

Dynamics of invasion in a giant hornet: what limits distributions and what are the consequences of geographic expansions?

BIOL 3309 Case Study (Group Activity #3)
Due September 28, 2020

Part I – Introduction

The geographic distributions of species are limited by three main categories of factors: (1) abiotic conditions suitable for a given species (“A”), (2) biotic interactions suitable for a given species (“B”), and (3) mobility (“M”), or the idea of a species being able to reach potentially suitable regions (based on biotic and abiotic conditions). For example, some species have evolved in Africa, and their dispersal ability limits their mobility to reach North America. Climate change, natural disasters, or human-mediated dispersal may all change a species “M” and allow said species to reach geographic regions they have not been able to colonize in the past. In the context of the BAM diagram, this may look like the below figure:

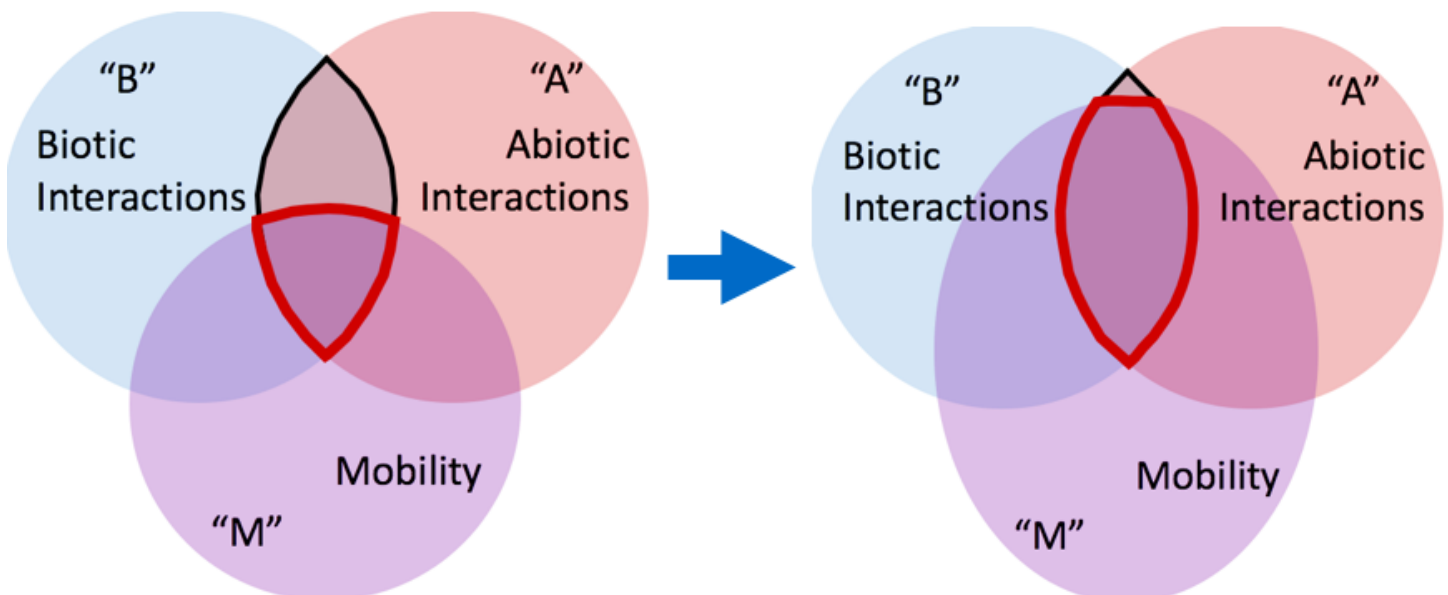


Figure 1. An example of an increase in mobility, increasing the size of the realized niche of a hypothetical species (red outlined region of Venn diagram).

