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Four new species of *Pyropia* (Bangiales, Rhodophyta) from the west coast of North America: the *Pyropia lanceolata* species complex updated

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Abstract

Recent molecular studies indicate that the *Pyropia lanceolata* species complex on the west coast of North America is more speciose than previously thought. Based on extensive *rbc*L gene sequencing of representative specimens we recognize seven species in the complex, three of which are newly described: *Py. montereyensis* **sp. nov.**, *Py. columbiensis* **sp. nov.**, and *Py. protolanceolata* **sp. nov.** The new species are all lanceolate, at least when young, and occur in the upper mid to high intertidal zone primarily in winter and early spring. *Pyropia montereyensis* and *Py. columbiensis* are sister taxa that are distributed south and north of Cape Mendocino, respectively, and both occur slightly lower on the shore than *Py. lanceolata* or *Py. pseudolanceolata*. *Pyropia protolanceolata* is known thus far only from Morro Rock and the Monterey Peninsula, California; it occurs basally to the other species in the complex in the molecular phylogeny. A fourth newly described species, *Pyropia bajacaliforniensis* **sp. nov.**, is more closely related to *Py. nereocystis* than to species in this complex proper. It is a thin species with undulate margins known only from Moss Landing, Monterey Bay, California, and northern Baja California; it also occurs in the high intertidal in spring. *Porphyra mumfordii*, a high intertidal winter species that has frequently been confused with species in the *Py. lanceolata* complex, has now been confirmed to occur from Calvert Island, British Columbia, to Pescadero State Park, California.

Keywords

Bangiales, British Columbia, California, new species, northeast Pacific, *Pyropia lanceolata* species complex, *Pyropia nereocystis*, *rbc*L gene

Introduction

The foliose Bangiales are one of the best-studied groups of marine red algae occurring on the west coast of North America. The first two species to be named from the region were two of the most common, *Porphyra perforata* J. Agardh (1883) and *Porphyra nereocystis* C.L. Anderson (Blankinship & Keeler, 1892). Hus (1900, 1902) summarized knowledge of the genus on the Pacific Coast, recognizing eleven species and describing three new forms of *Porphyra* C. Agardh, the genus to which all foliose Bangiales belonged at the time. One of those new forms, *P. perforata* f. *lanceolata* Setchell & Hus in Hus (1900), was erected to accommodate lanceolate forms that were dioecious; this taxon was later raised to specific status in Smith and Hollenberg (1943: 213), who also added two more species of *Porphyra* to the flora. It was Krishnamurthy (1972) who significantly revised the genus in the region and added seven new species, mostly from Washington State. A summary of knowledge at the time was provided by Conway et al. (1975), with detailed descriptions of Pacific Northwest species of *Porphyra* with emphasis on British Columbia and Washington State; their work was updated by Garbary et al. (1981).

Studies up to then mostly utilized thallus morphology and the pattern of reproductive cell disposition and division as defining features for species. Mumford and Cole (1977) added chromosome numbers as a useful feature, and Lindstrom and Cole (1990, 1992a, b, c) and Lindstrom (1993) utilized isozymes in addition to morphology, chromosome numbers, biogeography and habitat as characters for separating and recognizing even more species.

The taxonomy of foliose Bangiales entered a new phase with the application of DNA sequencing methods. Lindstrom and Fredericq (2003) sequenced the chloroplast *rbc*L gene of many West Coast species, and Lindstrom (2008) included numerous additional specimens, indicating the need to describe even more species, as did Kucera and Saunders (2012) utilizing the mitochondrial 5′end of the *COI* gene. Sequencing also indicated that a wholesale revision of the order was needed (first suggested by Oliveira et al. 1995). This led to a revision of the genera of foliose Bangiales by Sutherland et al. (2011), redefining, resurrecting or creating eight genera of bladed Bangiales. Among these eight genera, four (*Boreophyllum* S.C. Lindstrom, *Fuscifolium* S.C. Lindstrom, *Porphyra* and *Pyropia* J. Agardh) occur on the west coast of North America, and among these *Pyropia* is by far the most speciose.

The resurrected genus *Pyropia* contains a number of clades that are resolved with substantial support, and many of these clades are biogeographically circumscribed (Sutherland et al. 2011). One such clade is the northeast Pacific *P. lanceolata–P. pseudolanceolata* complex, first identified as such by Lindstrom and Cole (1992b), who recognized that a number of species were confused under these names. Members of this clade, like other species of *Pyropia*, have monostromatic blades. As resolved by Sutherland et al. (2011), this clade contains *Pyropia* sp. 480, *Py. pseudolanceolata* (V. Krishnamurthy) S.C. Lindstrom, *Py. hiberna* (S.C. Lindstrom & K.M. Cole) S.C. Lindstrom, *Py. fallax* (S.C. Lindstrom & K.M. Cole) S.C. Lindstrom, *Py. conwayae*

(S.C. Lindstrom & K.M. Cole) S.C. Lindstrom, and *Pyropia* sp. 485, indicating that at least two species are as yet undescribed and suggesting uncertainty over the identity of *Py. lanceolata* (Setchell & Hus) S.C. Lindstrom.

In the present study, we analyzed *rbc*L and 18S rRNA (SSU) gene sequences from recently collected specimens belonging to this clade from the west coast of North America extending from Baja California to Alaska. We also include the closely related northeast Pacific species *Py. nereocystis* and *Py. kanakaensis* (Mumford) S.C. Lindstrom (Lindstrom 2008, Sutherland et al. 2011), and we analyzed short DNA sequences from the type sheets of *P. lanceolata* and *P. hiberna* to resolve their relationship, and to determine whether any of the undescribed species could be the same as one of these species. These new data support the recognition of at least four additional species. Below we discuss these species, their relationships to each other, and the characters that distinguish them.

Materials and methods

Specimens were collected by the authors or by those named in the Acknowledgments (Table 1, Suppl. material 1). Collections were made along the west coast of North America from Baja California, Mexico, to the western tip of the Aleutian Islands, Alaska, between 1992 and 2014. Upon collection, the specimens were damp-dried and then desiccated in silica gel. Pieces or separate specimens were pressed to make herbarium vouchers, which are deposited in UBC or UC. Silica-gel dried specimens were returned to the lab, where they were extracted following the CTAB protocol as implemented by Lindstrom and Fredericq (2003). PCR amplification and sequencing of the *rbc*L gene was carried out as described in Lindstrom (2008) except that KitoF1 (5' ATGTCTCAATCCGTAGAATCA 3') was used as the forward primer rather than F57. DNA from type material of *P. lanceolata* and *P. hiberna* was extracted, amplified and sequenced following the protocol described in Lindstrom et al. (2011), except for using 3X the primer concentration used previously. The type fragments were extracted in a separate laboratory (Hartnell College) and processed employing the precautionary steps proposed by Hughey and Gabrielson (2012). For amplification of type material, primers F625 (5'CTCACAACCATTTATGCGTTGG 3') and R900 (5'GCGAGAATAAGTTGAGTTACCTG 3') were cycled together.

Sequences of the *rbc*L gene of *Pyropia* sp. FAL from Playa Saldamando, Baja California, Mexico, HQ687535, and *Pyropia* sp. MIG from Faro de San Miguel, Baja California, Mexico, HQ687536, were also included in the analyses because of their close relationship to *P. kanakaensis* and *P. nereocystis* (Sutherland et al. 2011) and because of the identity of *Pyropia* sp. MIG with one of our unknown specimens. We selected two specimens of *Pyropia* sp. (AB118586 and AB287965) as outgroups based on their close genetic identity to *Py. nereocystis* using the GenBank blastn algorithm (accessed 06 Sept 2014).

Sequences were aligned using BioEdit version 7.0.9.1 (Hall 1999). Maximum parsimony (MP) analysis was performed using PAUP* 4.0b10 (Swofford 2002) as

Table 1. Specimens for which the *rbc*L gene was sequenced in this study and used in the phylogenetic analyses. All herbarium vouchers are deposited in UBC unless noted otherwise. Numbers indicate the total number of specimens with the identical sequence (see Suppl. material 1). Specimens in brackets were included in initial analyses but excluded from the analysis shown in Fig. 1. Specimen P814 in Fig. 1 represents a combination of P814 and P827 (Calvert I., BC, 27 May 2013, K. Hind, SCL 15332, KP904063) to provide a more complete sequence.

Extract	Collection site	Collection date	Collector	Collection no.	GenBank no.	Specimens with identical sequence
Pyropia fallax						
[P172	Clover Pt, BC, Canada	27 Apr 2002	S.C. Lindstrom	no voucher?	EU223056	n=5]
P191	Harling Pt, BC, Canada	25 Apr 2005	S.C. Lindstrom	SCL 12565	EU223057	unique
[P225	Akutan Bay, AK, USA	31 Jul 2004	S.C. Lindstrom	SCL 11611	EU223064	unique]
P525	Chichagof Hbr, AK, USA	04 Jun 2008	S.C. Lindstrom	SCL 13483	KP903917	unique
P544	Surveyor Bay, AK, USA	11 Jun 2008	S.C. Lindstrom	SCL 13709	KP903919	n=2
P557	Foster I., BC, Canada	27 May 2009	S.C. Lindstrom	SCL 14121	KP903922	n=23
P577	Hallo Bay, AK, USA	03 Jul 2009	M.R. Lindeberg	UBC A89044	KP903923	n=10
[P815	Calvert I., BC, Canada	25 May 2013	S.C. Lindstrom	SCL 15293	KP903936	n=2]
P820	Calvert I., BC, Canada	26 May 2013	S.C. Lindstrom	SCL 15304	KP903940	n=2
P851	Calvert I., BC, Canada	18 Feb 2014	S.C. Lindstrom	SCL 15595	KP903948	n=17
Pyropia conwayae						
P430	French Beach, BC, Canada	12 Mar 2007	S.C. Lindstrom	SCL 13109	EU223044	n=2
[P494	Charleston, OR, USA	04 Apr 2008	S.C. Lindstrom	SCL 13303	KP903957	n=2]
P589	Camel Rock, CA, USA	14 Feb 2010	S.C. Lindstrom	SCL 14287	KP903961	n=13
Pyropia montereyensis						
P603	Fort Bragg, CA, USA	15 Feb 2010	S.C. Lindstrom	SCL 14311	KP903964	n=7
P645	N of San Simeon, CA, USA	18 Feb 2010	S.C. Lindstrom	SCL 14374	KP903967	n=4
P656	S of Ventura Beach, CA, USA	20 Feb 2010	S.C. Lindstrom	SCL 14392	KP903968	unique
P763	Spanish Bay, CA, USA	02 Feb 2012	J.R. Hughey	UBC A90632	KP903972	n=4
Pyropia columbiensis						
P491	Trinidad St. Beach, CA, USA	12 Apr 2008	F.J. Shaughnessy	Frank#1 in HSC	KP903982	n=2
P859	Calvert I., BC, Canada	18 Feb 2014	S.C. Lindstrom	SCL 15599	KP903999	n=20
Pyropia lanceolata						
[P584	Trinidad boat launch ramp, CA, USA	14 Feb 2010	S.C. Lindstrom	SCL 14276	KP904008	unique]

