

# ONE GRASS, TWO GRASS, ICE GRASS, NEW GRASS: A SECOND TAXON OF *PHIPPSIA* (POACEAE) IN THE CANADIAN ARCTIC BASED ON MOLECULAR DATA

Samantha L. Godfrey<sup>1,2</sup> and Lynn J. Gillespie<sup>1,2</sup>

<sup>1</sup>Department of Biology, University of Ottawa, Ottawa, ON. <sup>2</sup>Research and Collections, Canadian Museum of Nature, Ottawa, ON.

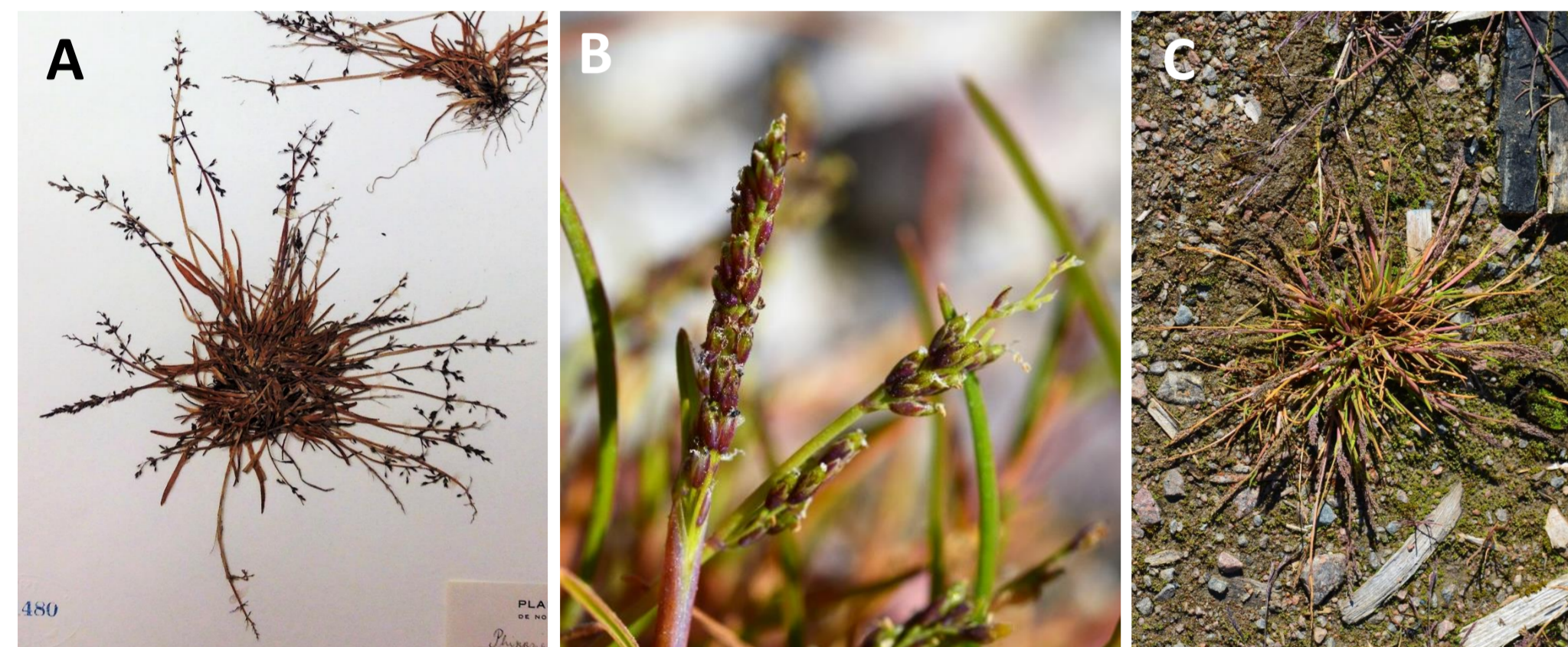
## INTRODUCTION

*Phippsia* (Trin.) R. Br. is a genus of two arctic-alpine grasses, *Phippsia algida* (Sol.) R. Br. and *P. concinna* (Th. Fr.) Lindeb. They are commonly known as ice grass and snow grass, respectively.

