free Space for Parasitoids Hypothesis: female parasitoids should seek enemy-free space for their larva through host choice

Key Prediction: negative relationship between risk of predation and probability of parasitism

Known Influences of Parasitism

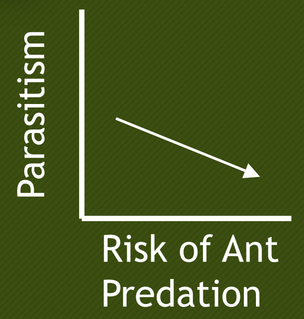
Traits of Caterpillar and Host Plant are known to have large effects on parasitism

Caterpillar species vary in their resistance to parasitism

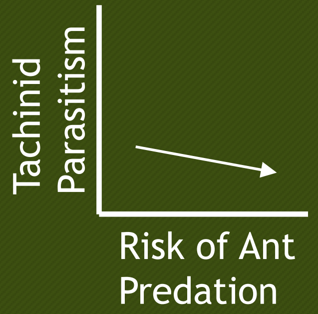
Variation in Volatile Organic Compounds or other host plant traits also influence parasitoids

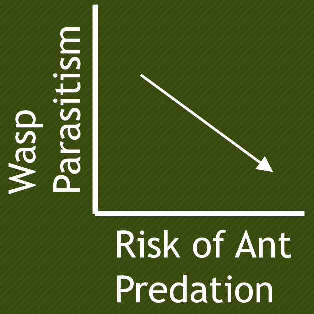
Predictions

Main Prediction: Negative relationship between a caterpillar's risk of predation and probability of parasitism

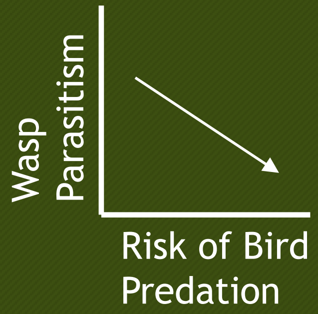


Wasp prediction: Probability of wasp parasitism should be most negatively associated with ant predation





Fly prediction: Probability of fly parasitism should be most negatively associated with bird predation



Methods: General Overview

Data from several field studies were combined to assess how variation in predation risk correlated with rates of parasitoid attack.

We created generalized linear models with proportion of parasitism as the response variable, and predation risk as the main predictor variable

Methods: Experimental Design

The experiments were designed as factorial exclusions of birds and ants

Caterpillar densities on exclusion and access branches can quantify the effect of predators

Caterpillars were collected and reared to calculate the probability of parasitism

Methods: Study System

Hickory

Red Maple

Black Cherry

Red Oak

Birch

Beech

Witch Hazel

White Oak

Methods: Effect Sizes

X_T = Mean of caterpillar density on exclusion branches

X_C = Mean caterpillar density on control branches

$$LRR = \ln(X_T / X_C)$$

$$LRR^{\Delta} = LRR + 1/2\left[\frac{(SD_T)^2}{N_T X_T^2} + \frac{(SD_C)^2}{N_C X_C^2}\right]$$

Variance utilizes standard deviation and sample size to account for sampling variability

$$var(LRR) = \frac{(SD_T)^2}{N_T X_T^2} + \frac{(SD_C)^2}{N_C X_C^2}$$

$$var\left(LRR^{\Delta}\right) = var(RR) + 1/2\left[\frac{(SD_T)^4}{N_T^2 X_T^4} + \frac{(SD_C)^4}{N_C^2 X_C^4}\right]$$

