

Comparing herbivory in native and invasive honeysuckles using natural history collections

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PROJECT OVERVIEW

The enemy release hypothesis describes one strategy by which invasive plants become successful colonizers. Migration away from a plant's native range may release it from the herbivory from its native predators, allowing it to grow unrestricted¹. *Lonicera* is a widespread and diverse clade of honeysuckles and an ideal system to study this hypothesis with 11 invasive and 12 native species in the US. *Lonicera tatarica* is invasive and widespread in North America, being native to Eastern Europe and Asia (Fig 1A, 1C), while *L. canadensis* is native to Eastern North America (Fig 1B).

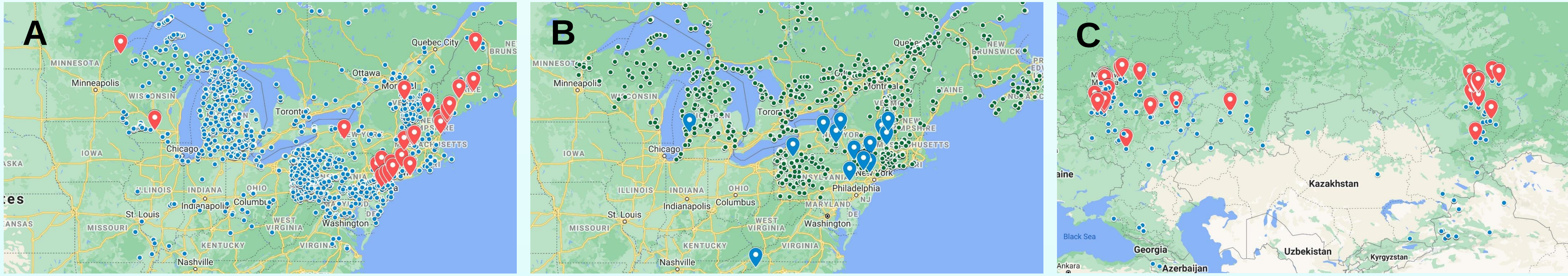


Fig 1. A. Global distribution of *L. tatarica* and *L. canadensis*. Current distribution of *L. tatarica* in northeastern North America shown as blue dots. Specimens sampled in this study shown in red. **B.** Current distribution of *L. canadensis* in northeastern North America shown as green dots. Specimens sampled in this study shown in blue. **C.** Current distribution of *L. tatarica* in Eurasia shown as blue dots. Specimens sampled in this study shown in red. Occurrence data from GBIF², maps made in Google Maps.

Currently there are over 3000 specimens digitized worldwide of *L. tatarica* and *L. canadensis*. Multiple forms of herbivory damage can be recognized and quantified on herbarium specimens but working with these specimens brings biases³. In this study we propose two hypotheses:

1. *L. tatarica* in its native and invasive range experience differing levels of herbivory
2. *L. tatarica* and *L. canadensis* experience differing levels of herbivory in the same geographic range