The taxonomy of this genus is controversial. There is disagreement on whether its two taxa should be recognized as distinct species [1,2], subspecies [3,4], or as a single species [5]. A third taxon, *P. concinna* ssp. *algidiformis* H. Sm. [6], remains a source of confusion, applied to supposed hybrids and other specimens with intermediate morphology [7,8]. Previous studies found no or minimal genetic variation between the two species, and did not include Canadian *Phippsia* [3,4].

*Phippsia algida* has a circumpolar distribution, while the range of *P. concinna* is contested. The majority of authors consider it absent from North America, with a few exceptions. Individual researchers have included Alaska [9], both Alaska and the Yukon [10], and the Canadian Arctic Archipelago [11,12] within the species' range.

The primary objective of the present study is to resolve the taxonomy of *Phippsia*, focusing on the North American Arctic. The study aims to investigate whether the species differ molecularly and to verify that the North American taxa are congruent with their Eurasian counterparts. Objectives will be achieved through DNA sequencing with a smaller morphological component.



**Figure 1:** A) *Phippsia concinna* from Svalbard, Norway, possessing diffuse panicles with spreading branches typical of the species (Dahl, CAN 241480). B) Close up of *P. algida* from Nauyasat, Nunavut illustrating a typical narrow, compressed panicle (Gillespie et al. 11351, CAN). C) Large *P. algida* from Iqaluit, Nunavut with notably dense panicles (Godfrey and Gillespie 3, CAN). Photos by S.L. Godfrey.

