Ecology & Evolutionary Biology
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Phymata americana

Hot models: predicting the current and future distributions of two ambush bug species

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Phymata pennsylvanica

Introduction

The fundamental niche[1]: a species persists in a limited space given a series of environmental variables.

- Overlapping distributions implies a combination of environmental variables allowing persistence
- Ranges may shift with climate change, leading to greater overlap (species hybridization or competition/collapse) or less overlap
- Species Distribution Models (SDM) like Maxent[2] can identify influential environmental variables and forecast future ranges

Objectives

1. Identify the environmental variables that have the largest influence on the distribution of *P. americana* and *P. pennsylvanica*.
2. Predict current and future ranges of *P. americana* and *P. pennsylvanica*.

Study Organisms

P. americana and ***P. pennsylvanica***

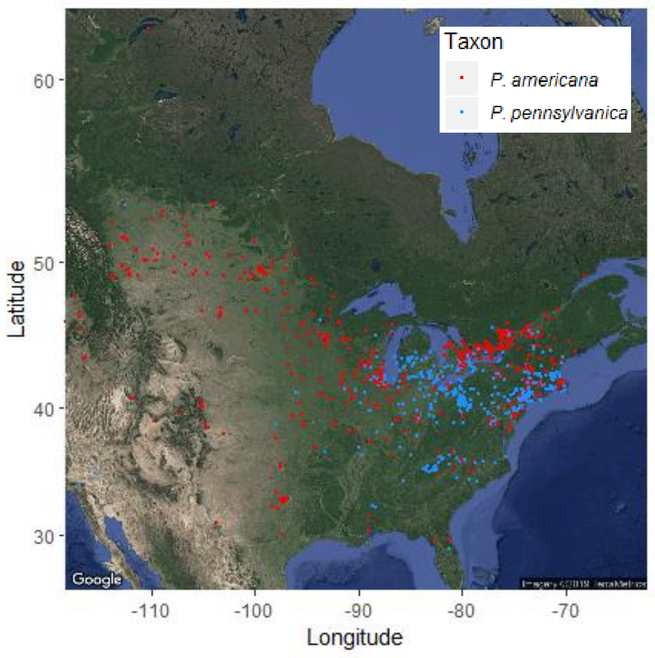

Figure 1. Localities of ambush bug sightings.

- Two closely-related, parapatrically-distributed (Figure 1) ambush bug species that can hybridize[3]
- Range shifts observed (Figure 2)

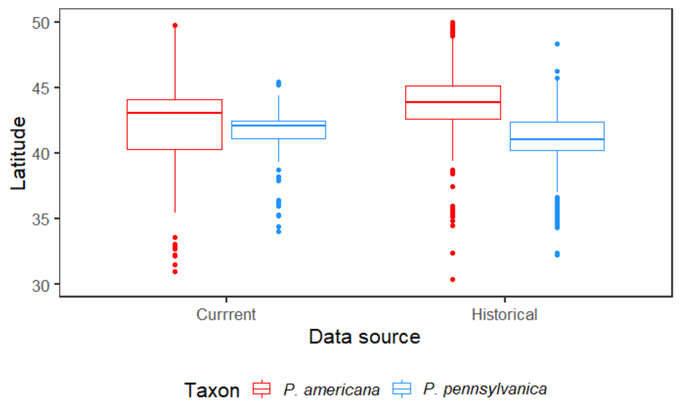

Figure 2. Distribution shifts in latitudes. Outliers removed to facilitate visualization.

Results

P. americana		*P. pennsylvanica*
	Objective 1: Identification of environmental variables	
Precipitation seasonality	**Largest relative percent contribution to the model**	April precipitation
September maximum temperature	**Largest percent contribution as an isolated variable**	November minimum temperature
Precipitation seasonality	**Variable with the most information not present in others**	October precipitation
	Objective 2: Predicting current and future ranges	
570,000 km^2	**Total current suitable habitat**	290,000 km^2
4% decrease	**Range shifts at RCP2.6** (projections based on lowest CO_2 emissions)	0.19% decrease
24% decrease	**Range shifts at RCP8.5** (projections based on highest CO_2 emissions)	24% decrease