RESULTS

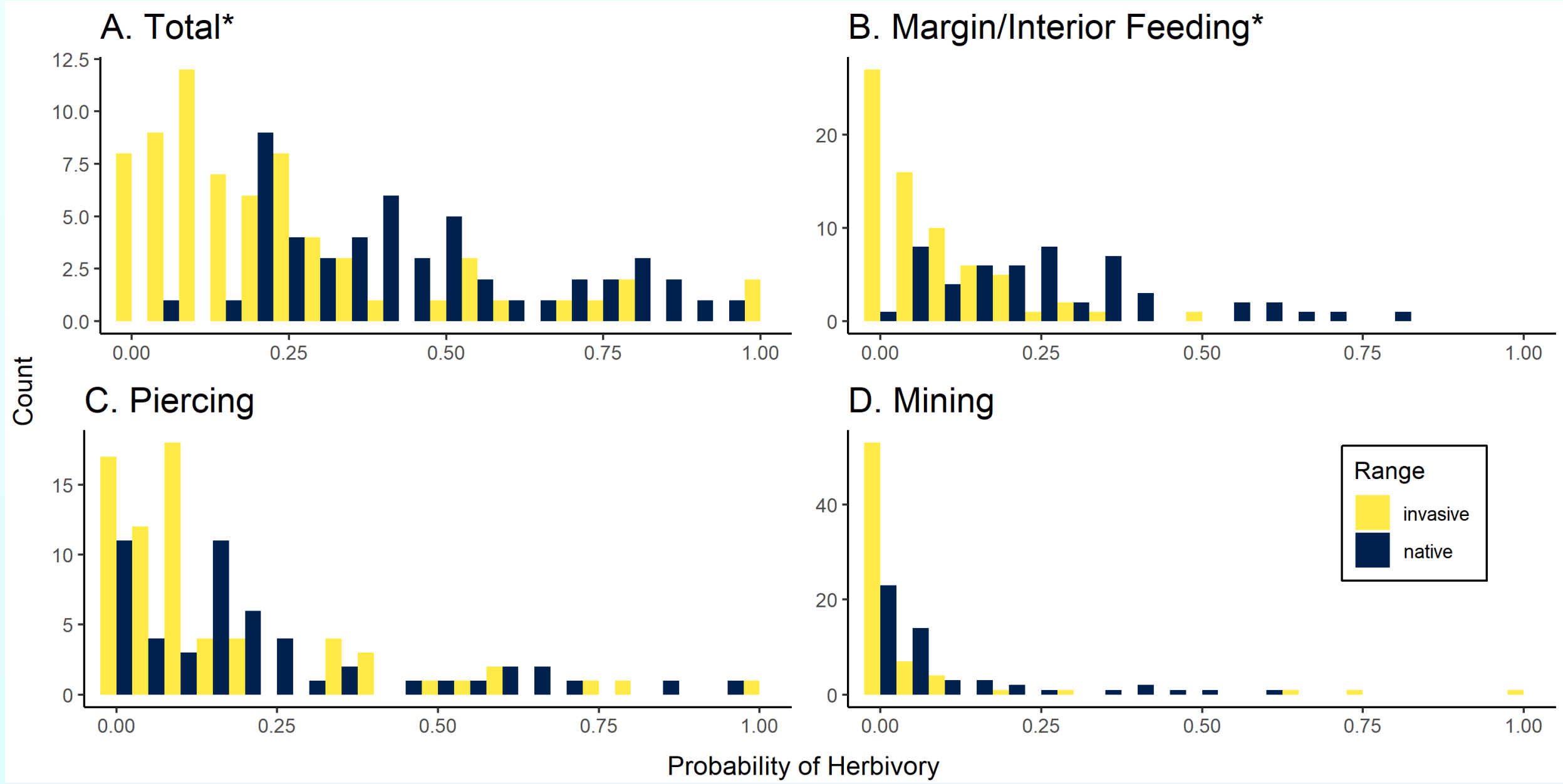


Fig 4. Histograms of probability of herbivory in herbarium specimens of *L. tatarica* in Russia (blue, n = 52) and northeastern North America (yellow, n = 69). Significant differences of herbivory damage reflecting the comparison of *L. tatarica* occurring in native versus invasive ranges were found for All Herbivory types combined (A) and Margin/Interior Feeding (B), but not Piercing (C) or Mining (D) ($p < 0.05$). ($p_A = 1.32 \times 10^{-6}$, $p_B = 2.09 \times 10^{-10}$, $p_C = 0.178$, $p_D = 0.0922$)