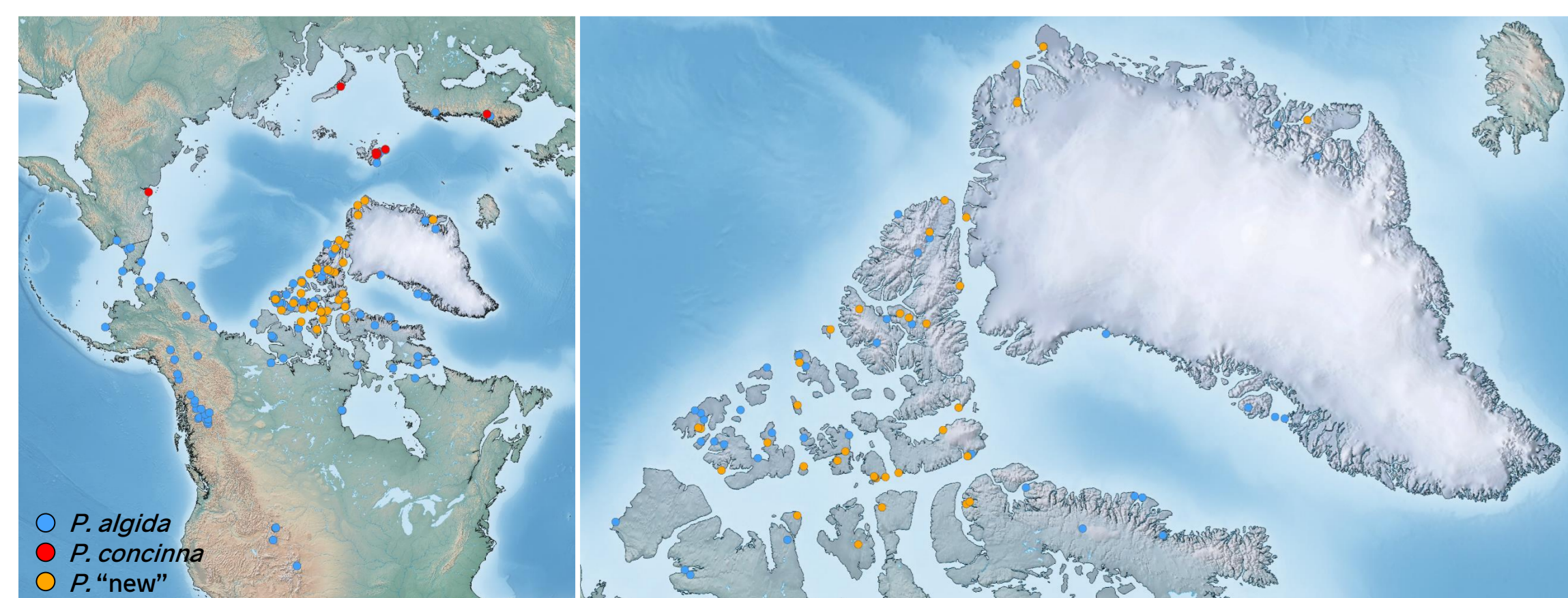
## METHODS

### DNA Sequencing

- Genomic DNA was extracted for 223 *Phippsia* specimens from silica-gel preserved tissues and herbarium vouchers from CAN, RM, ALA, O & V.
- ITS and ETS nrDNA regions were successfully PCR-amplified and sequenced for 171 specimens.
- 17 cpDNA regions were screened for variability: *matK*, *rbcL*, *trnT-L*, *trnL-F*, *rpoB-trnC*, *psbA-trnH*, *psbK-l*, *atpF-H*, *rps16*, *ccsA*, *ndhG-ndhI*, *rpl32-ccsA*, *trnK-rps16*, *atpH-atpI*, *ndhF-rpl32*, *rps16-trnQ*, *trnP-rps18*. The bolded regions were selected for more thorough investigation with 46 specimens.
- The aligned and concatenated nrDNA and cpDNA datasets were analysed using maximum parsimony in PAUP 4.0 [13].

