Exploring the extent of range shifts for snowflies (Plecoptera: Capniidae) in a changing world

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Introduction

Stoneflies provide pivotal ecosystem services in both aquatic and terrestrial ecosystems:

- food sources for predators
- indicators of water quality
- mediate nutrient cycling and energy flow[1].

Snowflies emerge as adults from Holarctic streams in harsh snowy environments in a frenzied pursuit to pass on their genes[2].

Changes in Capniidae species' ranges and distributions in response to altered climate regimes have generally led to them inhabiting more northward and higher altitudinal habitats[3,4,5] .

Methods

I queried GBIF for largest locality datasets for 3 genera, then projected each species' suitable habitat to their modern distribution. Cloglog maps were transferred with Worldclim variables in the best-case climate scenarios with SSP126. The global circulation model ACCESS-CM2 with no set threshold predicted the range for all species for the years 2061-2080.

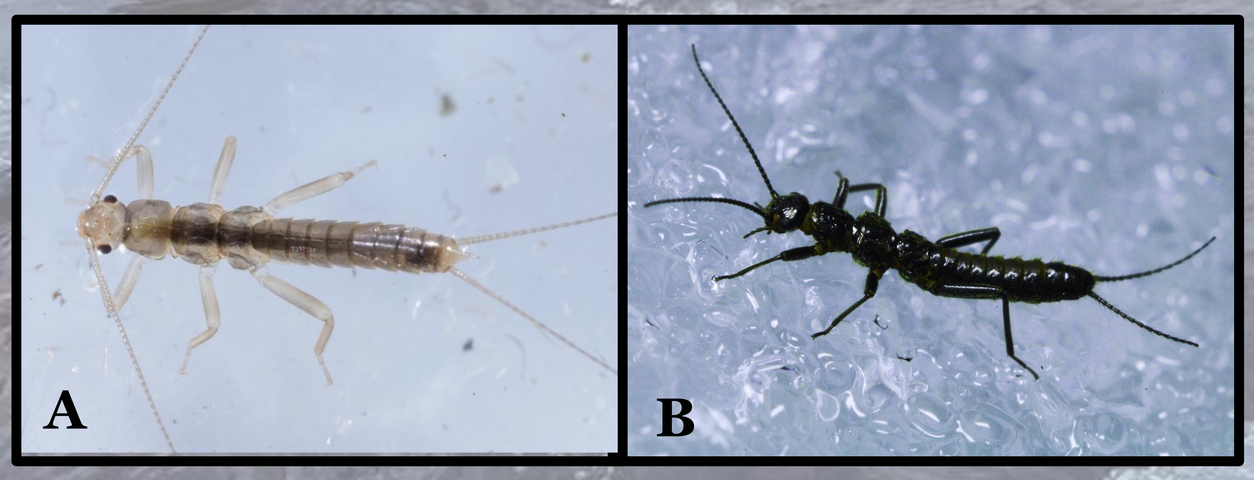

Figure 1. A. *Capnia zijinshana* nymph (iNaturalist: slowswakey). B. *Capnia sp.* from Utah emerged as an adult onto snow (C. Riley Nelson).