Extract	Collection site	Collection date	Collector	Collection no.	GenBank no.	Specimens with identical sequence
P612	Van Damme St. Park, CA, USA	16 Feb 2010	S.C. Lindstrom	SCL 14321	KP904024	unique
P625	Bodega Marine Lab, CA, USA	16 Feb 2010	S.C. Lindstrom	SCL 14341	KP904029	unique
P638	Pescadero St. Park, CA, USA	17 Feb 2010	S.C. Lindstrom	SCL 14365	KP904038	n=39
P641	Pacific Grove, CA, USA	17 Feb 2010	S.C. Lindstrom	SCL 14369	KP904039	n=2
Pyropia pseudolanceolata						
[P332	Chaichei Islets, AK, USA	20 Apr 1995	S.C. Lindstrom	SCL 9104	KP904049	unique]
P351	Dundas I., BC, Canada	19 Apr 2007	S.C. Lindstrom	SCL 13136	EU223163	n=7
P411	Sedanka Pt, AK, USA	03 Jun 2005	S.C. Lindstrom	SCL 12137	EU223165	unique
P488	Sunset Beach, OR, USA	06 Apr 2008	S.C. Lindstrom	SCL 13311	KP904052	n=3
P537	Alaid I., AK, USA	07 Jun 2008	S.C. Lindstrom	SCL 13630	KP904056	n=28
Pyropia protolanceolata						
P480	Spanish Bay, CA, USA	01 Jan 2008	P.W. Gabrielson	PWG 1604	KP904005 KP903902 (SSU)	same as P797
P767	Morro Rock, CA, USA	04 Apr 2012	J.R. Hughey	UBC A90634	KP904006 KP903909 (SSU)	same as P480
Pyropia kanakaensis						
Pkan	Kanaka Bay, WA, USA	undated	M.J. Wynne	MICH	AF452431	unique
P132	Baker Beach, CA, USA	25 May 2002	S.C. Lindstrom	SCL 11409	EU223098	n=3
P222	Olympic Pen., WA, USA	31 May 2003	S.C. Lindstrom	SCL 10932	EU223099	unique
Pyropia bajacaliforniensis						
P766	Moss Beach Jetty, CA, USA	30 Apr 2012	J.R. Hughey	no voucher?	KP904065	same as Pyropia sp. MIG
Pyropia sp. MIG	Faro de San Miguel, BC, Mexico			WELT A024422	HQ687536	same as P766
Pyropia sp. FAL	Saldamando, BC, Mexico	21 May 2002	L.E. Aguilar Rosas & R. Aguilar Rosas	WELT A024418	HQ687535	unique
Pyropia sp.						
s/n	San Carlos Beach Park, CA, USA	05 Jan 2015	J.R. Hughey	UC 1966781	KP876025	unique
Pyropia nereocystis						
P320	Passage I., AK, USA	30 Jun 2003	M.R. Lindeberg	SCL 11215	EU223116	unique
P814	Calvert I., BC, Canada	24 May 2013	S.C. Lindstrom	SCL 15280	KP904062	n=6

implemented by Lindstrom and Fredericq (2003). Maximum likelihood (ML) was performed using RAxML 7.2.6 [as implemented on the T-rex website (http://www.trex.uqam.ca/index.php?action=raxml; Stamatakis 2006, Buc et al. 2012)], and data were partitioned by codon position. Bayesian phylogenetic analyses were performed on the Bio-Linux7 platform (Field et al. 2006) with MrBayes 3.2.1 (Huelsenbeck et al. 2001, Ronquist and Huelsenbeck 2003). We followed the MrBayes 3.2 manual, which recommends continuing analyses by increasing the number of generations until the average standard deviation of split frequencies drops below 0.01. All runs were performed using a sample frequency of 10 with two independent analyses. To calculate the Potential Scale Reduction Factor and posterior probabilities, the sump and sumt burn-in values were set to discard 25% of the samples.

Results

Thirty-seven *rbc*L gene sequences (Table 1) were included in the phylogenetic analyses that generated Fig. 1. Both MP and ML generated the same tree topology, as did Bayesian analysis. Several unique sequences were omitted from the analyses after it was determined that their omission did not alter the topology of the phylogenetic tree. In addition to these sequences, the Suppl. material 1 includes 186 additional specimens that were identical to those in Fig. 1. With AB118586 and AB287965 as outgroup species, three major clades are apparent, the *Py. nereocystis* clade, the *Py. kanakaensis* clade and the *Py. lanceolata* clade (formerly called the *P. lanceolata–P. pseudolanceolata* complex).

Within the *Py. lanceolata* clade, *Py. protolanceolata* diverges first. This species is sister to *Py. pseudolanceolata*, then *Py. lanceolata*, but this order of divergence is without support. The clade is terminated by two pairs of sister taxa, the closely related *Py. montereyensis* and *Py. columbiensis* species pair, and the somewhat more distantly related *Py. conwayae* and *Py. fallax* pair. Both of these species pairs represent a southern and northern species, as is also the case for *Py. lanceolata* and *Py. pseudolanceolata*. For the most closely related pair, *Py. montereyensis* and *Py. columbiensis*, the former has to date only been found south of Cape Mendocino whereas the latter has only been collected from Cape Mendocino north; thus these species do not appear to overlap in their distributions. In the case of *Py. conwayae* and *Py. fallax*, the species overlap in distribution between southern Vancouver Island and southern Oregon. Of these species pairs, the former pair is more constrained in its distribution, occurring only between southern California and central British Columbia whereas the latter pair extends from central California to at least the westernmost Aleutian Island. For *Py. lanceolata* and *Py. pseudolanceolata*, this older species pair shows an even wider area of overlap, between Sitka Sound, AK, and Crescent City, CA. All species in the *Py. lanceolata* clade occur on strongly supported branches, and all but *Py. protolanceolata* show some intraspecific variation (to 0.4%) in their *rbc*L sequences (only two specimens of *Py. protolanceolata* were sequenced due to the infrequency of collection). The nonoverlapping intraspecific versus interspecific

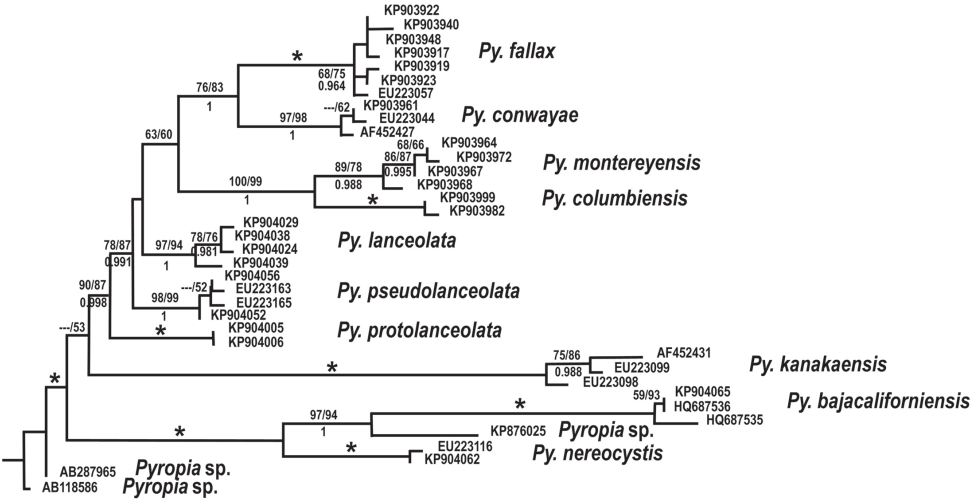

Figure 1. Maximum likelihood tree of the *Py. lanceolata* complex and close relatives. An asterisk indicates 100% bootstrap support in (left to right) maximum parsimony (nreps=10000) and maximum likelihood (nreps=1000), above the line, and a Bayesian probability of 1.0 below the line. Only bootstrap values >50 and Bayesian probabilities >0.900 are shown.

divergence, also referred to as the ''barcode gap'', allows specimens to be assigned unambiguously to genetic clusters that constitute putative genetic species (Le Gall and Saunders 2010).

In the *Py. nereocystis* clade, *Py. nereocystis* is sister to two divergent species. *Pyropia* sp. has been collected several times in early winter from the uppermost intertidal on the Monterey Peninsula; it is the subject of a separate study and will be described there. *Pyropia bajacaliforniensis*, the other species, has been collected in late spring on the central California and northern Baja California coasts. The type specimen, described below, diverges from two other collections by 0.3% (4 base pairs); this level of divergence is within the typical species variation exhibited by the *rbc*L gene in foliose Bangiales of up to 0.4% (Nelson and Broom 2010, Mols-Mortensen et al. 2012) although levels up to 1% have been reported for a few species (Lindstrom 2008).

Pyropia kanakaensis terminates its own long branch, suggesting a long evolutionary history separate from its closest relatives. It also shows significant within species variation.

We also sequenced the 18S rRNA gene in representatives of these species (Table 1, Suppl. material 1) to complement the data in Sutherland et al. (2011). There was relatively little variation among species and little structure to the phylogenetic tree except for weak support for sibling relationships between *Py. nereocystis* and *Py. kanakaensis* and between *Py. lanceolata* and *Py. pseudolanceolata*.

Characters of the species in the *Py. lanceolata* clade are summarized in Table 2. Most specimens are lanceolate with slightly undulate margins. All are monostromatic with one chloroplast per cell although chloroplast division prior to cell division can give the appearance of cells being vegetatively diplastidial. Among the species, only

Table 2. Comparison of morphological features of species in the *Pyropia lanceolata* clade.

Feature	*Py. fallax*	*Py. conwayae*	*Py. montereyensis*	*Py. columbiensis*	*Py. lanceolata*	*Py. pseudolanceolata*	*Py. protolanceolata*
Shape	Ovate to broadly lanceolate	Lanceolate	Lanceolate, occasionally oblanceolate	Lanceolate to somewhat ovate (rarely obovate)	Lanceolate	Lanceolate to ovate	Linear to lanceolate
Thickness	49–66 µm	53–113 µm	50–110 µm	50–115 µm	45–100 µm	65–150 µm	28–65 µm
Width (males)	to 5.0 cm	2.0–11.0 cm	to 2.3 cm	to 5.5 cm	1.2–1.5 cm	1.0–5.4 cm	to 1.2 cm
Length (males)	to 30 cm	to 83 cm	to 69 cm	to at least 31 cm	10–14 cm	to 31 cm	to 16 cm
Width (females)	same as males	4.0–8.2 cm	to 4.8 (10) cm	to 12 cm	1.0–3.5 cm	1.8–9.0 cm	not seen
Length (females)	same as males	to 40 cm	to 68 cm	to at least 28 cm	to 43 cm	to 34 cm	not seen
Color	Margin reddish, center greenish	Dark gray-green	Olive-green to grayish or brownish purple	Olive-green to grayish or brownish purple	Olive-green, brown (golden), or grayish purple	Olive-green to greenish gray or grayish purple	Dusky rose
Spermatangia	1–2 × 2–4 × 8	2–4 × 4 × 16	2–4 × 2–4 × 8–16	2–4 × 2–4 × 8	2–4 × 2–4 × 8	2–4 × 2–4 × 8	2 × 2 × 8
Zygotosporangia	in tiers of 4–8	2–4 × 2–4 × 2–4	2–4 × 2–4 × 4–8	2–4 × 2–4 × 2–4	2–4 × 2–4 × 4–8	2–4 × 2–4 × 4–8	not seen
Elevation	Mid to high intertidal	Mid intertidal	Mid to high intertidal	Mid to high intertidal	Upper mid to high intertidal	High intertidal	Very high intertidal
Phenology	Winter to late spring (mid summer in north)	Late winter to late spring	Winter to mid spring	Winter to early spring (rarely to mid summer)	Winter to early spring	Winter to early spring (mid summer in north)	Winter to early spring
Distribution	Attu I., AK, to southern OR	Tofino, BC, to Land's End, San Francisco, CA	Fort Bragg to just south of Ventura, CA	Calvert I., BC, to Cape Mendocino, CA	Sitka Sound, AK, to Cambria, CA	Attu I., AK, to Crescent City, CA	Spanish Bay & Morro Bay, CA
Haploid chromosome number	2	2	unknown	unknown	3	3	unknown

Py. fallax is monoecious, with spermatangial patches or streaks among pale red zygotosporangia, which occur in submarginal patches, mottles, streaks or hieroglyphs. The remaining species are almost invariably dioecious, with spermatangia occurring along cream-colored margins and with the red zygotosporangia occurring along the margin and across the distal end of the thallus in patches usually intermixed with vegetative cells, giving the appearance of red hieroglyphs. All species occur on rock, often near sand.

Below we describe in detail the previously unnamed species in this clade, as well as a new species in the *Py. nereocystis* clade.

Pyropia montereyensis **S.C. Lindstrom & J.R. Hughey, sp. nov.**
Fig. 2

Description. Thalli lanceolate and acuminate (occasionally oblanceolate) when young, becoming ovate to nearly orbiculate and often cleft when post-reproductive, base cuneate to strongly umbilicate when old; 50–75 mm thick when dried and young, 90–110 mm thick when old; males to at least 2.3 cm wide and 69 cm long; females to at least 4.8 cm wide and 68 cm long (although usually narrower; to 10 cm broad when old); color uniform throughout the thallus except for reproductive areas, olive green when fresh, drying to grayish or brownish purple. Thalli dioecious. Spermatangia in packets of 2–4 × 2–4 × 8–16. Zygotosporangia in packets of 2–4 × 2–4 × 4–8. Habitat: mid to high intertidal rock, usually associated with sand. Phenology: Winter to mid spring. Distinguished from other species of *Pyropia* by unique *rbc*L and 18S rRNA gene sequences.

Holotype. Saxicolous in the upper intertidal on rocks partially buried in sand at the north end of Spanish Bay, Pacific Grove, California, USA (36°37.16'N 121°56.52'W), *Hughey*, 02 Feb 2014, *UC2050590*. GenBank sequence KP903972 (*rbc*L).

Isotypes. *UBC A90632*.

Etymology. This species is named for the biogeographic region in which it is found following the boundaries of Croom et al. (1995) more closely than those of Valentine (1966).

Distribution. Fort Bragg to just south of Ventura Beach, California, USA.

