Remnants of The Bering Land Bridge: DNA Barcoding Arthropods in the Pribilof Islands

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Abstract

Alaska has a distinct biogeographic history and a rapidly warming climate. It is thus a critical and time-sensitive region for bio-inventory. Our goal is to better understand Alaska's endemic arthropods (species known only from Alaska).

Samples were collected on Saint Paul Island in 2022. Saint Paul Island is within the Pribilof archipelago, and comprised a portion of the Bering Land Bridge. **Due to the isolation of the Pribilofs, we predict the arthropod fauna of these islands will contain more genetically unique populations than comparable samples from mainland Alaska.**

The collected samples were sorted and databased. Preliminary identification and photography is underway. Resultant tissue samples will be loaded into 96-well plates and sent to the University of Guelph for DNA barcoding. The resulting DNA barcodes will enable us to test our prediction and create a checklist of Saint Paul Island's non-marine macroinvertebrate fauna.

Preliminary results include the detection of multiple arthropod taxa previously undocumented in the Pribilof Islands. We expect our genetic barcoding results to greatly increase the number of newly documented species. Our results will also allow deeper insight into the mysteries of Beringia and Alaska's unique genetic biodiversity.

Background

Due to Alaska's rapidly changing climate and novel biogeographic history, bioinventory of the region is of significant concern. During the most recent glacial maximum, Alaska served as a refuge for many organisms, resulting in the existence of hundreds of endemic nonmarine macroinvertebrate species. In the summer of 2022, PhD student Taylor Kane and her advisor Dr. Derek Sikes collected samples of nonmarine macroinvertebrates on Saint Paul Island.

St Paul is the largest of the two principal islands within the Pribilof archipelago. These islands were once high-elevation regions of the Bering Land Bridge and part of Beringia's glacial refugium which acted as a bridge for dispersal between Asia and North America. This resulted in a high rate of endemism and complex patterns of evolution and biogeography.

Literature research indicates 17% of the arthropods of the Pribilofs are potential state-endemics – the highest rate of endemism within Alaska. Despite this, the island's arthropods have received little taxonomic attention over the last century. The majority of our knowledge of this fauna comes from a 100-year-old publication[1]. This high rate of endemism provides an opportunity to document Alaska's unique genetic diversity and better understand the biogeographic history of Beringian arthropods.

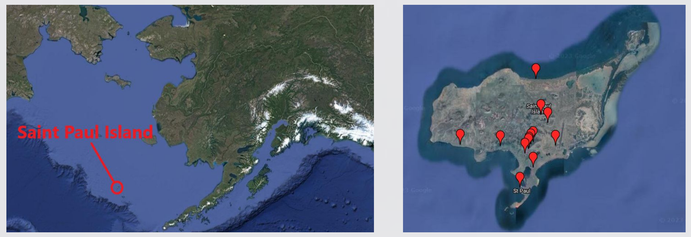
Endemic taxa often have small population sizes and geographic distributions. Cold adapted Alaskan endemic arthropods are likely to be more intensely impacted by climate change,[2] particularly on islands such as the Pribilofs where they can't track their ideal climate.

The Cytochrome C Oxidase Subunit 1 (COI) mitochondrial gene is commonly used to "DNA barcode" animal species. This gene is highly conserved at the species level, and can be reliably used to delimit most animal species.[3] We will obtain DNA barcodes for 380 Saint Paul Island specimens, and reference them against records in the Barcode of Life Database (BOLD). This will enable us to test our prediction that the arthropod fauna of these islands will contain more genetically unique populations than comparable samples from mainland Alaska.

Methods

Field Work (Taylor Kane & Derek Sikes):

- Samples collected across Saint Paul Island using diverse methods - net sweeping, filtering leaf litter, hand collecting
  - Field collection took place from July 28-August 1, 2022
  - Samples were collected in 70% Ethanol, and stored at -20° C



Left: Saint Paul Island in relation to Alaska. Right: Summer 2022 collection localities on Saint Paul Island

Lab Work (Luke Lawson, Lucy White, Razan Yousif):

- Samples processed, soft-bodied specimens sorted in ethanol, hard-bodied specimens pinned and pointed
  - We processed samples from individual collection events under microscopes and gave them preliminary morphospecies assignments.

Left to right: Beetles from one sample locality, whole sample, collembola from one sample locality. Photos: Luke Lawson, Taylor Kane

- Specimens labelled and entered into ARCTOS
  - Labels generated using ARCTOS data and printed on archival paper
  - Labels placed inside ethanol vials with data matrix codes on stickers applied to underside of vials
  - Paper labels with accompanying data matrix codes applied to pins
- Sorted by morphospecies and specimens selected for DNA barcoding
  - Specimens will be identified to the lowest taxonomic level possible, with the aim to have 3 individuals per taxon to serve as replicates when sequencing

Left to right: Pinned specimens, Razan Yousif and Luke Lawson processing Saint Paul specimens. Photos: Razan Yousif, Taylor Kane

- DNA barcode voucher specimens will be photographed
- Legs pulled and loaded into DNA barcoding plates
  - Insects are bilaterally symmetrical, pulling legs from one side maintains morphological integrity of the specimen while providing adequate genetic material
  - 4 plates, each plate has 96 wells with 1 control well for a total of 380 specimens sent in for barcoding

Next steps:

DNA Barcoding (University of Guelph):

- Plates sequenced at Canadian Center for DNA Barcoding at the University of Guelph.

Analysis:

- DNA barcodes will be grouped into BINs (Barcode Index Numbers), which are analogous to species.
- Count how many BINs are unique to the Pribilofs (contain no samples from elsewhere).
- We will generate multiple similar-sized comparable samples by selecting already DNA-barcoded specimens from the Alaskan mainland.
- Count how many mainland BINs are unique within each comparable mainland sample.
- See if our prediction is correct that the Pribilofs will have more unique BINs than our comparable mainland samples.

Preliminary Results

During our preliminary sorting and processing of samples, we have detected a number of taxa that had previously not been documented within the Pribilof Islands. These include:

Order Thysanoptera
(Family, Genus and Species currently unidentified), Common name: Thrips

Family Ptilidae
(Genus and Species unidentified), Common name: Featherwinged Beetle

Subfamily Orthocladiinae
This unusual brachypterous (flightless) midge is likely an undocumented endemic, due to its low vagility

Gibellula arachnophila
While not the focus of this project, we discovered this fungus that had never been recorded in Alaska on one of our spider specimens. Identification of the spider is pending.

Broader Impacts

By better understanding the rate of endemism on Saint Paul Island, we will be better equipped to answer questions about how macroinvertebrate species dispersed across the Bering Land Bridge during the most recent glacial maximum as well as map out biogeographic connections between Asia and North America. Furthering assessments of Alaskan biodiversity will also help us to identify species of conservation interest.

The study also represents the first comprehensive research on the arthropods on Saint Paul Island since McAtee (1923). In addition to confirming the status of previously documented endemic species, this study will provide an updated baseline inventory for future monitoring efforts.

References and Acknowledgements

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