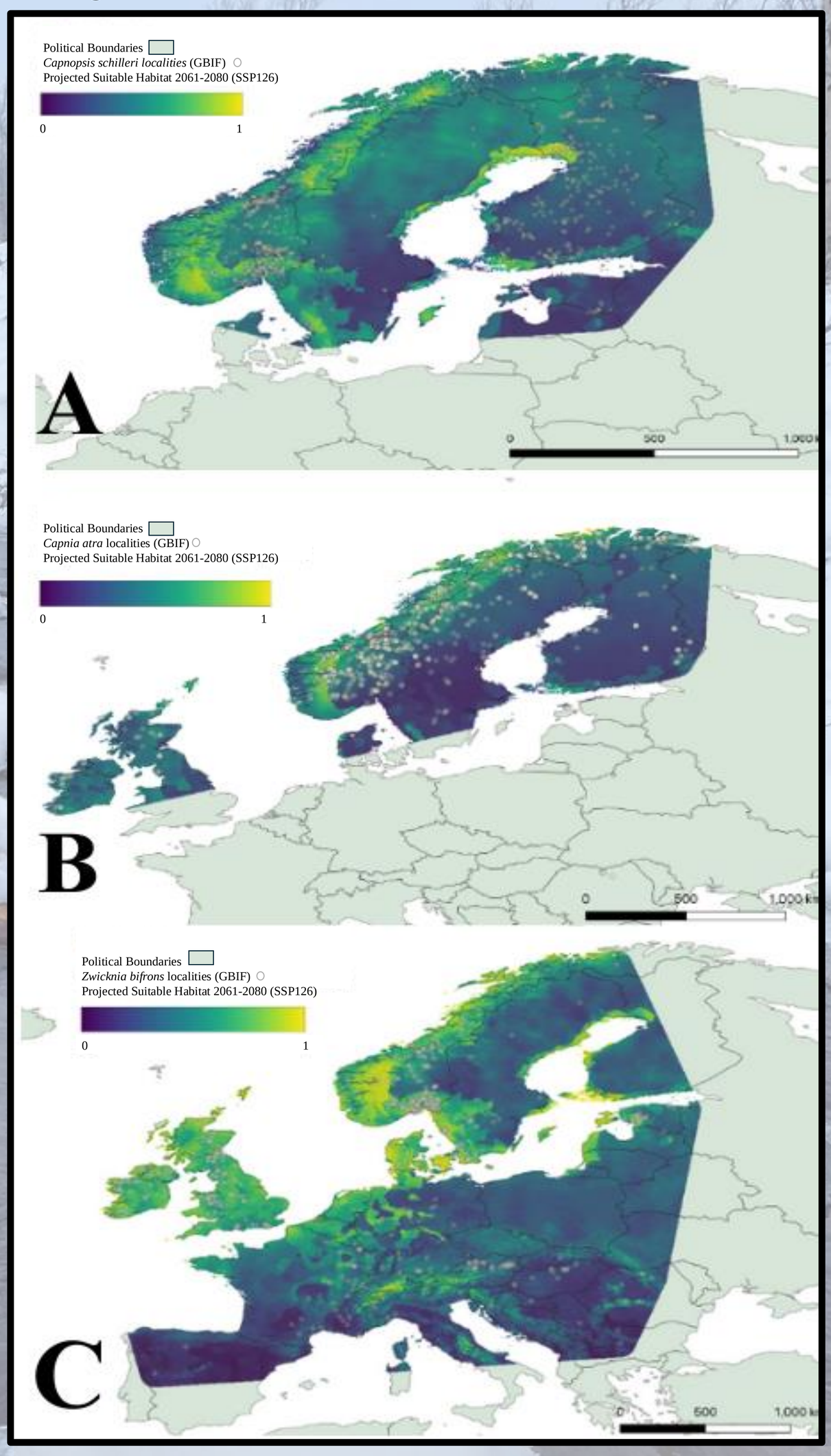

Figure 2. A. *Capnopsis schilleri* future suitable habitat projection. B. *Capnia atra* future suitable habitat projection. C. *Zwicknia bifrons* future suitable habitat projection

Results and Discussion

Capnopsis schilleri will not have suitable habitat within inland Scandinavia and will be more likely to subsist along the coastlines in 2061-2080 (Figure 2, A). *Capnopsis schilleri*'s most influential bioclimatic variables are the mean temperature of the warmest quarter and the mean temperature of the wettest quarter. *Capnia atra* will be much less likely to be found in the United Kingdom and Southeastern portions of Scandinavia in future climatic projections according to the model (Figure 2; B). *Capnia atra* distributions are similarly influenced heavily by the mean temperature of the wettest quarter and mean temperature of the driest quarter. *Zwicknia bifrons* will be much more likely to inhabit higher latitudes in Scandinavia and higher altitudes such as the Italian alps in future climatic projections (Figure 2; C). *Zwicknia bifrons* distributions are impacted by isothermality and the mean temperature of the warmest quarter. Overall, these European snowfly distributions will indeed be limited to high altitudes and latitudes.

References: 1. DeWalt, R. E., & Ower, G. D. (2019). Ecosystem services, global diversity, and rate of stonefly species descriptions (Insecta: Plecoptera). *Insects*, *10*(4), 99. **2.** Bouchard Jr, R. W., Schuetz, B. E., Ferrington Jr, L. C., & Kells, S. A. (2009). Cold hardiness in the adults of two winter stonefly species: Allocapnia granulata (Claassen, 1924) and A. pygmaea (Burmeister, 1839)(Plecoptera: Capniidae). *Aquatic Insects*, *31*(2), 145-155. **3.** Ward, J.V. (1992) Aquatic insect ecology, Vol. 1. Biology and habitat. Wiley, New York . **4.** Annaratone, B. (2023). *The Influence of Climate and Landscape on Allocapnia mohri Distribution in Arkansas* (Doctoral dissertation, University of Arkansas). **5.** Ross, H. H., & Yamamoto, T. (1967). Variations in the winter stonefly Allocapnia granulata as indicators of Pleistocene faunal movements. *Annals of the Entomological Society of America*, *60*(2), 447-458.