We did not obtain an SSU sequence from type material of this species. The SSU sequence in GenBank (KP903907) for this species is from another Monterey Peninsula site: Carmel River State Beach.

Pyropia columbiensis **S.C. Lindstrom, sp. nov.**
Fig. 3

Description. Thalli lanceolate when young, becoming somewhat ovate (rarely obovate) when mature; base cuneate, becoming umbilicate; 50–115 mm thick; males to at least 5.5 cm wide and more than 31 cm long; females to 12 cm wide and more than

Figure 2. Holotype of *Py. montereyensis*. North end of Spanish Bay, Pacific Grove, California, USA, *Hughey*, 02 Feb 2014 (*UC2050590*).

Figure 3. Holotype of *Py. columbiensis*. South end of West Beach, Calvert Island, British Columbia, Canada, *S.C. Lindstrom 15596*, 18 Feb 2014, *UBC A90636*.

28 cm long, but thalli mostly narrower; color uniform throughout the thallus except for reproductive areas, olive-green when fresh, drying to grayish or brownish purple. Thalli dioecious. Spermatangia in packets of 2–4 × 2–4 × 8. Mature zygotosporangia in packets of 2–4 × 2–4 × 2–4. Habitat: mid to high intertidal rock, usually associated with sand. Phenology: winter to early spring (a few thalli may persist as late as mid summer). Distinguished from other species of *Pyropia* by unique *rbc*L and 18S rRNA gene sequences.

Holotype. Saxicolous in the upper mid intertidal on rocks partially buried in sand at the south end of West Beach, Calvert Island, British Columbia, Canada (51°39.14'N 128°08.42'W), *S.C. Lindstrom 15596*, 18 Feb 2014, *UBC A90636*. GenBank sequences KP903995, KP903996 (*rbc*L), KP903910 (SSU).

Isotypes. SCL 15594 (*UC 2050591*), SCL 15599 (*UBC A90637*), SCL 15600 & 15601 (*UBC A90638*).

Etymology. This species is named for the biogeographic region in which it is found, using the terminology of Valentine (1966), but with a modification of the boundaries to extend from Cape Mendocino, California, to the central coast of British Columbia. It also commemorates the centenary of the University of British Columbia herbarium, which was established in early 1916.

Distribution. Calvert Island, British Columbia, Canada, to Cape Mendocino, California, USA.

Pyropia montereyensis and *Py. columbiensis* are essentially morphologically identical and represent the southern and northern species of a vicariant pair, respectively.

Pyropia protolanceolata S.C. Lindstrom & J.R. Hughey, sp. nov.

Fig. 4

Description. Thalli linear to lanceolate, base cuneate; 28–65 mm thick; to 1.2 cm wide and 16 cm long; color uniform throughout the thallus except for reproductive areas: dusky rose. Thalli dioecious. Spermatangia in packets 2 × 2 × 8. Zygotosporangial thalli not observed Habitat: very high intertidal, above *Py. lanceolata* and *Py. montereyensis* when they co-occur. Phenology: Winter to early spring. Distinguished from other species of *Pyropia* by unique *rbc*L and 18S rRNA gene sequences.

Holotype. Saxicolous in the uppermost intertidal, above *Pyropia lanceolata*, northeast side of Morro Rock, Morro Bay, California, USA (35°22.29'N 120°51.98'W), *J.R. Hughey*, 04 Apr 2012, *UBC A90634*. GenBank sequences KP904006 (*rbc*L), KP903909 (SSU).

Etymology. This species is named for its basal position in the phylogeny of the *Py. lanceolata* complex.

Distribution. Thus far known only from Spanish Bay, Monterey Peninsula, and northeast side of Morro Rock, Morro Bay, California, USA.

Figure 4. Holotype of *Py. protolanceolata*. Northeast side of Morro Rock, Morro Bay, California, USA, *J.R. Hughey*, 04 Apr 2012, *UBC A90634*.

Pyropia bajacaliforniensis **L.E. Aguilar Rosas & J.R. Hughey, sp. nov.**
Fig. 5

Description. Thalli broadly lanceolate to ovate, sometimes irregularly lobed, base becoming cordate with age; 45–115 mm thick; 1–5 cm wide to at least 15 cm long; monostromatic, with one or two chloroplasts per cell; margin ruffled, often irregular in outline; color pale dusky pink (in California) or lilac gray (Baja California). Monoecious. Spermatangial packets 4 × 4 × 8, cream-colored, variable in shape, mostly marginal in distal portion of thalli but sometimes forming submarginal streaks. Zygotosporangial packets 2–4 × 2–4 × 2–4, appearing as small pinkish speckles because of intermixing of reproductive and vegetative cells. Habitat: upper intertidal rock. Phenology: late winter to late spring. Distinguished from other species of *Pyropia* by unique *rbc*L and 18S rRNA gene sequences.

Holotype. Upper intertidal rock, Playa Saldamando, Baja California, Mexico (31°55.60'N 116°45.30'W), *L.E. Aguilar Rosas & R. Aguilar Rosas 764*, 21 May 2002, *UC 1966778*. GenBank sequences HQ687535 (*rbc*L), DQ084424, DQ084425 (SSU).

Isotypes. *UC 1966778*, *UBC A90700*.

Etymology. The specific epithet refers to the provenance of the type material, where it is especially abundant in spring.

Distribution. Moss Landing, California, USA; Playa Saldamando and Faro de San Miguel, Baja California, Mexico.

Discussion

Molecular phylogenetic analysis of the foliose Bangiales indicates that *Pyropia* is the most speciose genus in the order; it also displays the most morphological variation and the widest geographical distribution. Still, there are many geographically restricted clades (Fig. 1, Sutherland et al. 2011). This indicates that much speciation in the order has occurred in particular geographical regions. The *Py. lanceolata* clade and its close relatives (*Py. kanakaensis*, the *Py. nereocystis* clade) are an example of a geographically restricted clade, with species known thus far only from the northeast Pacific, from Baja California, Mexico, to the Aleutian Islands, Alaska. Several of the species are highly restricted geographically: *Py. bajacaliforniensis* (in the related *Py. nereocystis* clade) is known only from the Moss Landing area of Monterey Bay, CA, and northern Pacific Baja California. Other species are limited to particular areas of coastal California: *Py. protolanceolata* thus far known only from Morro Bay and Spanish Bay, California, and *Py. montereyensis* from southern to northern California south of Cape Mendocino. In contrast, *Py. lanceolata* and especially *Py. pseudolanceolata* are widely distributed, occurring from California to Alaska although *Py. lanceolata* is replaced by *Py. pseudolanceolata* at many sites from British Columbia north. As with all geographic records, these are based on collections to date and are subject to revision due to both more intense collecting efforts in the region as well as changes in distributions due to changing environmental conditions.

Figure 5. Holotype of *Py. bajacaliforniensis*. Playa Saldamando, Baja California, Mexico, *L.E. Aguilar Rosas & R. Aguilar Rosas 764*, 21 May 2002, *UC 1966778*. Scale bar 2.5 cm.

The phylogeny of this group of related species suggests a number of patterns that have occurred in the evolution of some of the species. For example, the diplastidial condition in vegetative cells of *Py. kanakaensis* has also been observed in species in the *Py. lanceolata* complex (Smith and Hollenberg 1943, Lindstrom and Cole 1992b), where division of the chloroplast seems to precede by days or even weeks cell division associated with reproductive cell formation. In species of the *Py. lanceolata* clade, the two chloroplasts remain close together (Smith and Hollenberg 1943, Fig. 10) whereas they move to opposite ends of the cell in *Py. kanakaensis* (Mumford 1973).

Although the habitat of *Py. nereocystis* as an obligate epiphyte on the kelp *Nereocystis* is unique, and *Py. kanakaensis* occurs primarily in the lower mid intertidal, the remaining species have adapted to the rigors of the mid to high intertidal. In the *Py. lanceolata* clade proper, *Py. lanceolata*, *Py. pseudolanceolata*, and *Py. protolanceolata* are mostly restricted to the high intertidal and are among the highest-occurring species of seaweeds, as are *Py. bajacalifornienses* and *Pyropia* sp. in the *Py. nereocystis* clade. *Pyropia fallax* can occur in the high intertidal but also extends into the mid intertidal, where its sister taxon, *Py. conwayae*, is found. Where they co-occur, *Py. conwayae* usually occurs at a slightly lower elevation than *Py. lanceolata*. *Pyropia columbiensis* and *Py. montereyensis* also occur primarily in the upper mid to high intertidal although perhaps not as high as *Py. lanceolata* and others. Exact elevation of occurrence depends on many factors such as wave exposure, direction the rock is facing as well as season and latitude (and longitude for northern populations). Although thalli can be common on bedrock, when that is the predominant habitat in an area, all of the species can also be abundant on rock protruding from wave-swept sandy shores.

Whereas *Py. bajacalifornienses* and *Py. kanakaensis* are spring and spring-summer species, respectively (appearing on the shore ~April, disappearing in June in the case of the former, and persisting as late as November for the latter), the remaining species, including *Py. nereocystis*, appear to be winter-spring species, reaching their peak abundance from February to April, and then depending on the species and the location, disappearing from the shore from April to August or later (these later dates occurring for populations near the northern limits of the species).

Because of their similar morphologies, habitats, seasonalities and overlapping distributions, species in this complex have been frequently confused. Much of what has been published on *Py. pseudolanceolata* in particular has actually applied to different species. For example, the haploid chromosome number reported by Mumford and Cole (1977) for this species was actually for *Porphyra mumfordii*, and the culture conditions for conchocelis growth and maturation reported by Waaland et al. (1990) were probably for *Py. conwayae*. Moreover, the *rbc*L sequence reported for this species by Lindstrom and Fredericq (2003) was that of *Py. lanceolata*, as were the culture conditions reported for conchospore release (Lindstrom et al. 2008).

There have also been problems with the identity of *Pyropia lanceolata*. Krishnamurthy (1972) lectotypified *Porphyra perforata* f. *lanceolata*, the basionym of *Porphyra lanceolata*, with UC 95720 (collected by Setchell in Carmel Bay, California on 11 Jan 1899), but Lindstrom and Cole (1992b) felt that the specimens on the sheet did not accord with

Smith's description or with the major portion of Setchell & Hus' description. They therefore designated MO 24356 in UC (Lindstrom and Cole 1992b, Fig. 8), collected by H.T.A. Hus at Land's End, San Francisco, California, as lectotype since that collection better fit with the original description. The latter contains two outer specimens that are linear in habit, and four inner specimens that are lanceolate. Since modern DNA methods allow the sequencing of historic material, we sequenced a 251 bp region of the *rbc*L gene for the two outer and two inner specimens on MO 24356, a single specimen on UC 95720 (https://ucjeps.cspace.berkeley.edu/ucjeps_project/imageserver/blobs/c68a16ad-5ba5-4c15-8d8d/derivatives/OriginalJpeg/content), which all showed a similar morphology, as well as five of the six specimens on the type sheet of *Py. hiberna* (UBC A80269: http://bridge.botany.ubc.ca/herbarium/details.php?db=ubcalgae.fmp12&layout=ubcalgae_web_details&recid=210219&ass_num=A80269), a species closely related if not identical to *Py. lanceolata* (Sutherland et al. 2011). Seven of the specimens fell within the variation observed for contemporary collections of *Py. lanceolata* (Table 3). Specifically, UC 95720 from Carmel Bay, Monterey Peninsula, and four of the UBC A80269 specimens, all from Pacific Grove, Monterey Peninsula, had sequences identical to the two contemporary specimens from Pacific Grove. The contemporary Monterey Peninsula specimens differed from specimens of *Py. lanceolata* from other geographical regions by 0.3%, an amount insufficient to recognize them as a separate species. The distinctness of Monterey Peninsula genotypes within a species has been observed for other organisms (e.g., *Mastocarpus papillatus* (C. Agardh) Kützing, Lindstrom et al. 2011). The two identical inner specimens (one female and one male) on the lectotype sheet of MO 24356 from Land's End differed by 2 bp from the five Monterey Peninsula specimens noted above, but were identical to other *Py. lanceolata* specimens from outside of the Monterey Peninsula. In contrast, the two outer specimens on the same sheet (female far left and male far right) differed from these two inner specimens by 5 bp over the 251 bp region (but by only 3 bp from Monterey Peninsula *Py. lanceolata* and by only 2 bp from all *Py. conwayae* sequenced). Thus, at this time, we are unable to assign a name to the two outer linear specimens on the sheet of MO 24356. Since MO 24356 is heterotypic, we therefore narrow the lectotypification of MO 24356 to the middle four specimens. Our results also confirm that *Py. hiberna* S.C. Lindstrom & K.M. Cole, 1992: 435 is a heterotypic synonym of *Py. lanceolata*. The fifth specimen on the type sheet of *Py. hiberna* did not match among any described foliose Bangiales sequences but did match a recent collection we recognize here as *Pyropia* sp. (to be described later in a separate paper). *Pyropia lanceolata* was identified as Unknown #3 in Lindstrom (2008).