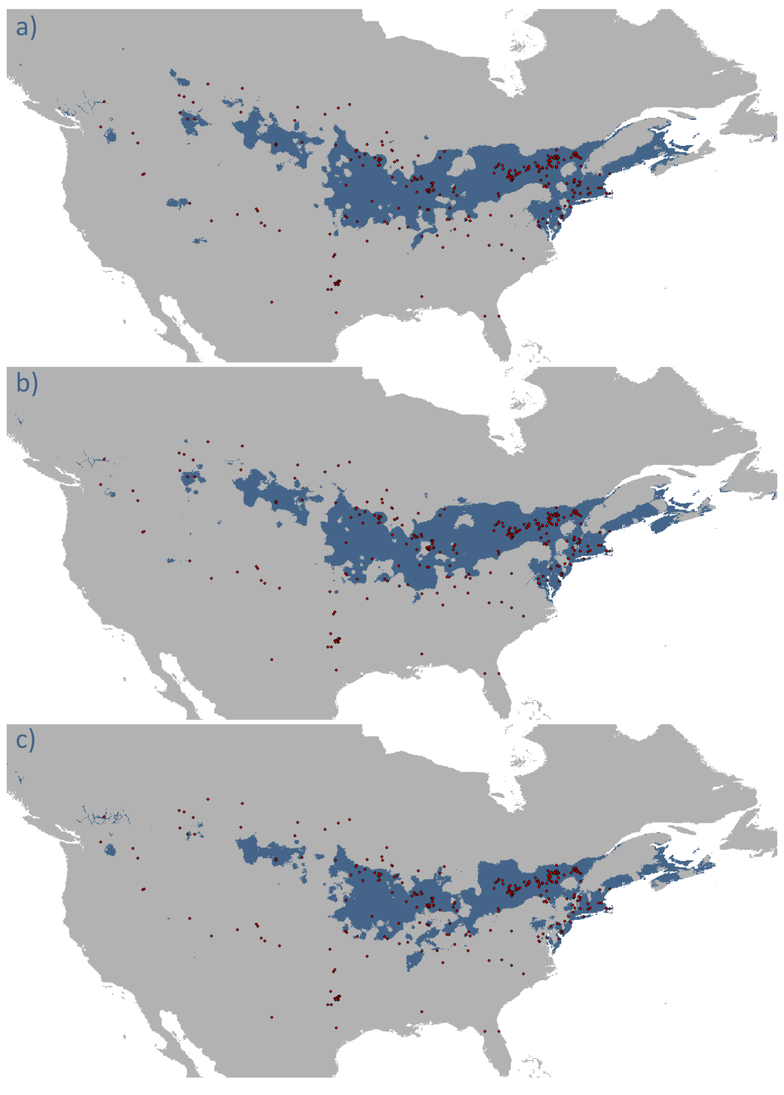

Figure 3. Actual sightings (points), predicted current range (a), and predicted future distributions of *P. americana* under RCP2.6 (b) and RCP8.5 (c).