Methods: Modeling

Binary Response Variable ~ Predictor Variable(s) + Fixed Effects

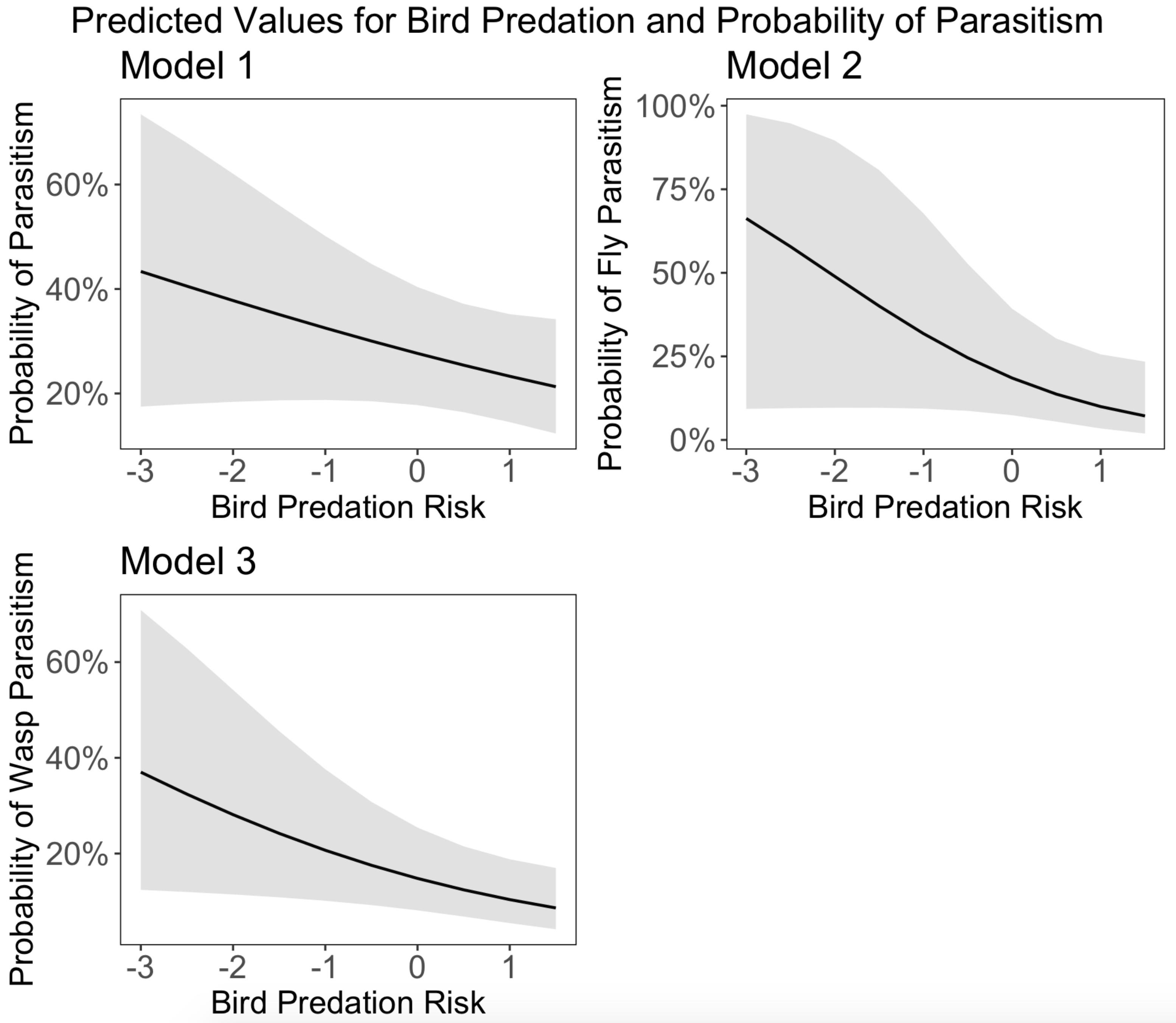
$$(Parasitized\!:\!Unparasitized) \sim LRR_{birds} + LRR_{ants} + host\ plant + caterpillar\ species$$

Response Variables			Predictor Variables	
All Parasitism	Tachinid Parasitism	Hymenopteran Parasitism	Risk of Predation	Fixed Effects
Model 1	**Model 2**	**Model 3**	Bird	Caterpillar Species and Host Plant
Model 4	**Model 5**	**Model 6**	Ant	Caterpillar Species and Host Plant
Model 7	**Model 8**	**Model 9**	Bird and Ant	Caterpillar Species and Host Plant