In the earlier paper on the *Py. lanceolata* complex (Lindstrom and Cole 1992b), they included *Porphyra mumfordii* as one of the species. This was in part because this entity had previously been misidentified as *P. pseudolanceolata* (Conway et al. 1975, Mumford and Cole 1977). Subsequent DNA sequencing studies have shown that these species are unrelated (Lindstrom and Fredericq 2003, Lindstrom 2008), despite the fact that *P. mumfordii* continues to be easily confused with species in the *Py. lanceolata* complex in the field because of similar habitat, seasonality and habit (see Lindstrom and Cole 1992b for a detailed comparison of these species).

Table 3. Details of sequences of type material (specimen identifier, collection site, collection date, collector, type status, GenBank accession number, and current identification). All sequences represent positions 655–905 in the 1467-bp long *rbc*L gene.

Specimen	Collection site	Collection date	Collector	Type Status	GenBank accession no.	Current identification
UC95720	Carmel Bay, CA	11 Jan 1899	W.A. Setchell	Krishnamurthy (1972) lectotype of *P. lanceolata*	KP904067	*Py. lanceolata*
UBC A80269 leftmost	Pacific Grove, CA	29 Dec 1990	S.C. Lindstrom	Holotype of *P. hiberna*	KP904068	*Py. lanceolata*
UBC A80269 third from left	Pacific Grove, CA	29 Dec 1990	S.C. Lindstrom	Holotype of *P. hiberna*	KP904069	*Py. lanceolata*
UBC A80269 third from right	Pacific Grove, CA	29 Dec 1990	S.C. Lindstrom	Holotype of *P. hiberna*	KP904070	*Py. lanceolata*
UBC A80269 second from right	Pacific Grove, CA	29 Dec 1990	S.C. Lindstrom	Holotype of *P. hiberna*	KP904071	*Py. lanceolata*
MO24356 in UC center male	Land`s End, San Francisco, CA	08 Feb 1899	H. Hus	Lindstrom and Cole (1992b) lectotype of *P. lanceolata*	KP904072	*Py. lanceolata*
MO24356 in UC center female	Land`s End, San Francisco, CA	08 Feb 1899	H. Hus	Lindstrom and Cole (1992b) lectotype of *P. lanceolata*	KP904073	*Py. lanceolata*
UBC A80269 second from left	Pacific Grove, CA	29 Dec 1990	S.C. Lindstrom	Holotype of *P. hiberna*	KP904074	*Pyropia sp.*
MO24356 in UC left male	Land`s End, San Francisco, CA	08 Feb 1899	H. Hus	Lindstrom and Cole (1992b) lectotype of *P. lanceolata*	KP904075	probably *Py. conwayae* or *Py. lanceolata*
MO24356 in UC right female	Land`s End, San Francisco, CA	08 Feb 1899	H. Hus	Lindstrom and Cole (1992b) lectotype of *P. lanceolata*	KP904076	probably *Py. conwayae* or *Py. lanceolata*

In conjunction with the present study, we have extended the range of *P. mumfordii* south to Pescadero State Park, California, and north to Calvert Island, British Columbia (Suppl. material 1).

As noted above, the species in the *Py. lanceolata* clade show little morphological differentiation. Therefore, the following key to species in this clade relies heavily on geographic distribution and on modest differences in seasonality and elevation on the shore.

1 Blade oblong or lanceolate, monoecious, sexes intermixed on thalli....***Py. fallax***
– Blade ovate or lanceolate, usually dioecious, if monoecious, sectored.....**2**
2 Mid to upper mid intertidal, often associated with sand, in late winter and spring **3**
– High intertidal to supralittoral, usually on bedrock, winter to very early spring **5**
3 Mid intertidal, from Land's End, San Francisco, California, to Tofino, British Columbia, but most common on the Oregon coast and along the Strait of Juan de Fuca..... ***Py. conwayae***
– Mid to upper mid intertidal, common on exposed coastlines **4**
4 Known from Cape Mendocino north in California and on Calvert Island, central coast of British Columbia ..... ***Py. columbiensis***
– Known from just south of Ventura Beach north to the Monterey Peninsula and from Fort Bragg, California ..... ***Py. montereyensis***
5 Known only from Spanish Bay, Monterey Peninsula, and northeast of Morro Rock, Morro Bay, California ..... ***Py. protolanceolata***
– Widely distributed from California to Alaska.....**6**
6. Common high intertidal winter species in California (isolated populations at Whiffen Spit and Calvert I., BC, and Sitka Sound, AK) ..... ***Py. lanceolata***
– Common high intertidal winter species from Oregon to Alaska..... .....***Py. pseudolanceolata***

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Supplementary material 1

Data for additional sequenced specimens

Authors: Sandra C. Lindstrom, Jeffery R. Hughey, Luis E. Aguilar Rosas

Data type: List

Explanation note: List of specimens by species, including collection data and GenBank accession numbers.

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RESEARCH ARTICLE

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New vascular plant records for the Canadian Arctic Archipelago

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Abstract

The Canadian Arctic Archipelago is a vast region of approximately 1,420,000 km^2, with a flora characterized by low species diversity, low endemicity, and little influence by alien species. New records of vascular plant species are documented here based on recent fieldwork on Victoria and Baffin Islands; additional records based on recent literature sources are mentioned. This paper serves as an update to the 2007 publication *Flora of the Canadian Arctic Archipelago*, and brings the total number of vascular plants for the region to 375 species and infraspecific taxa, an increase of 7.7%. Three families (Amaranthaceae, Juncaginaceae, Pteridaceae) and seven genera (*Cherleria* L., *Cryptogramma* R. Br., *Platanthera* Rich., *Sabulina* Rchb., *Suaeda* Forssk. ex J.F. Gmel., *Triglochin* L., *Utricularia* L.) are added to the flora, and one genus is deleted (*Minuartia* L.). Five species are first records for Nunavut (*Arenaria longipedunculata* Hultén, *Cryptogramma stelleri* (S.G. Gmel.) Prantl, *Puccinellia banksiensis* Consaul, *Saxifraga eschscholtzii* Sternb., *Utricularia ochroleuca* R.W. Hartm.)

Keywords

Floristics, Nunavut, Northwest Territories, Victoria Island, Baffin Island, Amaranthaceae, Juncaginaceae, Pteridaceae, *Cryptogramma*, *Platanthera*, *Suaeda*, *Triglochin*, *Utricularia*

Introduction

The Canadian Arctic Archipelago (CAA) is a group of islands occupying the northern third of Canada extending about 3000 km south to north and east to west, and covering approximately 1.42 million square kilometers. The archipelago comprises three very large islands, Baffin (507,451 km^2), Victoria (217,291 km^2), Ellesmere (196,236 km^2),

twelve islands between 10,000 and 71,000 km^2, and many thousands of smaller islands (Fig. 1). Politically the majority of islands are within the territory of Nunavut, while the westernmost part of the CAA is within the Northwest Territories. During the last glacial maximum (LGM) ice sheets covered almost the entire area; today glaciers cover only about 11% of the land area (Sharp et al. 2014). The Arctic flora as a whole is characterized as a young flora with low species diversity, low endemicity, and is little influenced by alien species (Daniëls et al. 2013). These characteristics are especially true for the flora of the CAA, which comprises only 349 recorded species and infraspecific taxa, no endemic species, and few, if any, stabilized alien species (Aiken et al. 2007).

Study of the Canadian Arctic Archipelago flora started with expeditions searching for a northwest passage in the early 1800s, such as the Parry Expedition (see Aiken et al. 2007 for a historical summary and list of collectors). Botanical collecting in this vast, difficult to access region continued sporadically through the 19th and early 20th centuries, mostly as part of large scientific expeditions. The first regional vascular plant floras appeared in the mid-1900s: Polunin's (1940) *Botany of the Eastern Canadian Arctic* and Porsild's (1955) *Vascular plants of the Western Canadian Arctic Archipelago*. Soon after, Porsild (1957, 1964) published a flora covering the entire CAA. In 2007 Aiken et al. published an updated flora for the CAA in digital format using Delta software.

Aiken et al. (2007) recorded and provided descriptions, maps and an interactive key for 349 species and infraspecific taxa (341 species plus eight subspecies) of vascular plants in the CAA, including three lycopods, eight monilophytes (ferns and *Equisetum* L.), and 338 flowering plants (no gymnosperms present). The genus *Papaver* L. was not fully treated at the time because it was undergoing revision; Solstad (2007) provided a provisional key of five species under the taxon entry *Papaver* spp., all of which are now recognized as distinct and occurring in the flora area (Elven et al. 2011). Counting these additional *Papaver* species (*P. cornwallisense* D. Löve, *P. dahlianum* Nordh., *P. labradoricum* (Fedded) Solstad & Elven, *P. lapponicum* subsp. *occidentale* (C.E. Lundstr.) Knaben, and *P.* sp. "Banks" [= *P. hultenii* Knaben]) brings the total to 353 species and infraspecific taxa (345 species), of which 342 are angiosperms. Aiken et al. (2007) comment in their Introduction that their flora "will provide a basis for much more research on Arctic plants in Canada in the coming years. There are many potentially very interesting areas that have never been botanised…. In these sites, certainly new records, as well as interesting new species to the Arctic Archipelago, are waiting to be discovered."

Recent fieldwork by our team on Victoria Island in 2008 and 2010, and on Baffin Island in 2012, led to discoveries of species new to the CAA and many significant range extensions. Here we document our major findings, including species, genera and families new to the CAA and species new to the western and eastern parts of the Arctic Islands. A subset of these are first records of species for Nunavut. We also summarize the literature pertinent to the CAA flora published since 2007 (or that was not included in Aiken et al. 2007), including new species described, significant new records, and new records resulting from taxonomic and nomenclatural changes. This publication serves as an update to Aiken et al. (2007).

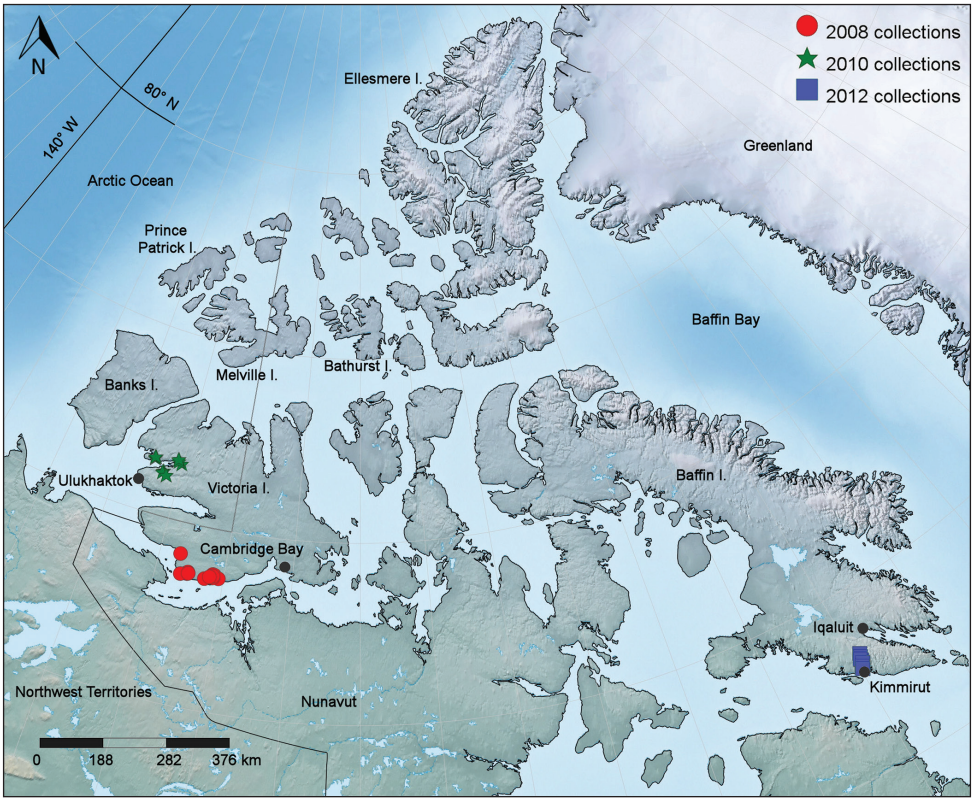

Figure 1. Map of the Canadian Arctic Archipelago showing 2008, 2010 and 2012 collection sites for new vascular plant records.