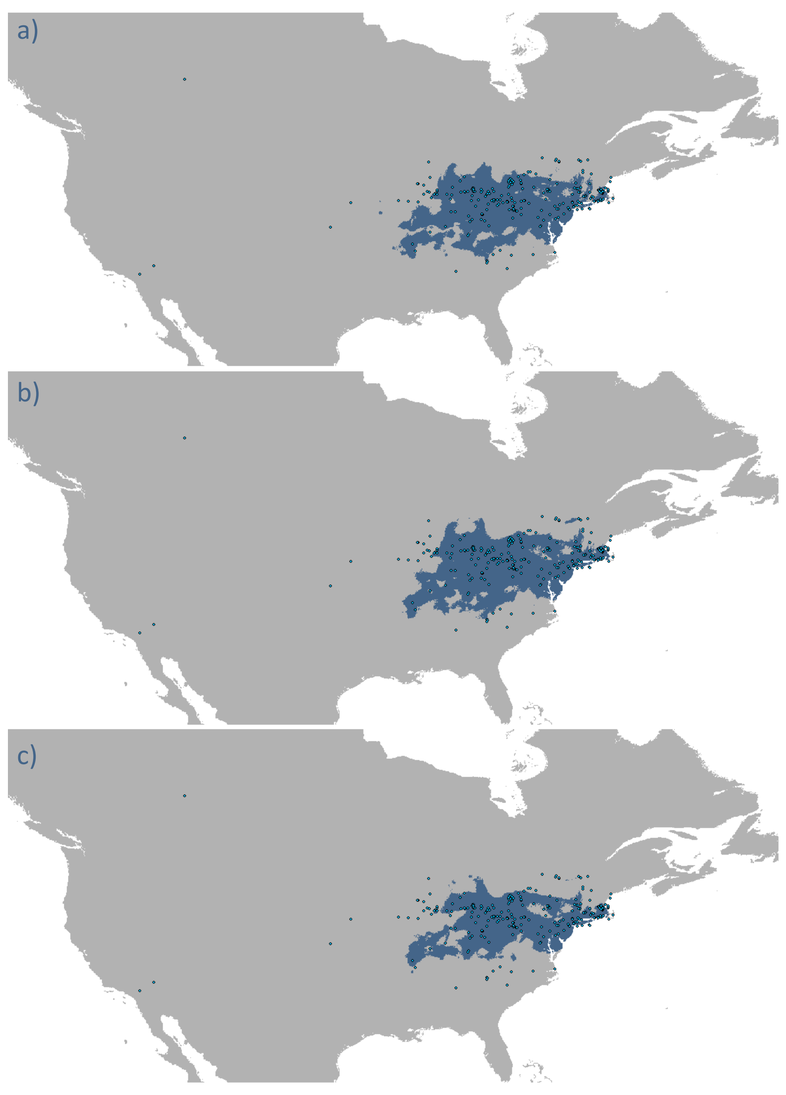

Figure 4. Actual sightings (points), predicted current range (a), and predicted future distributions of *P. pennsylvanica* under RCP2.6 (b) and RCP8.5 (c).

Discussion

Evidence of environmental requirements for *P. americana* and *P. pennsylvanica*

- Variables contribute to realized niches, leading to parapatric distributions
- Abiotic factors identified that should be studied for ambush bug taxonomy and conservation

Predicted ranges decrease with worsening climate change scenarios

- At RCP2.6, *P. pennsylvanica* is less sensitive to changes or have already reached range boundaries
- At RCP8.5, almost a quarter of currently suitable habitat is predicted to be unsuitable
  - However, there is less range overlap
- Caveat: actual distributions may be smaller than predicted.
  - Other factors can affect ranges (e.g., biotic interactions, anthropogenic factors, physical barriers)
  - Requires field research to test direct effects

Methods

Species distribution data collected from museum archives and the citizen science websites iNaturalist.org and BugGuide.net.

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Environmental data collected from WorldClim.org[4] included 55 variables for current environmental and four Representative Concentration Pathways (projected climate change scenarios).

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Predict ranges using Maxent (Maximum Entropy for Species Distribution Modeling[2]): generated current predicted distributions and four future predicted distributions for *P. americana* and *P. pennsylvanica*.

↙ ↘

Identifed the most important bioclimatic variables by creating response curves and jackknife plots on Maxent.

Created binary maps on ArcMap using Maxent's Maximum Sensitivity Plus Specificity (MSS) to determine suitable and unsuitable habitats.

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Calculated percent change using the attribute table of current and future binary maps on ArcMap.

References

1. Hutchinson GE. 1957. Concluding remarks. In: Cold Spring Harbor Symposia on Quantitative Biology. p. 415-427.
2. Phillips S. 2010. "A Brief Tutorial on Maxent" in Species Distribution Modeling for Educators and Practitioners. Lessons Conserv. 3:107-135.
3. Punzalan D., Rowe L. 2017. Hybridisation and lack of prezygotic barriers between *Phymata pennsylvanica* and *americana*. Ecol Entomol. 42(2):210-220.
4. WorldClim. 2011. WorldClim – Global Climate Data.

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