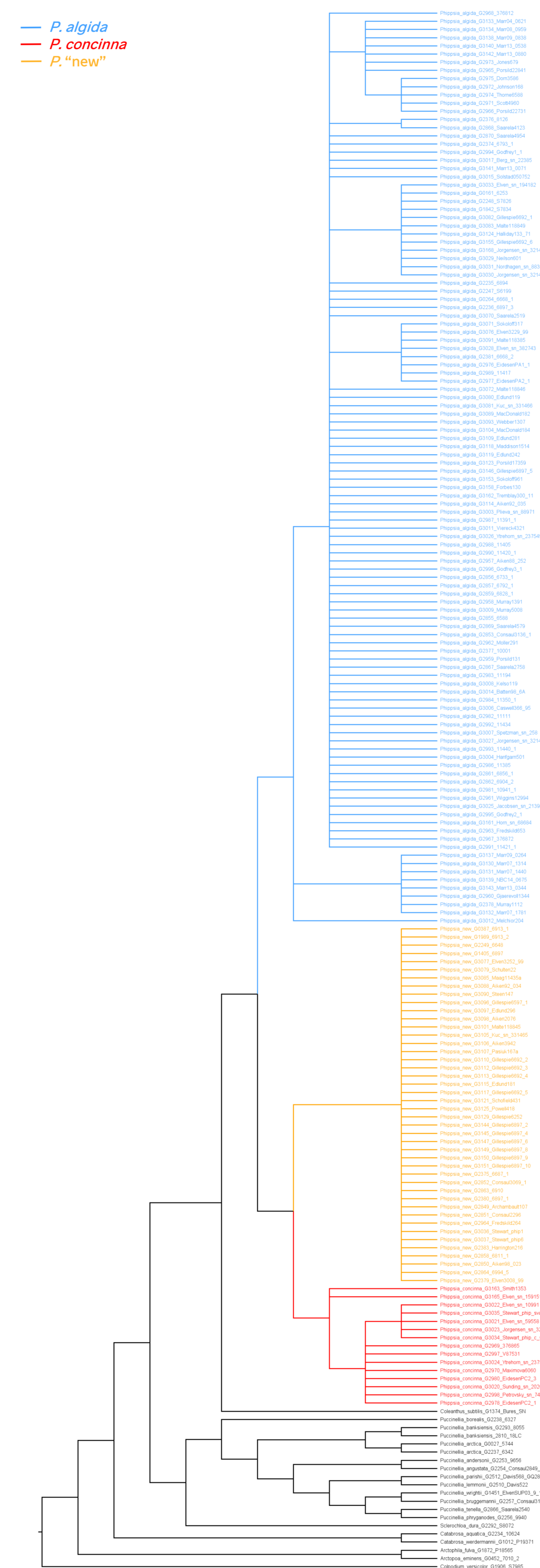
### Morphology

- 15 herbarium vouchers were measured for 26 quantitative and qualitative characters. An additional 8 derived characters were calculated. 28 characters were analyzed using principal components analysis (PCA) in PAST 3.17 [14].