Methods

Fieldwork in the CAA was carried out in 2008, 2010 and 2012. In July 2008 and 2010, we collected vascular plants on southern Victoria Island, Nunavut, and on north western Victoria Island, Northwest Territories (Fig. 1) (map generated with SimpleMappr; Shorthouse 2010). In July 2012 we collected along the Soper River in Katannilik Territorial Park and in the vicinity of Kimmirut (formerly Lake Harbour) on southern Baffin Island, Nunavut (Fig. 1). During these field seasons we collected 3021 vascular plant numbers, of which 81 are reported here as new records, representing 25 taxa. The first set of our collections is deposited in the National Herbarium of Canada (CAN), Canadian Museum of Nature. Duplicate specimens are deposited in ALA, ALTA, BABY, COCO, MICH, MO, MT, NYBG, O, UBC, US, UVIC, WIN, WTU (acronyms according to Thiers, continuously updated), as noted in the specimen citations. All specimens cited have been seen, unless otherwise noted. Species accounts are organized by major clade (monilophytes, monocots, and eudicots), and then alphabetically by family, genus and species. Family-level classifications follow Smith et al. (2006) for monilophytes and Angiosperm Phylogeny Group III (2009) for angiosperms. Numerous literature sources

were consulted for nomenclature at the species level and below, including the *Flora of the Canadian Arctic Archipelago* (Aiken et al. 2007), the *Flora of North America North of Mexico* (Flora of North America Editorial Committee 1993+), and the *Annotated Checklist of the Panarctic Flora (PAF): Vascular Plants* (Elven et al. 2011). English common names mostly follow the *Database of Vascular Plants of Canada (VASCAN)* (Brouillet et al. 2010+, Desmet and Brouillet 2013). Global species distributions are modified from Elven et al. (2011); they provided a summary of the main geographical distribution patterns but are not intended to be exhaustive. Images of CAN specimens cited under Specimens Examined are available on Figshare (http://figshare.com; see Appendix) and the Canadian Museum of Nature's collections online website (http://collections.nature.ca/en/Search).

Results

The new discoveries described here plus new species and significant distribution records published recently bring the total number of vascular plant taxa in the CAA to 42 families, 141 genera and 375 species and infraspecific taxa (368 species). Table 1 provides a summary of these additions to the flora of the CAA since the publication of Aiken et al. (2007). Twenty species and infraspecific taxa are documented here as new to the CAA, representing a 7.7% increase in the number of species and infraspecific taxa recognized in Aiken et al. (2007).

Three families (Amaranthaceae, Juncaginaceae, Pteridaceae) and seven genera (*Cherleria* L., *Cryptogramma* R.Br., *Platanthera* Rich., *Sabulina* Rchb., *Suaeda* Forssk. ex J.F. Gmel., *Triglochin* L., *Utricularia* L.) are added to the flora. One genus (*Minuartia* L.) is deleted from the flora. We document six recently described taxa as additions to Aiken et al. (2007). Three new species have been described recently from the CAA: *Draba simmonsii* Elven & Al-Shehbaz (Elven and Al-Shehbaz 2008), widely distributed across the CAA, *Draba cayouettei* G.A. Mulligan & Al-Shehbaz from northern Quebec and Southampton Island (Al-Shehbaz and Mulligan 2013) and *Puccinellia banksiensis* Consaul from Banks Island and Arctic coastal Alaska (Consaul et al. 2008; its presence in Nunavut on Victoria Island is documented here). Harris (2006) described three new *Braya* Sternb. & Hoppe subspecies endemic to the CAA: *B. humilis* subsp. *ellesmerensis* J.G. Harris, *B. glabella* subsp. *prostrata* J.G. Harris, and *B. thorild-wulffii* subsp. *glabrata* J.G. Harris. In addition, the first record in Canada and the CAA of a member of the *Puccinellia wrightii* (Scribn. & Merr.) Tzvelev complex was documented by Consaul et al. (2005) on Banks Island, although the precise identity of the single collection remains uncertain pending taxonomic revision of the species complex.

Several taxa are added to the flora of the CAA as a result of recent taxonomic revisions. *Chrysosplenium rosendahlii* Packer, described from Somerset Island (Packer 1963) but subsequently treated as a synonym of *C. tetrandrum* (Scoggan 1978, Aiken et al. 2007), is now considered a distinct species (Freeman and Levsen 2007), a status supported by molecular DNA barcode data (Saarela et al. 2013b). *Papaver hultenii*, described from the Coppermine River on mainland Nunavut and Alaska (Knaben 1959), was considered "apparently common on sandy and gravelly beaches and tundra

ridges" on coastal mainland Northwest Territories and north-western mainland Nunavut by Porsild and Cody (1980: 335), but was subsequently treated as a synonym of *P. lapponicum* by Kiger and Murray (1997). The species has been confirmed as distinct (Solstad 2009), and as occurring in the western CAA (Elven et al. 2011), where it is now known to be the dominant poppy species on southern Banks and Victoria Islands (collections at CAN and L.J. Gillespie, pers. obs.). *Papaver* sp. "Banks" of southern Banks Island (Solstad 2007, 2009) is now considered conspecific with *P. hultenii* (H. Solstad, pers. comm.). The polyphyletic genus *Minuartia* has been divided into eleven genera (Dillenberger and Kadereit 2014), resulting in the addition of two genera, *Cherleria* and *Sabulina*, and the deletion of *Minuartia* from the flora of the CAA.

Several older publications and collections from the Arctic Islands have come to light since the publication of Aiken et al. (2007). While processing older collections at CAN, we became aware of a significant range extension for *Saxifraga eschscholtzii* Sternb., previously known from only one locality in the CAA. *Leymus innovatus* subsp. *velutinus* (Bowden) Tzvelev, which was reported for Banks Island in Mason et al. (1972), Porsild and Cody (1980) and Barkworth (2007), was not included in Aiken et al. (2007). Its presence on Banks Island is confirmed here. Additionally, the publication by Thannheiser et al. (2001) with many new distribution records for the Canadian Arctic Islands was overlooked by Aiken et al. (2007). This publication documenting the flora at specific sites on Victoria Island stemmed from fieldwork focusing on plant ecology and phytosociology carried out between 1973 and 1998. No voucher collections were cited in the publication. Collections documenting some of the new records were located at TROM, but others, if they exist, could not be located.

Thannheiser et al. (2001) reported seven species as new to the CAA; of these, three are confirmed here by our new collections (*Andromeda polifolia* L., *Pinguicula vulgaris* L., *Suaeda calceoliformis* (Hokk.) Moq.), two were not new records at the time (*Poa hartzii* Gand., reported earlier in Porsild 1957; *Festuca hyperborea* Holmen, reported in Porsild 1964), and two remain unconfirmed (no voucher specimens found) but are likely not new records. One of these is *Puccinellia deschampsiodes* Th. Sör., a taxon now treated as a synonym of *P. nuttalliana* (Schult.) Hitchc. (Davis and Consaul 2007), which also includes *P. borealis* Swallen, previously known from Victoria Island (Porsild 1964, Porsild and Cody 1980). The other is *Parnassia palustris* L., recorded from Johansen Bay; this material has likely been re-identified as *P. kotzebuei* Cham. ex Spreng., which was recorded only from Hadley Bay but with Thannheiser collections present at TROM from both sites. Nine species were considered as new to the western CAA by Thannheiser et al. (2001). Of these, *Sabulina stricta* (Sw.) Rchb. is confirmed here by our new collections and *Carex microglochin* Wahlenb. was confirmed and included in Aiken et al. (2007). Two were not new records: *Puccinellia langeana* subsp. *typica* T.J. Sørensen ex Hultén [= *P. tenella* subsp. *langeana* (Berlin) Tzvelev] was reported in Porsild (1964), and *Hedysarum alpinum* L., for which two subspecies were recorded, but only one, *H. alpinum* subsp. *americanum* (Michx. ex Pursh) B. Fedtsch. [= *H. americanum* (Michx. ex Pursh) Britton], is considered present in the Arctic (Porsild 1957, Porsild and Cody 1980, Elven et al. 2011). *Koenigia islandica* L. and *Eleocharis acicularis* (L.) Roem. & Schult. could not be confirmed since no voucher specimens

Table 1. Vascular plant species new to the Canadian Arctic Archipelago (CAA) since the publication of Aiken et al. (2007). Records are based on field collections and literature sources. Species new to the CAA, western CAA, eastern CAA and Nunavut are given. New records for one adventive species, one species previously known from only one collection in the CAA, one recently described species, and confirmation of three species excluded by Aiken et al. (2007) are also included.

Family	Species	New to CAA	New to western CAA	New to eastern CAA	New to Nunavut	Other	Source
Pteridaceae	*Cryptogramma stelleri* (S.G. Gmel.) Prantl	X			X		Current study
Cyperaceae	*Carex bicolor* Bellardi ex All.		X				Current study
	Carex brunnescens (Pers.) Poir. subsp. *brunnescens*	X					Current study
	Eriophorum brachyantherum Trautv. & C.A. Mey.		X				Current study
Juncaceae	*Luzula wahlenbergii* Rupr.		X				Current study
Juncaginaceae	*Triglochin palustris* L.	X					Current study
Orchidaceae	*Corallorhiza trifida* Chatelain		X				Current study
	Platanthera obtusata (Banks ex Pursh) Lindl. subsp. *obtusata*	X					Current study
Poaceae	*Calamagrostis stricta* subsp. *groenlandica* (Schrank) Á. Löve					Confirmed for eastern CAA	Current study
	Hordeum jubatum L. subsp. *jubatum*					New records, adventive species	Current study
	Leymus innovatus subsp. *velutinus* (Bowden) Tzvelev					Confirmed for CAA	Mason et al. (1972), Porsild and Cody (1980), Barkworth (2007), current study
	Leymus mollis (Trin.) Pilg. subsp. *mollis*	X					Current study
	Puccinellia banksiensis Consaul	X			X	New records	Consaul et al. (2008), current study
Potamogetonaceae	*Stuckenia vaginata* (Turcz.) Holub	X					Current study
Amaranthaceae	*Suaeda calceoliformis* (Hook.) Moq.	X					Current study
Brassicaceae	*Braya humilis* subsp. *ellesmerensis* J.G. Harris	X					Harris (2006)
	Braya glabella subsp. *prostrata* J.G. Harris	X					Harris (2006)
	Braya thorild-wulffii subsp. *glabrata* J.G. Harris	X					Harris (2006)
	Draba simmonsii Elven & Al-Shehbaz	X					Elven and Al-Shehbaz (2008)
	Draba cayouettei G.A. Mulligan & Al-Shehbaz	X					Al-Shehbaz and Mulligan (2013)

Family	Species	New to CAA	New to western CAA	New to eastern CAA	New to Nunavut	Other	Source
Caryophyllaceae	*Arenaria humifusa* Wahl.		X				Current study
	Arenaria longipedunculata Hultén	X			X		Current study
	Sabulina stricta (Sw.) Rchb.		X				Current study
Ericaceae	*Andromeda polifolia* L.	X					Current study
	Orthilia secunda subsp. *obtusata* (Turcz.) Böcher			X			Current study
Fabaceae	*Oxytropis deflexa* subsp. *foliolosa* (Hook.) Cody		X				Current study
Lentibulariaceae	*Pinguicula vulgaris* L.		X				Current study
	Utricularia ochroleuca R.W. Hartm.	X			X		Current study
Papaveraceae	*Papaver hultenii* Knaben					Confirmed for CAA	Solstad (2009), Elven et al. (2011)
Primulaceae	*Primula egaliksensis* Wormsk.	X					Current study
Ranunculaceae	*Coptidium* × *spitsbergense* (Hadač) Luferov & Prob.	X					Current study
Salicaceae	*Salix arctophila* Cockerell ex A. Heller		X				Current study
	Salix fuscescens Andersson			X			Current study
Saxifragaceae	*Chrysosplenium rosendahlii* Packer					Confirmed for CAA	Packer (1963), Freeman and Levsen (2007)
	Saxifraga eschscholtzii Sternb.				X	New record	Current study
	Saxifraga rivularis subsp. *arctolitoralis* (Jurtz. & V.V. Petrovsky) M.H. Jørg. & Elven	X					Current study

were located, *Potentilla nivea* L. subsp. *nivea* could not be confirmed since it belongs to a taxonomically difficult species complex that has changed over time and largely remains poorly resolved, and two species remain to be confirmed, which also belong to taxonomically difficult species complexes (*Cerastium alpinum* L., *Castilleja caudata* (Pennel) Rebrist.; a specimen of the latter at TROM was determined as *Castilleja* cf. *caudata* by R. Elven and I. Alsos).