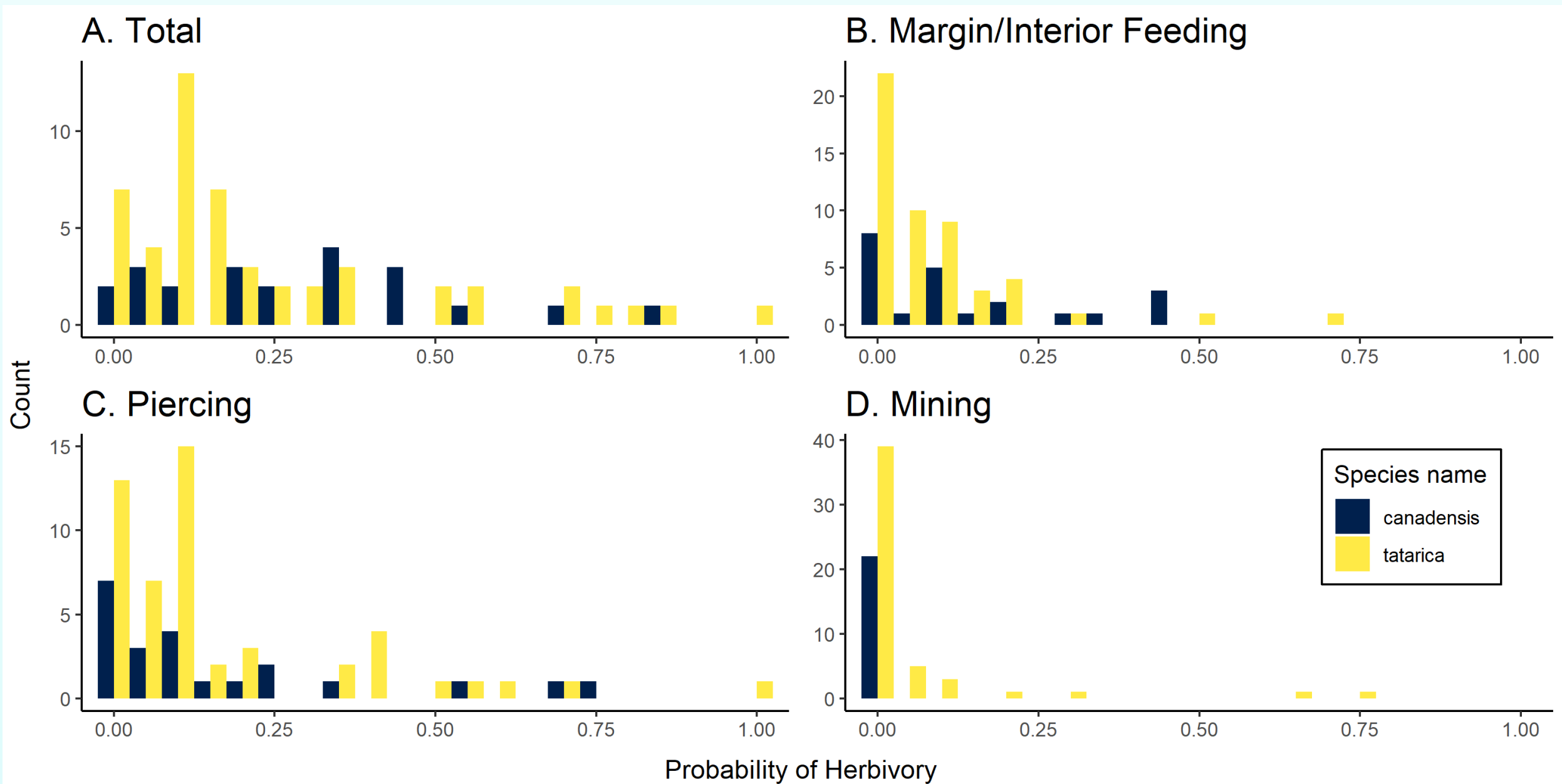


Fig 5. Histograms of probability of herbivory in herbarium specimens in northeastern North America for *L. tatarica* (yellow, n = 86) and *L. canadensis* (blue, n = 22). Significant differences of herbivory damage reflecting the comparison of *L. tatarica* and *L. canadensis* in the same geographic area were not found for All Herbivory types combined (A), Margin/Interior Feeding (B), Piercing (C), or Mining (D). ($p_A = 0.382$, $p_B = 0.102$, $p_C = 0.818$, $p_D = 0.122$)

***L. tatarica* in Russia experience more total herbivory and margin/interior feeding than *L. tatarica* in North America**

METHODS

- Digitized specimens were downloaded from the Mid-Atlantic Herbaria Consortium⁴ and Moscow Digital Herbarium⁵ portals from northeastern North America and Russia
- Digital 4cm grids were overlaid on each specimen in GIMP⁶ (Fig 2)
- Each specimen was manually scored for the presence or absence of each type of herbivory for each square with $\frac{1}{4}$ of the square covered by leaf tissue
- A probability of herbivory for each specimen was calculated for total damage, margin and interior feeding, and mining damage in R⁷
- Biases were assessed for *L. tatarica* dataset
 - We ensured coverage of species distributions to address geographic bias (Fig 1)
 - Temporal biases shown in Fig. 3 – native *L. tatarica* specimens seem to be collected more recently. We applied a strict cutoff removing 36 specimens collected before 1950. No cutoff applied for month of year.
- Analysis of variance (ANOVA) was run on each type of damage for the two hypotheses