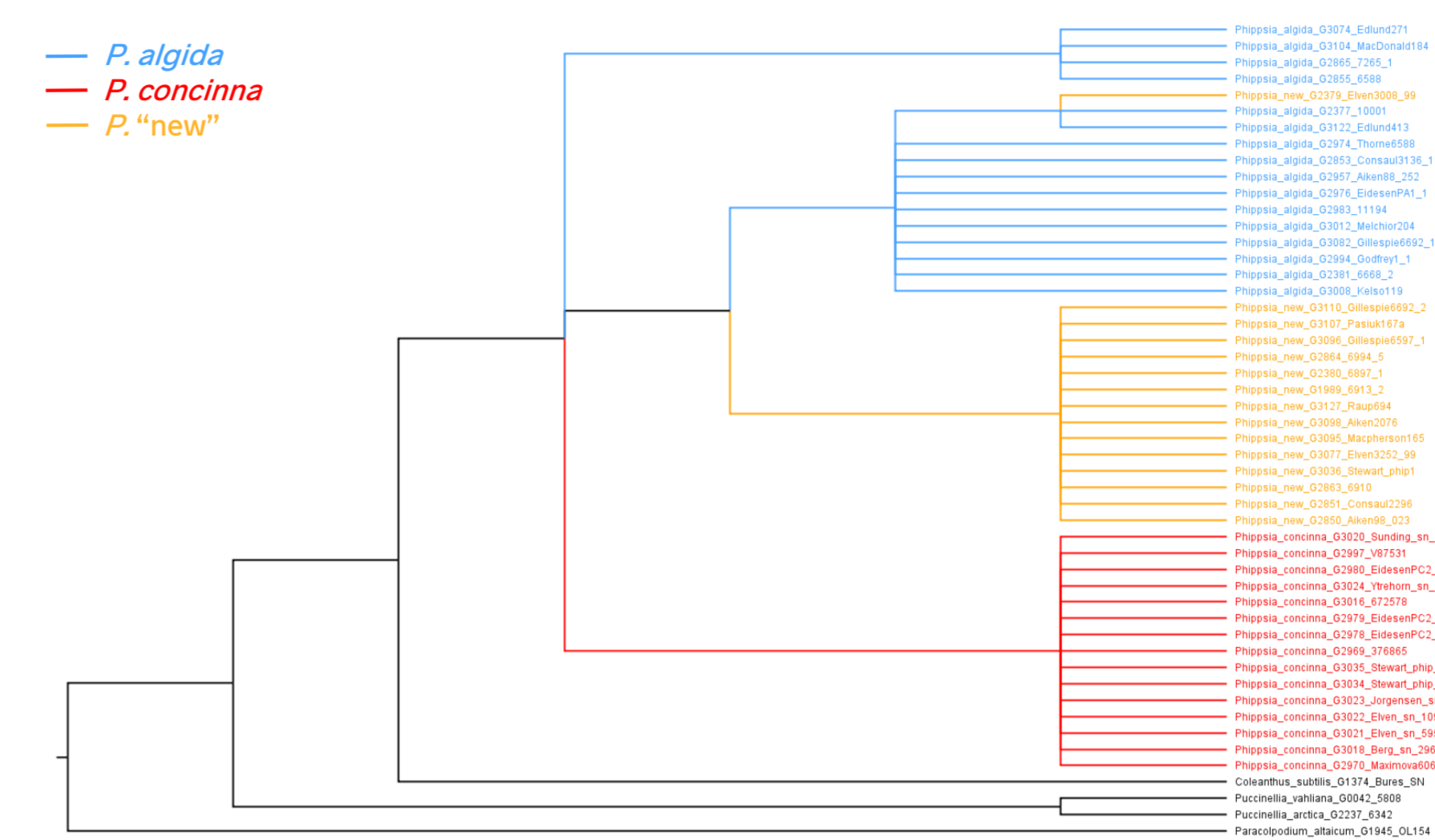


**Figure 2:** Distribution of *Phippsia* sampled for DNA sequencing. Colours denote the three major clades of the ITS and ETS consensus tree: *P. algida*, *P. concinna*, and a proposed third taxon from northern Canada and Greenland.