The majority of the new records described here are assumed to be discoveries of long established species that have simply been overlooked by botanists. One record, *Hordeum jubatum* L., an introduced weedy species found within the Kimmirut town site, is obviously a recent introduction. Documenting the present day flora is essential as baseline data for future studies of floristic changes resulting from the warming climate or from anthropogenic introductions due to increased human traffic.

Annotated list of new vascular plant records

MONILOPHYTES
Pteridaceae

***Cryptogramma stelleri* (S.G. Gmel.) Prantl**
Fig. 2

Common name. Steller's rockbrake

Distribution. Disjunct circumboreal (absent from Greenland and Europe)

Comments. This is the first record of the species, genus and family from the CAA and for Nunavut. The genus is easily distinguished from other fern genera in the Arctic Islands by its dimorphic fronds. We discovered one small population on a southeast facing cliff by Fundo Lake on the outskirts of Kimmirut. Plants were small with sterile fronds 3–5(7) cm long and fertile fronds 4–8 cm long, and were growing with moss in horizontal fractures in grey marble.

Uncommon and with a scattered and disjunct distribution, *C. stelleri* is found in North America primarily in the western montane boreal and eastern boreal zones (Alverson 1993). It is listed in North America as apparently secure only in Ontario and Quebec, vulnerable to critically imperilled in all other provinces, and vulnerable to possibly extirpated in all states where it occurs and is ranked (NatureServe 2014). Typical habitat in North America is considered to be crevices and rock ledges on calcareous cliffs in boreal habitats (Alverson 1993). Absent from most of the Northwest Territories, Porsild and Cody (1980) recorded it as rare on moist shale slopes in the Richardson and Mackenzie mountains. In northern Quebec it occurs in several small isolated populations mostly in coastal areas near treeline, in cracks on moist shady calcareous cliffs or sometimes on granitic rock in moist, low acid soils on ledges and overhangs (Dignard 2013). Three nearby sites on rocky escarpments near Kangiqsujuaq on the northern Quebec coast occur well within the Arctic (ca.

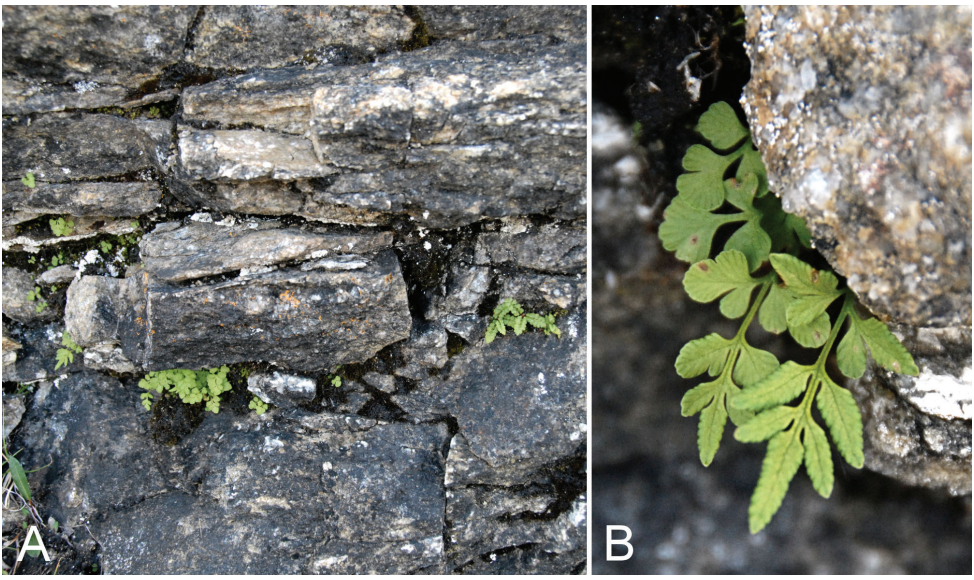

Figure 2. *Cryptogramma stelleri*: **A** habitat **B** habit, *Saarela et al. 2774*. Photographs by L.J. Gillespie.

61°36'N). Our collection from 62°50'44"N on nearby Baffin Island represents a new northern limit for eastern North America. Low spore production, limited dispersal ability, and restricted habitat preference are thought to contribute to its rarity and scattered distribution (Peck et al. 1990, Dignard 2013), and also suggests that this diminutive fern may simply have been overlooked in the past, rather than representing a recent introduction.

Specimens examined. Canada. Nunavut: Qikiqtaaluk Region, Baffin Island, Kimmirut, W end of Fundo Lake, ca. 2 km W of hamlet, 62°50'44"N, 69°54'6"W, 40 m, 22 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2774* (ALA, CAN-601315).

MONOCOTS
Cyperaceae

Carex bicolor Bellardi ex All.

Common name. Two-coloured sedge

Distribution. Circumpolar-alpine

Comments. This is the first report of the species from the western CAA, based on one collection from a sloped sandy riverbank on southern Victoria Island, Nunavut. The species is known from the southeastern CAA (Coats Island, Southampton Island, southern Baffin Island; Porsild and Cody 1980, Aiken et al. 2007). In the western Arctic, *Carex bicolor* is known from adjacent mainland Nunavut (Bathurst Inlet) and Northwest Territories (Porsild and Cody 1980, Saarela et al. 2013a).

Specimen examined. Canada. Nunavut: Kitikmeot Region, Victoria Island, W end of Johansen Bay at mouth of Mackenzie Creek, 68°36'4"N, 111°21'7"W, 0–20 m, 20 July 2008, *Gillespie, Saarela, Consaul & Bull 8118* (CAN-592505).

Carex brunnescens (Pers.) Poir. subsp. *brunnescens*

Common name. Brownish sedge

Distribution. Circumboreal-polar

Comments. This is the first report of the species from the CAA. Our collections were gathered in Katannilik Territorial Park on southern Baffin Island, where the cespitose species was found at three sites in damp, turfy places. It was rare at two sites (only a few scattered plants), and locally common at one site. Associated species include *Betula glandulosa* Michx., *Calamagrostis canadensis* var. *langsdorffii* (Link) Inman, *Chamerion angustifolium* (L.) Holub, *Carex arctogena* Harry Sm., *C. bigelowii* Torr. ex Schwein., *Pedicularis lapponica* L., *Poa arctica* R. Br. and *Taraxacum ceratophorum* (Ledeb.) DC.

This boreal species extends to the treeline across Canada, and into the Arctic zone in northern Quebec and northern Labrador, where it is moderately common (Porsild and Cody 1980, Cayouette 2008), and Greenland (Porsild and Cody 1980). Its discovery on Baffin Island increases the number of *Carex* species known from the CAA to 34. *Carex brunnescens* is classified in *Carex* sect. *Glareosae* G. Don (Toivonen 2002); five other species of this section (*C. ursina* Dewey, *C. glareosa* Schkuhr ex Wahlenb., *C. lachenali* Schkuhr, *C. marina* Dewey) occur in the CAA (Aiken et al. 2007).

Specimens examined. Canada. Nunavut: Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River valley, W bank, near confluence of Willow River, ca. 14 km S of Mount Joy, 63°9'18"N, 69°41'51"W, 41 m, 8 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2232* (CAN-601449); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River, W side, S of Livingstone Falls, 63°5'22"N, 69°44'22"W, 67 m, 11 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2346* (ALA, ALTA, CAN-601450, MO, MT, O, UBC, UVIC, WTU); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River, 9.5 km S (downstream) of confluence with Livingstone River, W bank, willow stands in gullies at base of E-facing slope, 63°2'32"N, 69°42'47"W, 25 m, 13 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2407* (CAN-601451, MICH, NYBG, WIN).

Eriophorum brachyantherum Trautv. & C.A. Mey.

Fig. 3

Common name. Short-anther cottongrass

Distribution. Circumboreal-polar

Comments. This is the first report of the species from the western CAA, where we collected it at several sites in the Minto Inlet area of Victoria Island, Northwest Ter-

Figure 3. *Eriophorum brachyantherum*: **A** habitat **B** inflorescence, *Saarela et al. 9899*. Photographs by J.M. Saarela.

ritories. These collections represent a major northeastern range extension of some 350 km from the nearest location on mainland Northwest Territories (Paulatuk; Saarela et al. 2013a) and a north-northeastern extension of some 380 km from the next closest mainland site (Kugluktuk) (Porsild and Cody 1980). It is known from the eastern CAA (one collection on eastern Baffin Island and two on Southampton Island; Porsild and Cody 1980, Aiken et al. 2007). The species was locally common at numerous sites growing in wet sedge meadows, associated with *Arctagrostis latifolia* (R. Br.) Griseb. subsp. *latifolia*, *Carex membranacea* Hook., *C. aquatilis* var. *minor* Boott, *C. fuliginosa* subsp. *misandra* (R. Br.) Nyman, *C. scirpoidea* Michx., *Elymus alaskanus* (Scribn. & Merr.) Á. Löve, *Eriophorum angustifolium* Honck., *E. triste* (Th. Fr.) Hadač & Á. Löve, *Juncus triglumis* var. *albescens* Lange, *J. biglumis* L., *Oxyria digyna* (L.) Hill, and *Salix reticulata* L. *Eriophorum brachyantherum* is a cespitose, non-tussock forming species easily distinguished from other cespitose *Eriophorum* species by its tall culms (Ball and Wujek 2002).

Specimens examined. Canada. Northwest Territories: Inuvik Region, Victoria Island, 8 km NE of Minto Inlet in valley at small river that feeds into head of inlet, 71°37'9.8"N, 115°26'21.5"W, 100 m, 7 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 9485* (ALA, CAN-598595, MT, O); Inuvik Region, Victoria Island, N side of small round lake (ca. 1 km diameter), ca. 4 km N of Boot Inlet on N side of Minto Inlet, 71°30'50.8"N, 117°21'43.6"W, 72 m, 11 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 9673* (ALA, CAN-598605, MT, O); Inuvik Region, Victoria Island, shore E of "Fish Lake" on lower

Kuujjua River, 71°12'7.7"N, 116°24'2.7"W, 57 m, 16 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 9899* (ALA, CAN-598607, MT, O); Inuvik Region, Victoria Island, shore E of "Fish Lake" on lower Kuujjua River, 71°12'7.7"N, 116°24'2.7"W, 57 m, 18 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 9982* (CAN-598924); Inuvik Region, Victoria Island, valley downstream from the junction of three rivers 6 km NE of head of Minto Inlet, 71°36'31.7"N, 115°27'23"W, 134 m, 21 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 10091* (CAN-598596); Inuvik Region, Victoria Island, wet sedge meadow on flat to gently sloping plateau E of junction of three rivers 6 km NE of head of Minto Inlet, 71°36'22.8"N, 115°26'30.9"W, 154 m, 21 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 10102* (ALA, ALTA, ARI, CAN-598910, MT, O, UBC, WIN, US); Inuvik Region, Victoria Island, 8 km NE of Minto Inlet in valley at small river that feeds into head of inlet, 71°37'16.6"N, 115°25'58.7"W, 164 m, 26 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 10305* (ALA, ARI, CAN-598598, MT, O, UBC, WIN).

Juncaceae

Luzula wahlenbergii Rupr.

Common name. Wahlenberg's woodrush

Distribution. Circumpolar-alpine

Comments. This is the first collection of this low Arctic species from the western CAA. The taxon is known from several sites on adjacent mainland Nunavut (Porsild and Cody 1980, Cody et al. 1989, Cody 1996, Cody and Reading 2005). Our collection represents a range extension in the central portion of its range of some 330 km north-northwest of the nearest site on mainland Nunavut (George Lake Camp, 65°55'10"N, 107°23'00"W, *Reading 466*, DAO; Cody and Reading 2005). This taxon is now known from eight sites in the CAA: the one reported here, and seven on southeastern Baffin Island. Elsewhere in the Canadian Arctic there are numerous collections of the species from northern Quebec and northwestern North America (Alaska, Yukon, western mainland Northwest Territories) (Porsild and Cody 1980, Swab 2000, Kirschner 2002, Hay 2013).

Specimen examined. Canada. Nunavut: Kitikmeot Region, Victoria Island, flat topped steep sided hill, 11 km NE of Johansen Bay airstrip, 68°39'12"N, 110°54'47"W, 120 m, 20 July 2008, *Gillespie, Saarela, Consaul & Bull 8170* (CAN-592326).

Juncaginaceae

Triglochin palustris L.

Fig. 4

Common name. Marsh arrowgrass

Distribution. Circumboreal-polar

Figure 4. *Triglochin palustris*: **A** habit **B** inflorescence, *Saarela et al. 2535*. Photographs by R.D. Bull.