Study Organism: *Vespa mandarinia*

The world's largest hornet *Vespa mandarinia*, also known as the Asian Giant Hornet (Figure 2), is a hymenopteran that evolved in eastern Asia. The Asian Giant Hornet (hereafter *Vespa*) is largely predatory, and hunts many insects that are smaller than it, including honeybees. Bees that have evolved in close proximity to *Vespa* have developed strategies for defense against *Vespa* attack. Recently, *Vespa* has invaded the Pacific Northwest in North America (likely due to human-mediated dispersal), where native bee populations have not evolved a defensive strategy against *Vespa* attack, and entire colonies of bees may be wiped out by a small group of hornets. This has led to sensationalist media stories about "murder hornets" across North America and has led people to kill large native hymenopterans across the USA because of taxonomic confusion, including species such as the Eastern Cicada Killer (*Sphecius speciosus*; Figure 2). It is relevant to note, that species such as cicada killers are native and have a developed niche in North America, which is a completely different story compared to the invasive *Vespa*. The following information and questions relate to the geographic distribution of *Vespa*, the dynamics of its invasion into North America, and potential consequences for industry. Many of the figures and information presented below are developed from Nuñez-Penichet et al. (2020) (citation at end of document).



Figure 2. *Vespa mandarina* (left) and the Eastern Cicada Killer (*Sphecius speciosus*; right). *Vespa* photo from Wikimedia Commons and *Sphecius* photo by Dr. Manthey (taken in Lubbock).

Part II – The original geographic distribution of *Vespa*

Vespa mandarina originally evolved in eastern Asia and has known occurrences in several countries (Figure 3).

- 1) In the paper, the authors posited a hypothesis of one of the aspects of the BAM diagram, and drew this as blue lines in Figure 3. What part of the BAM diagram do you think the blue lines represent?
- 2) There appears to be a large geographic break in the distribution between populations. One grouping (in eastern China, South Korea, Japan, and Taiwan) appears disjunct from populations in the Himalayas. What are two potential explanations for this disjunct distribution?



Figure 3. Known occurrence points (red dots) of *Vespa mandarina* in its native range. Blue lines indicate a hypothesis by the authors related to one aspect of the BAM diagram.

Part III – Potential Invasion Dynamics of *Vespa mandarina*

The authors of the *Vespa* paper (Nuñez-Penichet et al. 2020) used a technique called ecological niche modeling to predict the invasion dynamics of *Vespa* invasion in North America. Briefly, this technique uses known occurrence points and abiotic conditions from those occurrence points to predict habitat suitability in (1) areas that have not been surveyed, (2) areas not historically accessible to the species, (3) climatic conditions from the past or predicted for the future.

The predictions from this study identified different areas of potentially suitable habitat for *Vespa* in North America as depicted in Figure 4. Here, more yellowish colors indicate a higher probability of climatic suitability for *Vespa*. Based on this model, the authors ran geographic simulations to assess potential pathways of invasion across North America (Figure 4).

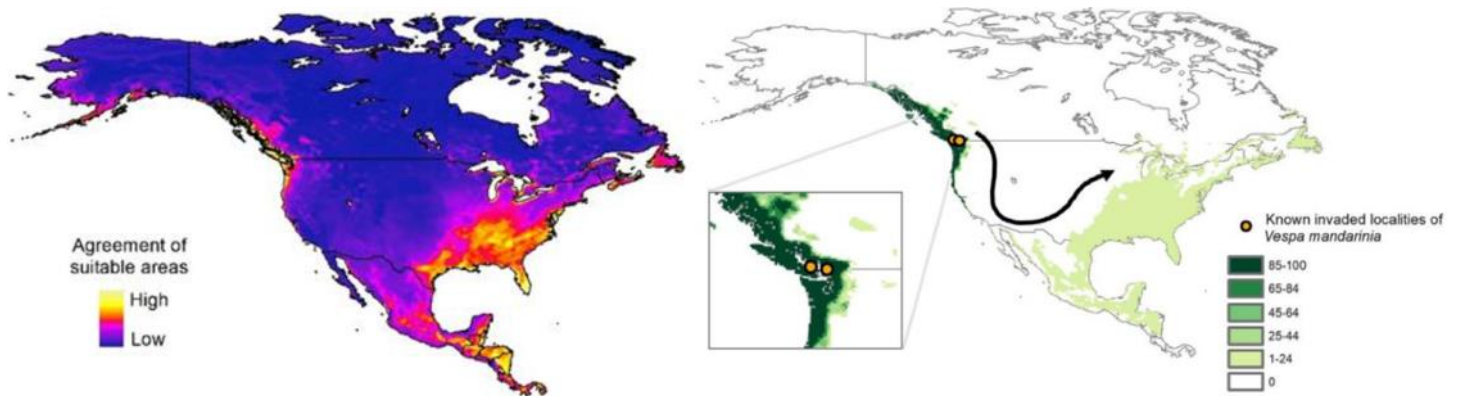


Figure 4. (Left) Potential suitable areas for *Vespa mandarina* in North America as predicted with ecological niche modeling. (Right) Results from simulations of the potential dynamics of invasion of *Vespa mandarina* in North America. Dark shades show areas that the species reached in a high proportion of simulation scenarios, while light shades represent areas reached rarely in simulation scenarios.