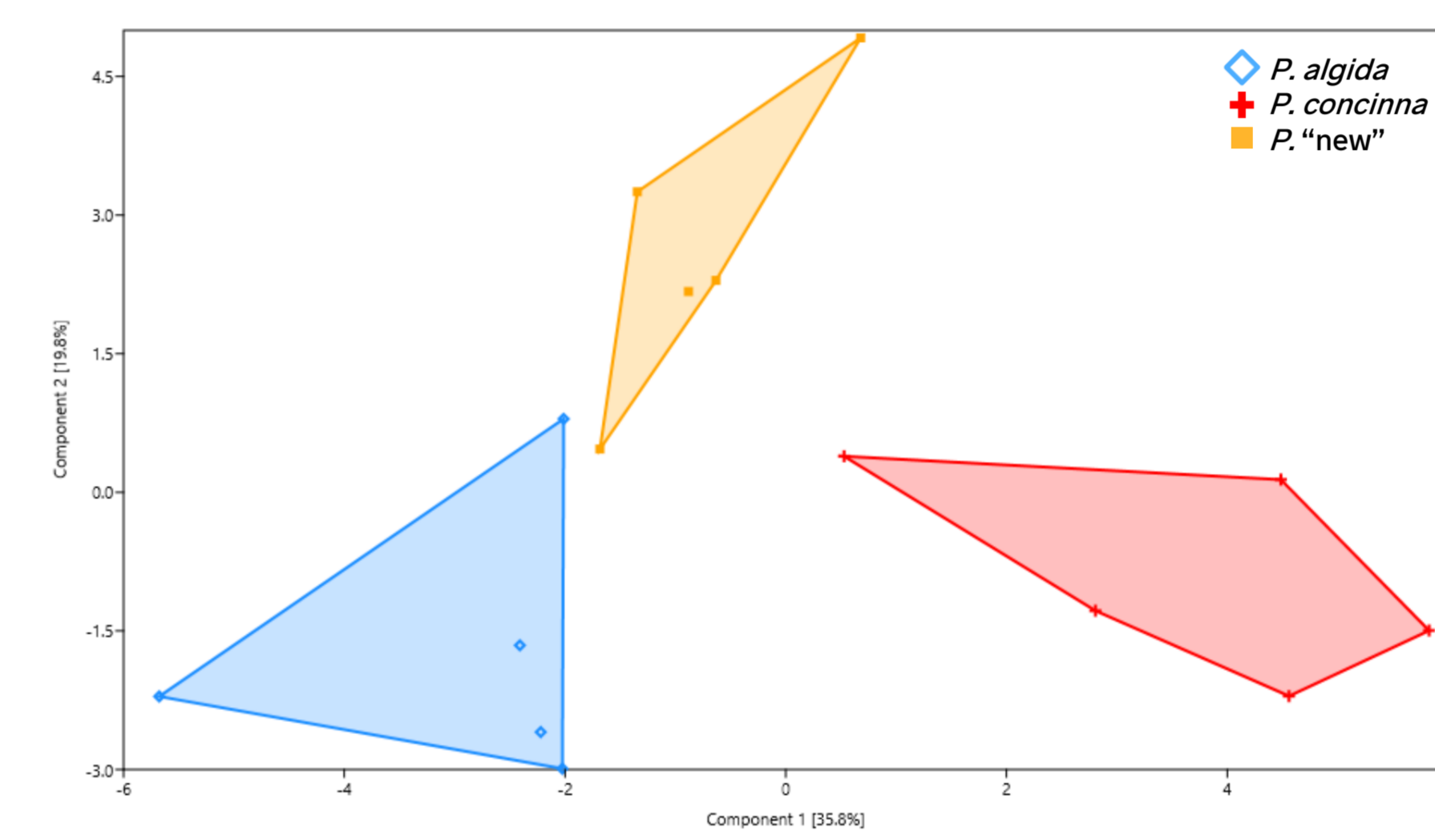
## RESULTS



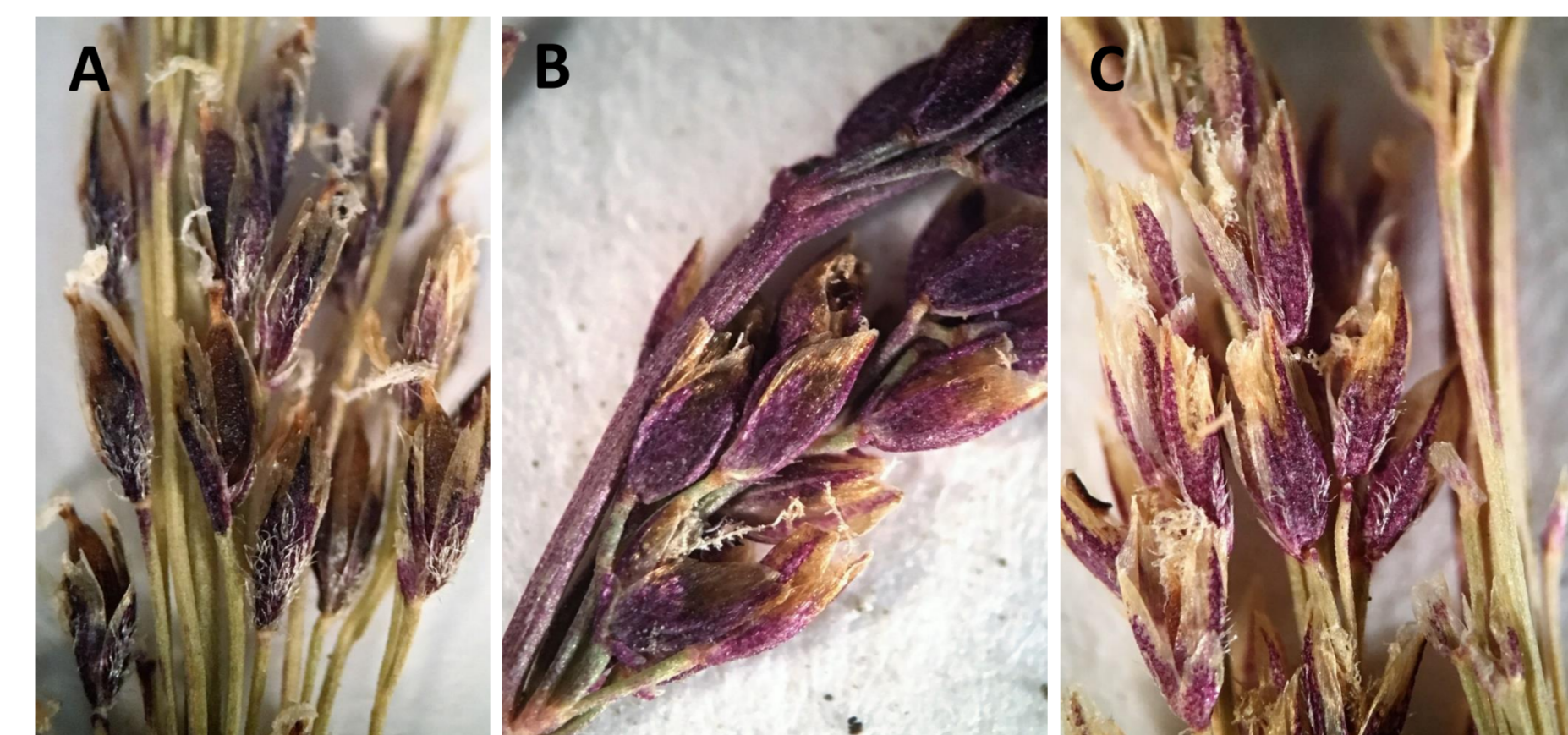
**Figure 3:** Strict consensus tree derived from maximum parsimony analysis of 191 concatenated ITS and ETS nrDNA sequences of *Phippsia* and outgroups. Bootstrap values are indicated above each branch.