Results: Models 1-3

Negative relationship between Probability of Parasitism and Bird Predation Risk

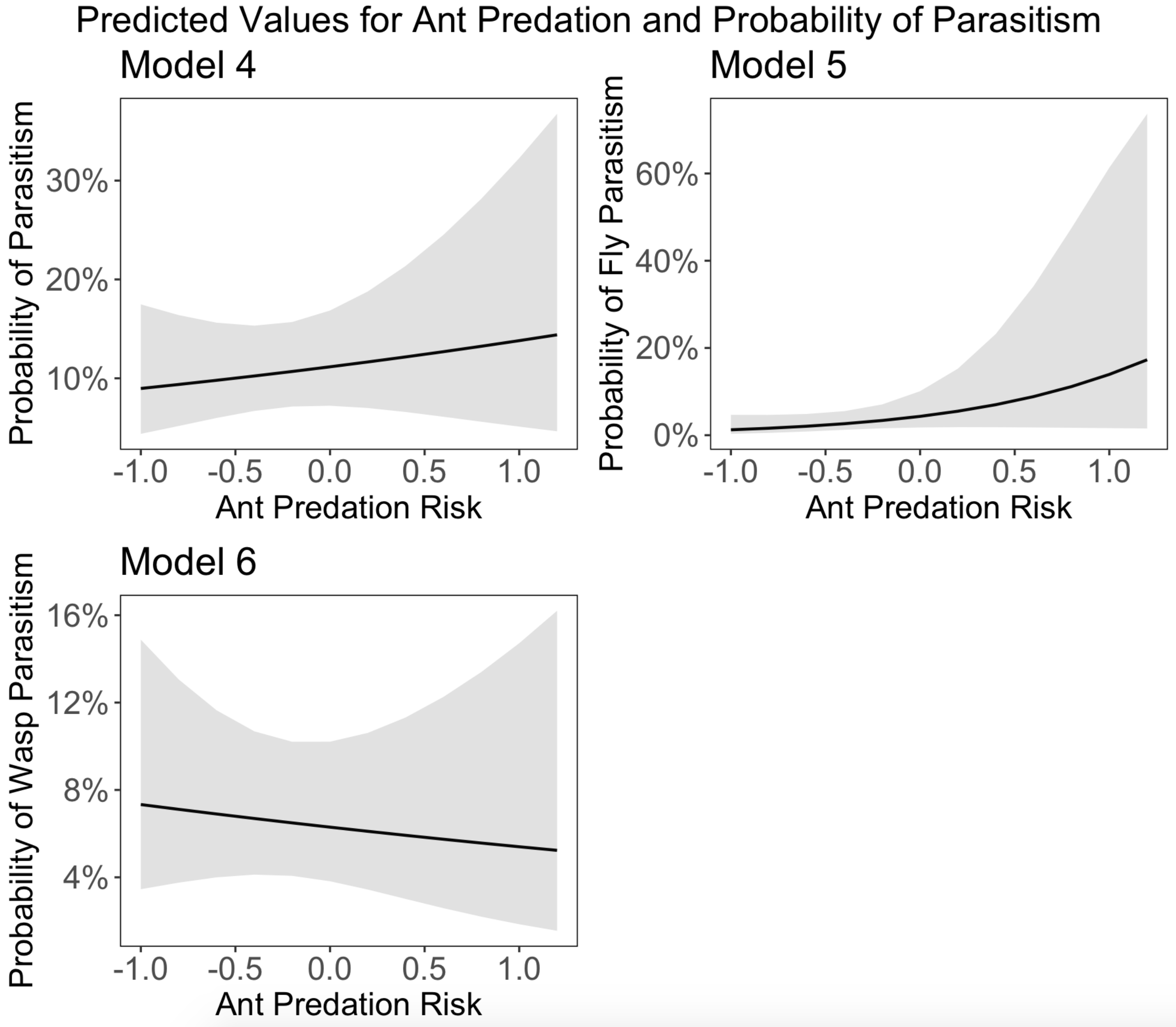
Trends are what we predicted but not significant