Comments. Discovery of this widely-distributed temperate and facultatively halophytic species growing in wet, brackish habitats at two sites on southern Baffin Island adds a new monocot family, Juncaginaceae, to the flora of the CAA. This taxon is diminutive on Baffin Island, ranging from 6–12 cm tall (larger elsewhere in its range, up to 42.5 cm tall; Haynes and Hellquist 2000a) and therefore easily overlooked, particularly when in flower (fruiting plants are more noticeable). On the mainland, it is known from several Arctic coastal and near-coastal sites in adjacent northern Quebec (Blondeau and Cayouette 2002, Hay 2013) and from a few sites on mainland Nunavut and the Northwest Territories (Porsild and Cody 1980, Blondeau and Cayouette 2002, Saarela et al. 2013a) and southern Greenland (Haynes and Hellquist 2000a). The larger and more robust species *Triglochin maritima* L., which occurs on the mainland Arctic (Porsild and Cody 1980, Hay 2013, Saarela et al. 2013a), is not known from the CAA.

One collection was gathered from a population in wet sandy ground in a dried up depression adjacent to meromictic Soper Lake, associated with *Eriophorum scheuchzeri* Hoppe, *Juncus arcticus* Willd., *Carex bicolor*, and *Dupontia fisheri* R. Br. The second collection was gathered from a sedge meadow at the input of Fundo Lake, associated with *Carex atrofusca* Schkuhr, *C. gynocrates* Wormsk. ex Drejer, *C. membranacea* Hook., *C. microglochin*, *C. rariflora* (Wahlenb.) Sm., *C. scirpoidea*, *Eriophorum angustifolium*, *E. callitrix* Cham., *E. russeolum* Fr., *E. scheuchzeri*, *Juncus arcticus*, *Kobresia simpliciuscula* (Wahlenb.) Mack. and *Trichophorum caespitosum* (L.) Hartm.

Specimens examined. Canada. Nunavut: Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper Falls, S side of Soper Lake, just SE of Soper Falls, 62°54'1"N, 69°50'54"W, 6 m, 17 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2535* (ALA, CAN-601427, MT); Qikiqtaaluk Region, Baffin Island, Kimmirut, N end of Fundo Lake below Taqaiqsirvik Territorial Park, 62°50'50"N, 69°53'40"W, 35 m, 20 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2652* (CAN-601426, O, WIN).

Orchidaceae

Corallorhiza trifida Chatelain

Fig. 5

Common names. Northern coralroot, early coralroot

Distribution. Circumboreal-polar

Comments. Our collections represent the first record of the species in the western CAA, and the second for the eastern CAA and Baffin Island. Thought to be the only orchid in the CAA (Aiken et al. 2007, but see *Platanthera obtusata*), it was previously known from only one collection and two sites in Auyuittuq National Park, Baffin Island (Gould 1997). Common throughout boreal Canada, its range is scattered and sparse north of the tree-line to the mainland Arctic coast from the Yukon to Bathurst Inlet, Nunavut, and along the Hudson Bay coast (Porsild and Cody 1980). In their treatment of *Corallorhiza trifida* for the Flora of North America, Magrath and Freudenstein (2002) reported the species from the western CAA. They mapped two dots on Victoria Island: one centered on the Cambridge Bay area, the other on south-central Victoria Island; and they shaded the southern half of Prince of Wales Island. We are not aware of specimens or other literature reports for these records; they do not appear in Freudenstein's (1997) revision of *Corallorhiza* in North America, nor does J. Freudenstein (pers. comm. 2014) know the source of these records (L. Magrath, first author of the FNA treatment, is deceased). Our collection from south-central Victoria Island (incidentally, this is one of the same areas mapped in Magrath and Freudenstein 2002) is the only confirmed record for the western CAA. It was recorded as uncommon on the low, densely vegetated, south-facing bank of a creek near its mouth, on a mostly sandy substrate, with *Dryas integrifolia*, *Bistorta vivipara* (L.) Gray, and *Hedysarum boreale* subsp. *mackenziei* (Richardson) S.L. Welsh (*Salix* and *Arctous rubra* (Rehder & E.H. Wilson) Nakai nearby).

In the Soper River valley on southern Baffin Island we found the species to be scattered, but never common, on densely vegetated river flats, riverbanks, and peaty wet meadows at several localities. Our three collections increase the number of records for Baffin Island to four. In adjacent northern Quebec, the species occurs along the coast and in the interior, known from only three Arctic localities (Houle 2013).

The species is a near-complete mycoheterotroph (Zimmer et al. 2008, Cameron et al. 2009), and in most of its range plants are green to yellow-green in colour (e.g., see

Figure 5. *Corallorhiza trifida*: **A** habitat **B** inflorescence **C** habit, *Gillespie et al. 8093* **D** habit, *Saarela et al. 1970*. Photographs by R.D. Bull.

photo in Houle 2013: 322). Freudenstein (1997) noted that lighter-coloured individuals tend to occur in more southern, forested areas, whereas darker-coloured forms occur in exposed northern sites, such as tundra. Earlier observations of the species at its northern

limits in Canada are consistent with this (Gould 1997, Saarela et al. 2013a: Fig. 19). Our collection from Victoria Island was prominently reddish-brown throughout (anthocyanic) (Fig. 5A–C); those from the Soper River valley less so (Fig. 5D). None of the populations we observed was as large as a population of 56 individuals found in Auyuittuq National Park of Canada, Baffin Island (Gould 1997). One population collected and surveyed in the Soper River valley had 19 stems in a 5 × 3 m area (*Saarela et al. 1970*); the population collected on Victoria Island had 14 stems in two clumps (*Gillespie et al. 8093*). A fourth occurrence was observed but not collected in the Soper River valley (near confluence of Willow River, ca. 14 km S of Mount Joy, 63°9'24"N, 69°41'35"W).

Specimens examined. Canada. Nunavut: Kitikmeot Region, Victoria Island, W end of Johansen Bay at mouth of Mackenzie Creek, 68°36'4"N, 111°21'7"W, 0–20 m, 20 July 2008, *Gillespie, Saarela, Consaul & Bull 8093* (CAN-592381; Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, densely vegetated river flat near Mount Joy, ca. 5 m wide band between river and dry stony floodplain, 63°14'52.7"N, 69°36'45.7"W, 75 m, 1 July 2012, *Saarela, Gillespie, Sokoloff & Bull 1970* (CAN-601648); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, peaty wet meadow along Soper River, ca. 0.5 km N of Mount Joy, 63°15'3"N, 69°36'6"W, 86 m, 2 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2036* (CAN-601649); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River, high water mark along riverbank, ca. 13 km downstream (S) of its confluence with the Livingstone River, 62°59'40"N, 69°42'46"W, 35 m, 13 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2415* (CAN-601650).

Platanthera obtusata **(Banks ex Pursh) Lindl. subsp.** ***obtusata***

Fig. 6

Habenaria obtusata (Banks ex Pursh) Richards
Lysiella obtusata (Banks ex Pursh) Rydb.

Common name. Northern bog orchid

Distribution. Boreal North America

Comments. This is the first record for this genus and species, and the second species of orchid discovered (see *Corallorhiza trifida*), in the CAA (Aiken et al. 2007). The species is currently considered to include two subspecies; all North American plants belong to subsp. *obtusata*, while Eurasian plants are treated as subsp. *oligantha* (Turcz.) Hultén (Sheviak 2003, Elven et al. 2011). This wide-ranging boreal species of damp or wet, turfy places (Correll 1978) is also found beyond the treeline in Canada from northern Yukon to northern Quebec (Porsild and Cody 1980, Cody 2000, Cody et al. 2003, Sheviak 2003, Saarela et al. 2013a). Porsild (1955) suggested that the species is likely to be found in southern areas of the western Arctic Islands, but it has not yet been found there. In Arctic Quebec, the species has been reported as occurring along the east coast of Hudson Bay (Polunin 1940, Porsild and Cody 1980, Sheviak 2003,

Figure 6. *Platanthera obtusata* subsp. *obtusata*: **A** habitat, *Saarela et al. 2197* **B** inflorescence **C** habit **D** old fruits, *Saarela et al. 2209*. Photographs by R.D. Bull.

Houle 2013) and at five sites on the north-central Ungava Peninsula (Maycock and Matthews 1966, Blondeau and Cayouette 2002, Houle 2013). Blondeau and Cayouette (2002) reported the species from two sites near Douglas Harbour along the northern coast, just south of Kimmirut, Baffin Island (mapped in Houle 2013). At one site the species was uncommon at the base of a scree slope along a stream margin, and at the second only a few individuals were found growing among rocks.

Along the Soper River on southern Baffin Island we collected three populations. The first (*Saarela et al. 2197*) had two subpopulations with a total of 80 plants, the second (*Saarela et al. 2209*) came from a population of over 100 plants in a 10 m^2 area, and the third (*Saarela et al. 2488*) was from a population of over 250 plants in a 80 m^2 area. Near the third population was an even larger population estimated at over 1000 plants that was not collected. These populations were found in moist sedge-willow hummocks set on small hills and valleys on the lower slopes of the Soper Valley away from the banks of the Soper River, growing in association with *Betula glandulosa*, *Salix arctophila* Cockerell ex A. Heller, *S. calcicola* Fernald & Wiegand, *S. reticulata*, *Empetrum nigrum* L., *Rhododendron lapponicum* (L.) Wahlenb., *Equisetum arvense* L., *Cassiope tetragona* (L.) D. Don, *Vaccinium uliginosum* L., and *V. vitis-idaea* L. While the first two populations were encountered within a few kilometers of each other, we encountered the third, largest population 20 kilometers away, suggesting that other populations may occur in the area where habitat is suitable.

Specimens examined. Canada. Nunavut: Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River valley, W bank, ca. 12 km S of Mount Joy, meadow along river opposite Group/Warden Cabin #7, 63°9'50"N, 69°40'2"W, 40 m, 8 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2197* (CAN-601651); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River valley, W bank, ca. 1 km S of Mount Joy, moderate S-facing slope, 63°9'39"N, 69°40'29"W, 55 m, 8 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2209* (CAN-601276); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River, 18.5 km downstream (S) of its confluence with the Livingstone River, 2 km S of Emergency Cabin #8, W side of river, 62°59'28"N, 69°43'30"W, 67 m, 15 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2488* (ALA, CAN-601652, O).

Poaceae

Calamagrostis stricta subsp. *groenlandica* (Schrank) Á. Löve

Fig. 7

Common name. Slim-stemmed reedgrass

Distribution. Circumboreal-polar

Comments. Our new collections confirm the presence of this taxon in the eastern CAA. We collected specimens from several populations in Katannilik Territorial Park on southern Baffin Island, in mesic to wet tundra habitats. The species is documented in the western CAA (Banks Island, Melville Island, Prince Patrick Island; Aiken et al. 2007, as C. *neglecta* subsp. *groenlandica* (Schrank) Matuszk). Porsild and Cody (1980) reported the taxon (as *C. neglecta* (Ehrh.) G. Gaertn., B. Mey. & Scherb.) from Devon Island, the Cumberland Peninsula of Baffin Island and Coats Island, but these records were not mapped in Aiken et al. (2007), nor could specimens be located at CAN or DAO. Associated species on Baffin Island include *Agrostis mertensii* Trin., *Arctagrostis*

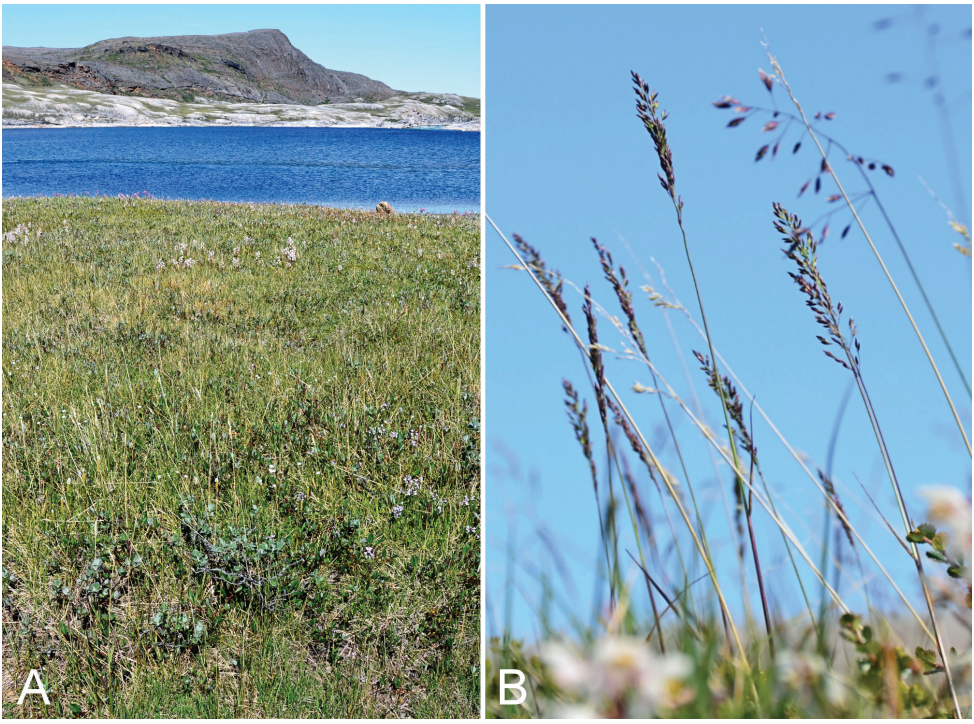

Figure 7. *Calamagrostis stricta* subsp. *groenlandica*: **A** habitat **B** habit, *Saarela et al. 2576*. Photographs by R.D. Bull.

latifolia subsp. *latifolia*, *Betula glandulosa*, *Carex rariflora*, *C. membranacea*, *Empetrum nigrum*, *Eriophorum vaginatum*, *Huperzia selago* (L.) Bernh. ex Schrank & Mart., *Luzula wahlenbergii*, *Rhododendron tomentosum* Harmaja subsp. *decumbens* (Aiton) Elven & D.F. Murray, *Salix arctica* Pall., *S. arctophila*, and *Vaccinium vitis-idaea*.