**Figure 4:** Strict consensus tree derived from maximum parsimony analysis of 50 concatenated *atpH-atpI*, *ndhF-rpl32*, *rps16-trnQ*, *trnP-rps18* cpDNA sequences of *Phippsia* and outgroups. Bootstrap values are indicated above each branch.



**Figure 5:** Principal components analysis of 15 *Phippsia* analyzed for 28 primary and derived morphological characters. The taxon of each specimen was verified by nrDNA results.



**Figure 6:** Spikelets of A) *Phippsia concinna*, densely pubescent, B) *P. algida*, glabrous (to minimally pubescent) and C) *P. 'new'*, intermediate pubescence, extending two thirds the length of the lemma (O 672578; Murray 1112, CAN 311167; Malte 118386, CAN 30721). Photos by S.L. Godfrey.

## CONCLUSIONS

- The combined molecular and morphometric results suggest that a second taxon, distinct from *P. concinna*, should be recognized in Canada.
- The proposed taxon has a High Arctic distribution (Fig. 2), restricted to Greenland and the Canadian Arctic Archipelago.
- Additional morphological work is necessary to determine whether the new taxon should be recognized at the species or subspecies level. Regardless, the name "*algidiformis*" is not available for this taxon [15].
- The cpDNA results also suggest possible hybridization between taxa. These findings should be investigated through more extensive cpDNA sampling combined with morphometric analyses.