Results: Models 4-6

Trends are not what we predicted and not significant

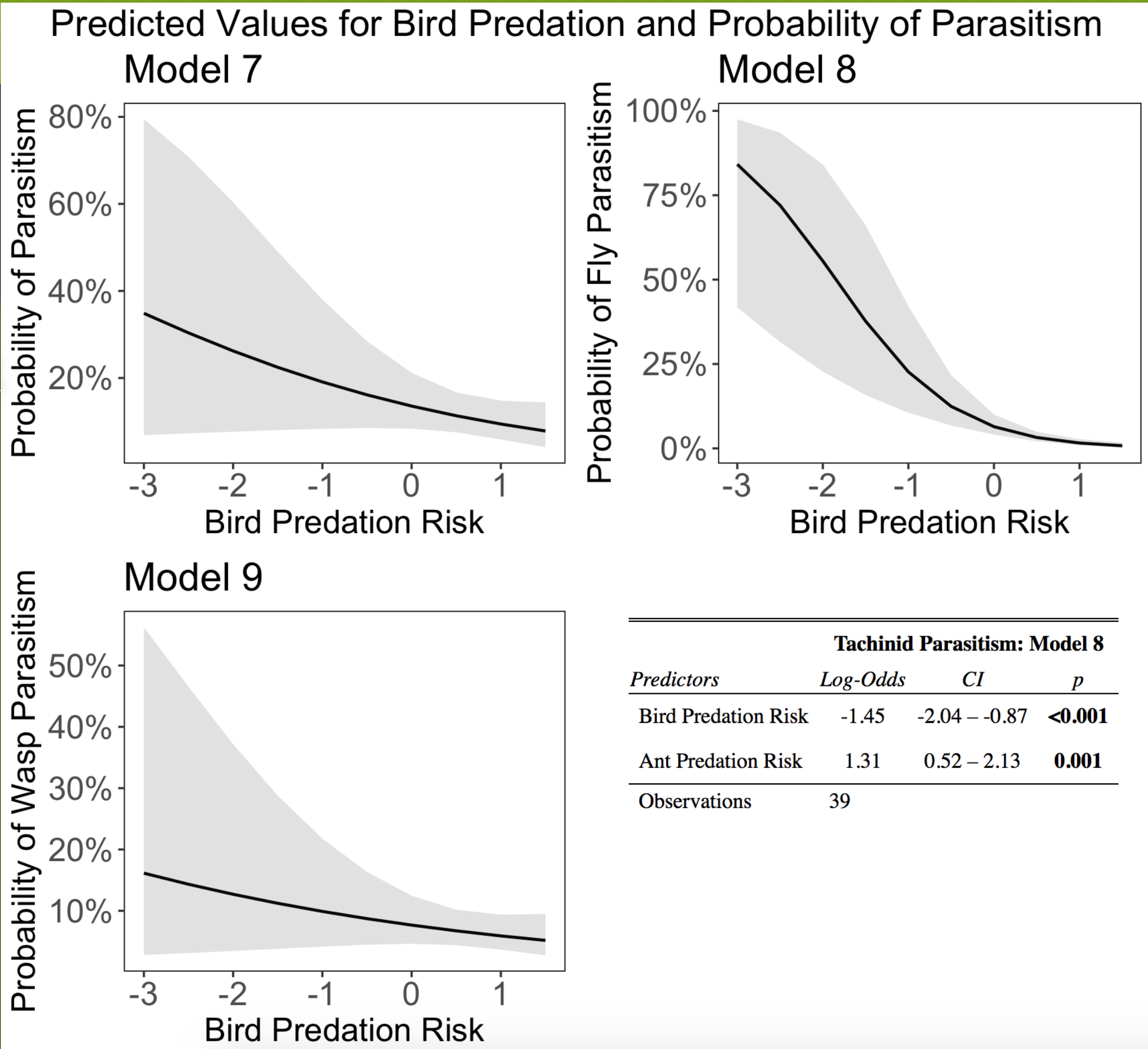
Risk of Ant Prediction had little to no effect on probability of parasitism



Results: Models 7-9 (Bird Predation)

Relationship between risk of bird predation and probability of parasitism is stronger

Highly significant relationship for fly parasitism



	Tachinid Parasitism: Model 8		
Predictors	*Log-Odds*	*CI*	*p*
Bird Predation Risk	-1.45	-2.04 – -0.87	**<0.001**
Ant Predation Risk	1.31	0.52 – 2.13	**0.001**
Observations	39		