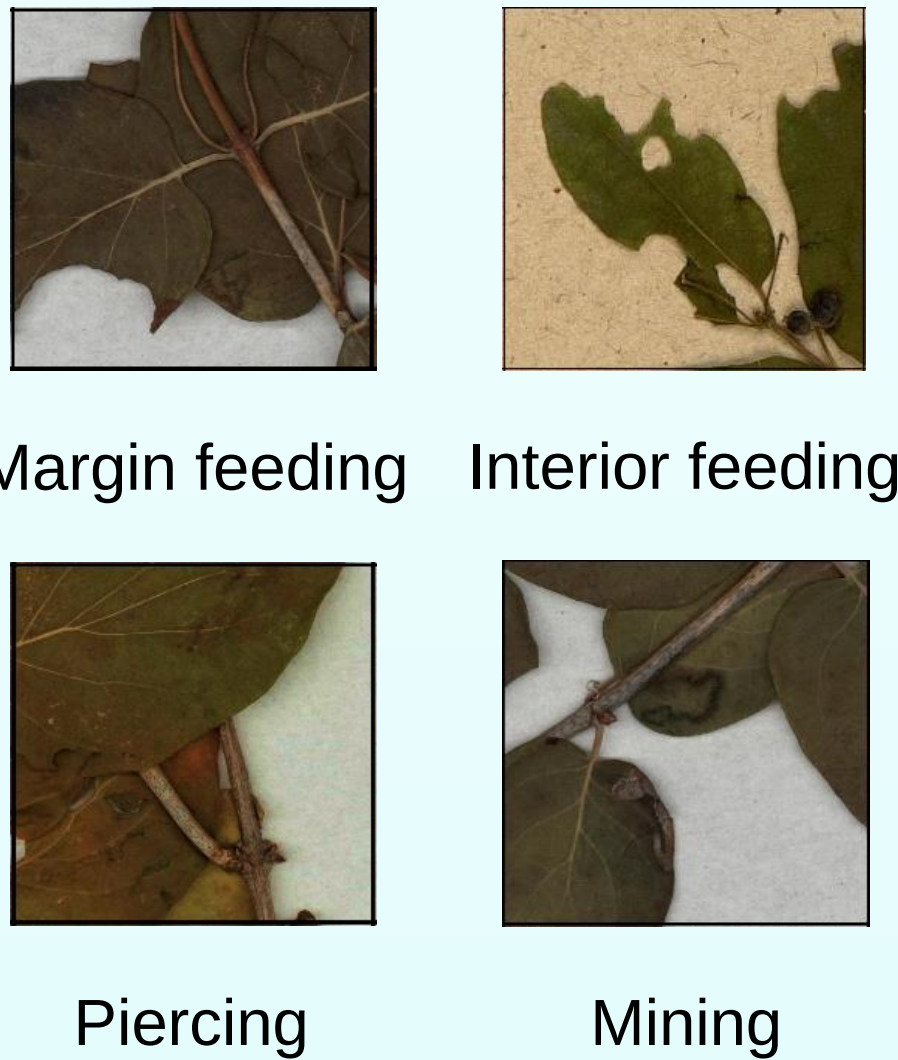


Fig 2. Herbarium specimen of *L. tatarica* from the Siberian Branch of the Russian Academy of Sciences (IHE SB RAS), downloaded from the Moscow Digital Herbarium⁵ and with 4cm grid overlaid in GIMP (specimen ID# = KUZ004633). Four types of herbivory damage are shown on the right.