- 3) Based on your knowledge of climate (e.g., temperature and precipitation) in North America, what climate conditions appear appropriate for *Vespa* colonization in North America?
- 4) The ecological niche modeling used occurrence points and climatic conditions to predict the potential niche of *Vespa* in North America, which aspect(s) of the BAM diagram likely did not get incorporated into the modeling? At large spatial scales, what consequences may these omission(s) have on predicted geographic distributions of *Vespa*?

Part IV – Potential consequences for agricultural industries

As mentioned in the introduction, bee species that did not evolve in close contact with *Vespa* have no defense mechanisms against their attack. Figure 5 indicates honey production in the USA and Mexico.

- 5) Based on the scenarios of invasion dynamics (Figure 4) and information about honey production (Figure 5), which states are most likely to be impacted regarding their honey industry if no *Vespa* mitigation strategies are implemented? Justify your answer.

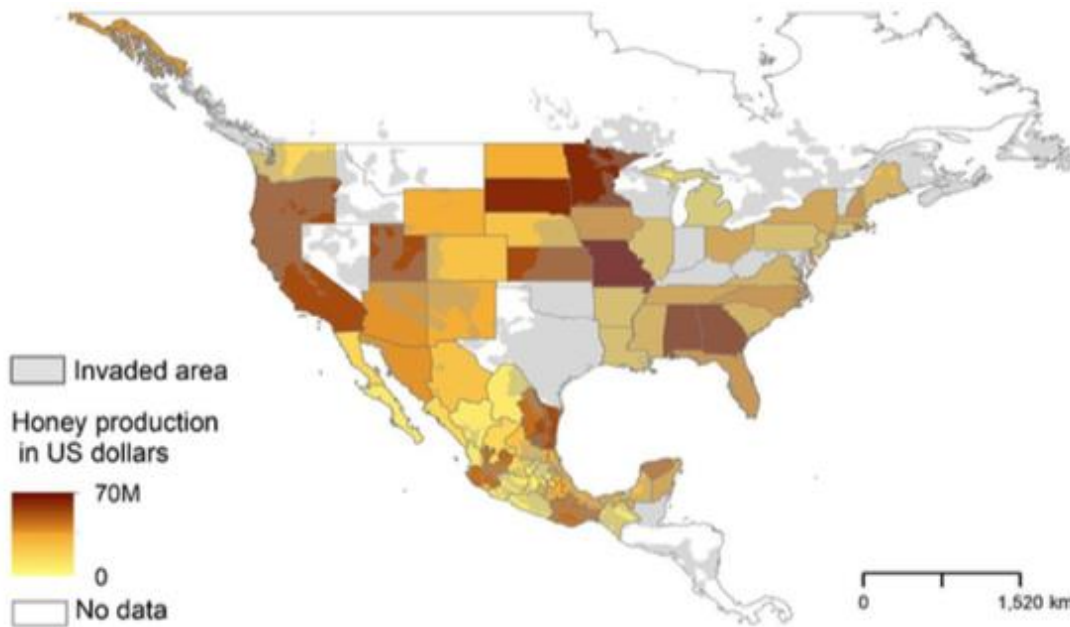


Figure 5. Representation of potential economic impacts of an invasion by *Vespa mandarinia*. Honey production (US dollars) in Mexico and USA in 2016. The area shaded in gray represents a maximum scenario of expansion (e.g., worst case scenario of simulations from Figure 4).

Citation:

Claudia Nuñez-Penichet, Luis Osorio-Olvera, Víctor H. Gonzalez, Marlon E. Cobos, Laura Jiménez, Devon A. DeRaad, Abdelghafar Alkische, Rusby G. Contreras-Díaz, Angela Nava-Bolaños, Kaera Utsumi, Uzma Ashraf, Adeola Adeboje, A. Townsend Peterson, Jorge Soberón. (PrePrint) Geographic potential of the world's largest hornet, *Vespa mandarinia* Smith (Hymenoptera: Vespidae), worldwide and particularly in North America. bioRxiv doi 10.1101/2020.08.11.246991

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