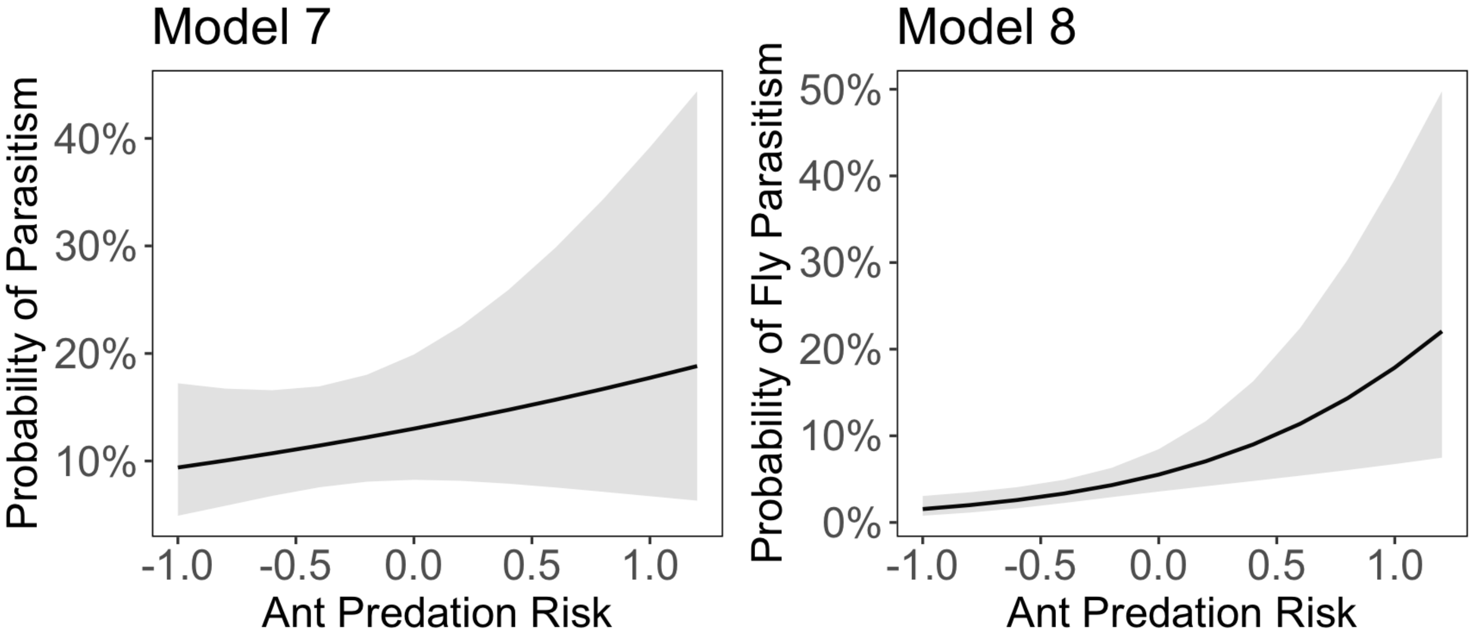
Results: Models 7-9 (Ant Predation)

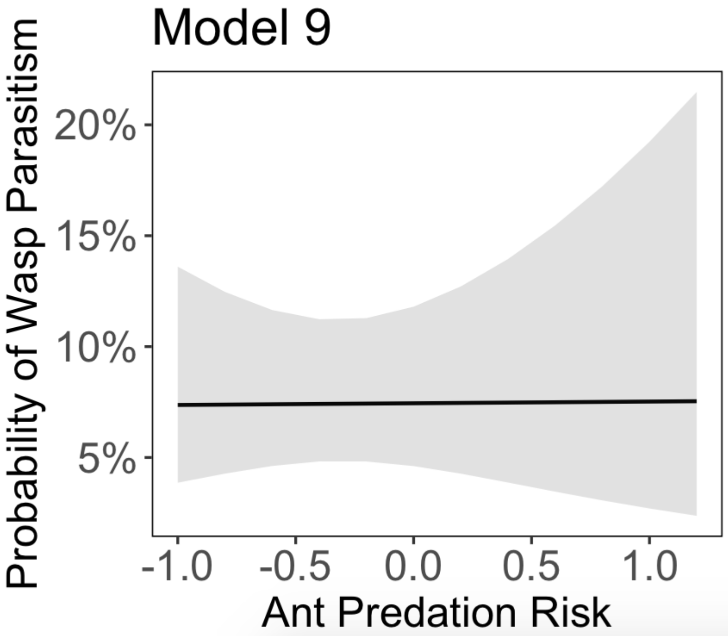
Risk of ant predation alone had little to no effect on probability of parasitism

When included alongside risk of bird predation effects of both are more detectable

Highly significant relationship for fly parasitism

Predicted Values for Ant Predation and Probability of Parasitism





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Conclusion

Fixed effects have large influence on probability of parasitism

EFS plays a role alongside fixed effects, but only when accounting for risk from both predators

What does it mean that probability of fly parasitism is a function of predation risk?