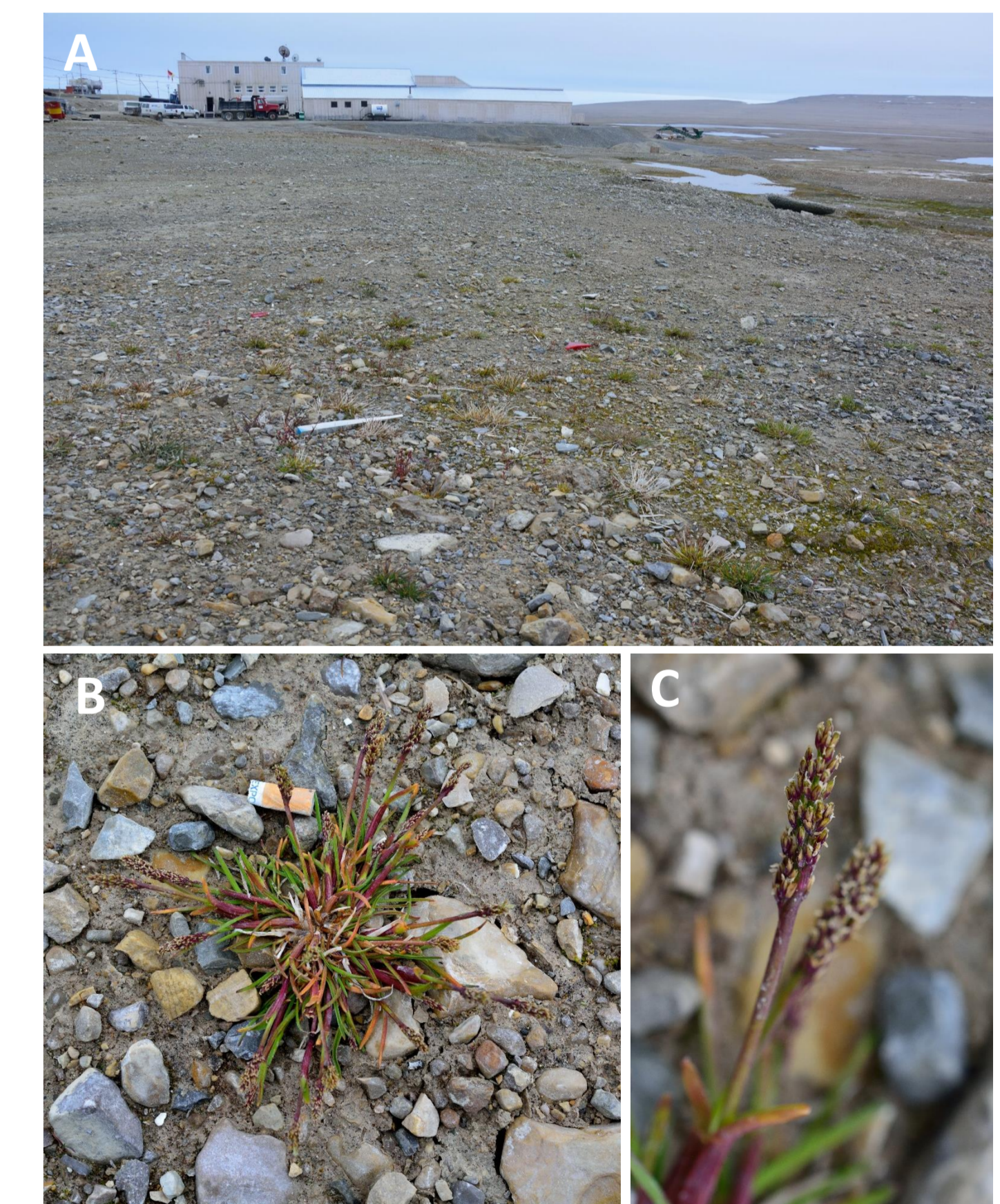
## REFERENCES

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- The nrDNA maximum parsimony consensus tree (Fig. 3) revealed three clades: *P. algida* from all regions sampled, typical *P. concinna* from Russia and Norway, and a third clade, labelled *P. "new"*, from northern Canada and Greenland that is most closely related to *P. concinna*.
- The cpDNA maximum parsimony consensus tree (Fig. 4) also supported three distinct clades, with a few exceptions. Most notably, a single *P. "new"* grouped with the main *P. algida* clade. In disagreement with the nrDNA tree, the cpDNA results suggest that *P. "new"* is most closely related to *P. algida*. However, the cpDNA dataset contains a much smaller number of informative characters, resulting in low bootstrap support.
- The preliminary morphometric analysis (Fig. 5) is in agreement with the molecular results. Members of the three nrDNA clades appear to be morphologically distinct.



**Figure 7:** A) Habitat, B) habit and C) inflorescence of *Phippsia "new"* from Cornwallis Island, Nunavut, as verified by nrDNA (Sokoloff 973, CAN). Its large, dense panicles appear superficially similar to those of *P. algida* shown in Fig. 1 C), potentially explaining the difficulty in recognizing two distinct taxa in Canada. Photos by P.C. Sokoloff.