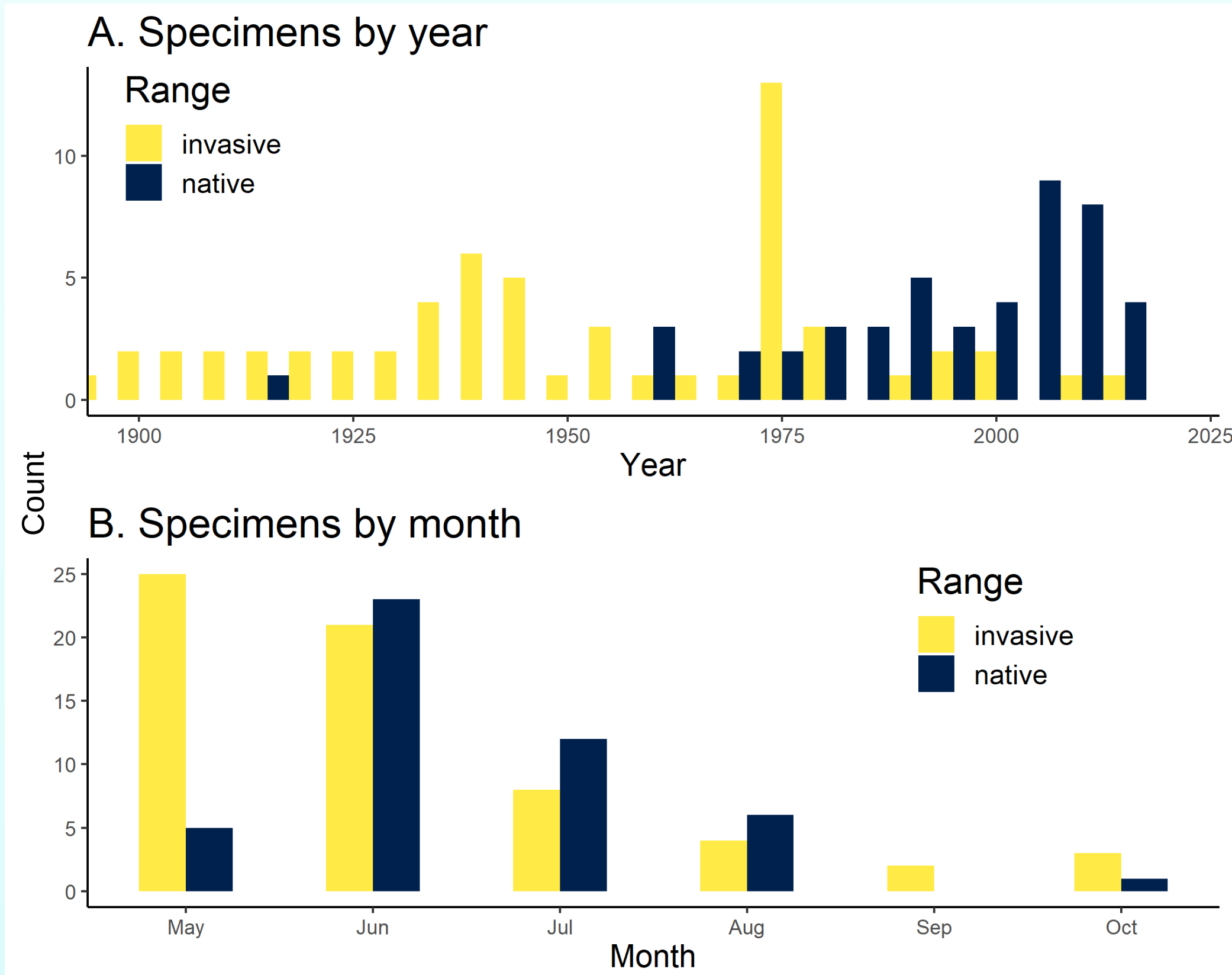


Fig 3. Bias assessments in *L. tatarica* dataset of 157 specimens. **A.** Histogram of *L. tatarica* specimens sampled by year. **B.** Histogram of *L. tatarica* specimens sampled by month. Specimens from Russia are shown in blue and specimens from the Northeast are shown in yellow.

DISCUSSION

L. tatarica's colonization of northeastern North America likely came with the loss of Asian insect predators, as per the enemy release hypothesis. Our data show that *L. tatarica* is experiencing less herbivory in its invasive range, in particular margin/interior feeding damage. It is necessary to address biases when working with herbarium specimens, including geographic, temporal, and collector's bias. We found no issue with biases of geography and time of year but did with year bias. The growing number of digitized herbarium specimens from natural history museums across the globe enables studies of this scale.

Next steps:

1. Score more specimens, be it from the same herbaria, different herbaria, or involving additional native and invasive species. Do other invasive *Lonicera* species use similar strategies in colonization?
2. Further bias assessments as we expand sample size
3. Use machine learning for herbivory detection. GinJinn⁸ is a deep-learning object-detection pipeline for herbarium specimens that members of my lab have used for leaf recognition and perhaps can be adapted for herbivory recognition.

REFERENCES

¹Keane, Ryan M. and Crawley, Michael J. (2002). Trends in Ecology and Evolution, 17(4): 164-170. ²GBIF.org (28 July 2021) GBIF Occurrence Download <https://doi.org/10.15468/dl.kdnz4w> ³Meineke, Emily, et al. (2018). Journal of Ecology, 107(1): 105-117. ⁴Mid-Atlantic Herbaria. 2021. Accessed on August 05. ⁵National Depository Bank of Live Systems. 2021. Accessed on August 05. ⁶The GIMP Development Team. (2019). GIMP. ⁷R Core Team (2021). R Foundation for Statistical Computing, Vienna, Austria. ⁸Ott, T., Palm, C., Vogt, R., & Oberprieler, C. (2020). Applications in plant sciences, 8(6), e11351

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