Spicebush swallowtail in defensive, snake-mimicking stance

Conclusion

Highlights that life-history differences may translate to ecological differences

Other factors like volatile organic compounds likely play a role

Community studies should increasingly consider many contributing factors as questions become more specific

Gregarious caterpillars on *Smilax*

Acknowledgments

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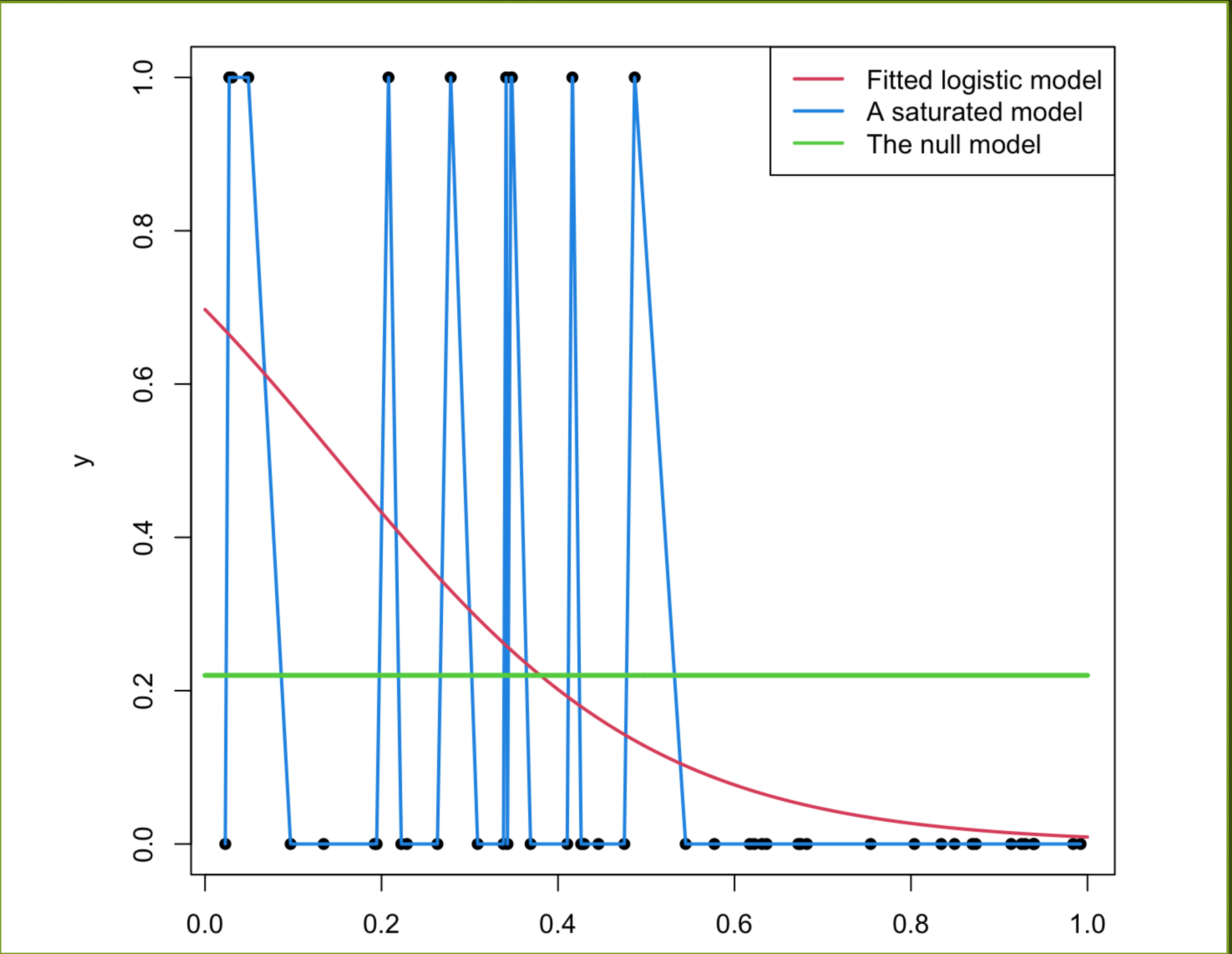
Emily Johnson

Rob Clark

A final big thank you to my parents and to Bella, for helping and supporting me this past year

Bonus Parasitoid: *Megarhyssa atrata* is a parasitoid of wood-boring insects

Analysis of Deviance



Measures the deviance of the fitted model with respect to the saturated model

The F-Test compares the reduction in deviance from adding each term to the null model