Specimens examined. Canada. Nunavut: Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River valley, E bank, large sedge meadow with several small ponds ca. 12.5 km S of Mount Joy, 0.5 km S of Group/Warden Cabin #7, 63°9'35"N, 69°40'3"W, 41 m, 7 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2191* (ALTA, CAN-601348, MO, US); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River, E bank, 12 km S of Mount Joy along river, at Group/Warden Cabin #7, 63°9'44"N, 69°39'28"W, 50 m, 9 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2255* (ALA, CAN-601345); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River, 5 km S (downstream) of confluence with Livingstone River, E bank, 63°4'32"N, 69°42'11"W, 30 m, 13 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2398* (CAN-601347); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River, 18.5 km downstream (S) of its confluence with the Livingstone River, 2 km S of Emergency Cabin #8, E bank of river, 62°59'13"N, 69°42'48"W, 28 m, 14 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2442* (ALTA, CAN-601346); Qikiqtaaluk Region, Baffin Island,

Katannilik Territorial Park Reserve, Soper Falls/Soper Lake, S side of Soper River, 62°54'6"N, 69°51'2"W, 8 m, 18 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2576* (CAN-601344, O).

Hordeum jubatum* L. subsp. *jubatum
Fig. 8

Common name. Foxtail barley

Distribution. North America–NE Asia

Comments. *Hordeum jubatum* is a widely distributed species that grows in meadows, along rivers, around lakes, and in disturbed habitats such as roadsides (von Bothmer et al. 2007). Two subspecies are recognized: subspecies *jubatum* and *intermedium* Bowden, which differ in the lengths of their glumes and lemma awns of the central spikelets (Bowden 1962, von Bothmer et al. 2007); the variation in these characters is continuous and some intermediate specimens cannot be assigned to subspecies (Bowden 1962, Baden and von Bothmer 1994). Bowden (1962) considered subsp. *intermedium* to be a hybrid between *H. jubatum* s.s. and *H. brachyantherum* Nevski, but to our knowledge this hypothesis has not been tested with molecular data. Some authors treat subsp. *intermedium* as a separate species, *H. caespitosum* Scribn. (e.g., Baum and Bailey 1994). *Hordeum jubatum* subsp. *jubatum* is a weedy species native from eastern Siberia and northeastern China through North America to Mexico, and it is introduced to South America, Europe and Central Asia (Baden and von Bothmer 1994, von Bothmer et al. 2007). It is generally considered to be native in western North America and adventive in eastern and southeastern North America (e.g., Hitchcock 1951, von Bothmer et al. 2007), but some authors consider it native across North America (Baden and von Bothmer 1994). Bowden (1962) noted the subspecies to be expanding its range in northern Canada. *Hordeum jubatum* subsp. *intermedium* grows in central and western Canada and United States, the Magdalene Islands, Quebec, and is disjunct in southern Mexico (Bowden 1962, Baden and von Bothmer 1994, von Bothmer et al. 2007).

Although the species is distributed primarily in temperate and sub-Arctic regions of North America there are sporadic collections of both subspecies from Arctic regions of Alaska (Klein 2011, Skinner et al. 2012) and Canada. On Canada's mainland Arctic, *H. jubatum* subsp. *intermedium* has been recorded from Hood River, Nunavut (*Anderson 473* in 1915, CAN-39857 & CAN-514373; Macoun and Holm 1921, Bowden 1962) and from Tuktoyaktuk, Northwest Territories (*Aiken & McLachlan 87-221* in 1987, CAN-530893). Two records of *H. jubatum* s.l. from Ungava Bay in northern (Arctic) Quebec and one from western Greenland are mapped in von Bothmer et al. (2007).

Hordeum jubatum was apparently accidentally introduced as early as the 1960s to Apex (near Iqaluit, Baffin Island, CAA) with straw used as animal feed and/or packing material (Aiken et al. 2007). Plants were observed (and collected) in the

Figure 8. *Hordeum jubatum* subsp. *jubatum*: habitat, *Saarela et al. 2737*. Photograph by R.D. Bull.

same area (around the Hudson's Bay Company house) in the mid- to late-1980s (*Aiken, Campbell & Robinson 86-445* in 1986, CAN-518325; *Aiken, Campbell & Robinson 86-337* in 1986, CAN-518217; *Aiken 89-115* in 1989, CAN-541784). These three specimens were not previously determined to subspecies. The two 1986 collections are intermediate between subspecies *jubatum* and *intermedium* and the 1989 collection is subsp. *jubatum*. It is unknown if these collections represent the same or separate introductions. The species was observed in the same area in 1998 and 2002 (no collections were made), but the site was overgrown by willows in 2005 and the species was absent (Aiken et al. 2007). We were at the site in July 2012 and did not encounter the species. There is also a 2003 collection from a separate locality in nearby Iqaluit (across from Joamie Ilinniarvik School, *Mallory s.n.*, CAN-585777). The label on this specimen indicates "possibly an accidental introduction as part of earlier project to hydro-seed grass around the school." It is not known if the species persists in the Iqaluit area.

We found three robust plants of *H. jubatum* subsp. *jubatum* in the community of Kimmirut in 2012, adding a second area of occurrence for the species on Baffin Island. Two plants were growing in a lush sewage runoff area near the garbage dump on slopes well above the coastal high tide line with *Chamerion latifolium* (L.) Holub, *Poa alpina* L., *P. glauca* Vahl, *Salix glauca* L., *Stellaria longipes* Goldie and *Taraxacum lapponicum* Kihlm. ex Hand.-Mazz., and one in the hamlet, growing on a rocky, sandy beach adjacent to the coast associated with *Poa arctica* and *Taraxacum lapponicum* (Fig. 8).

Based on the few individuals found in Kimmirut, these likely represent very recent introductions, which may have arrived naturally (dispersal by birds, for example) or been introduced unintentionally by humans. The presence of this species in Kimmirut should be monitored to determine if it is increasing its presence there, particularly at the sewage runoff site where a high nutrient load supports lush plant growth (J.M. Saarela and P.C. Sokoloff, pers. obs.).

Specimens examined. Canada. Nunavut: Qikiqtaaluk Region, Baffin Island, Kimmirut, rocky sandy slope between Northern Store and coast, 62°50'57"N, 69°52'12"W, 68 m, 22 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2737* (ALA, ALTA, CAN-601368); Qikiqtaaluk Region, Baffin Island, Kimmirut, S end of hamlet, below garbage dump and above high tide line at coast, 62°50'26"N, 69°52'20"W, 68 m, 22 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2755* (CAN-601369, O, US).

Leymus innovatus subsp. *velutinus* (Bowden) Tzvelev

Common Name. Northern downy ryegrass

Distribution. American Beringia

Comments. Although not reported in Aiken et al. (2007) for the CAA, this species was first reported for the CAA from Banks Island by Mason et al. (1972, as *Elymus innovatus* Beal), based on a collection from the Masik River Valley (71°37'N, 123°6'W, 20 July 1968, *W.R.M. Mason 93*, DAO-543555, not seen). There is also a collection in CAN (two sheets) from Sachs Harbour (Banks Island, Northwest Territories), previously determined as *Agropyron violaceum* (Hornem.) Lange (det. A.E. Porsild) and *Elymus alaskanus* subsp. *latiglumis* (Scribn. & J.G. Smith) Á. Löve (det. M.E. Barkworth, 1993), that has been re-determined as this species (det. J.M. Saarela). The taxon was mapped on southern Banks Island by Porsild and Cody (1980) and Barkworth (2007), probably based on the Mason collection and/or one or more correctly-determined duplicates of the Sachs Harbour collection in other herbaria. It grows in Alaska, the Yukon Territory, and the western Northwest Territories (Barkworth 2007) with Sachs Harbour and the Masik River Valley the only known locations in the CAA. *Leymus innovatus* (Beal) Pilg. and *L. mollis*—the only two species of the genus in the CAA—may be distinguished by the following key (adapted from Barkworth 2007):

1 Lemmas unawned, 11–20 mm long; glumes tapering from midlength or above, flat or rounded on the back, apices acute..... ***Leymus mollis***

– Lemmas awned, 7–12 mm long; glumes tapering from the base to the nearly subulate apices..... ***Leymus innovatus***

Specimens examined. Canada. Northwest Territories: Banks Island, Sachs Harbour, 71°58'N, 125°15'W, 17–25 July 1969, *M. Kuc 405* (CAN-432022, CAN-432023).

Leymus mollis* (Trin.) Pilg. subsp. *mollis

Common name. Sea lyme-grass, American dune grass

Distribution. Amphi-Pacific–North America

Comments. Two subspecies of *Leymus mollis* are recognized in North America: subsp. *mollis* and subsp. *villosissimus* (Scribn.) Á. Löve & D. Löve (Bowden 1957, Barkworth 2007, Elven et al. 2011). *Leymus mollis* subsp. *villosissimus* is an Arctic taxon, distributed from Siberia to Greenland, and common in the low CAA, while subsp. *mollis* grows along the east and west coasts of North America, along the Arctic coast of Quebec, in some interior locations (Great Slave Lake, for example) and in Greenland (Bowden 1957, Aiken et al. 2007, Barkworth 2007). Subspecies *mollis* has not previously been reported from the CAA (Bowden 1957, Aiken et al. 2007) and our collection from southern Baffin Island is thus the first record for the region. The collection was made on the outer sandy floodplains of Soper Lake, where the species was uncommon; subspecies *villosissimus* was more common in the region.

Specimens examined. Canada. Nunavut: Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper Falls, south side of Soper Lake, just southeast of Soper Falls, 17 July 2012, 62°54”08'N, 69°50”42'W, 6 m, *Saarela, Gillespie, Sokoloff & Bull 2529* (CAN-601371).

***Puccinellia banksiensis* Consaul**

Fig. 9

Common name. Dwarf alkaligrass

Distribution. Arctic NW North America

Comments. This species was described recently from three localities on southern Banks Island, Northwest Territories, and one locality in northern Alaska (Consaul et al. 2008). Saarela et al. (2013a) reported two collections from the lower Brock River on mainland Northwest Territories. Here we report six new localities for the species from southwestern Victoria Island—the first records for this island and for Nunavut, expanding the species' range eastwards in the CAA.

Specimens examined. Canada. Nunavut: Victoria Island, Oterkvik Point vicinity, ca. 9 km N of Coronation Gulf coast, 12 km N of point, 68°35'34"N, 112°35'43"W, 40–50 m, 5 July 2012, *Gillespie, Saarela, Consaul & Bull 7549* (CAN-600906); Johansen Bay, 18 km east-northeast of airstrip, Nakoyoktok River at outflow of large unnamed lake, 18 July 2008, 68°39'25"N, 110°42'30"W, 20–30 m, *Gillespie, Saarela, Consaul & Bull 8055* (CAN-592678), *8055-2* (CAN-592239); Victoria Island, Johansen Bay, main air landing strip, 20 July 2008, 68°35'50"N, 111°06'59"W, 120 m, *Gillespie, Saarela, Consaul & Bull 8077* (CAN-592679); Victoria Island, pingo, 23 km west of Johansen Bay airstrip, 20 July 2008, 68°36'23"N, 111°40'22"W, 100–120 m, *Gillespie, Saarela, Consaul & Bull 8146-2* (CAN-592688); Victoria Island, tundra between Sinclair

Figure 9. *Puccinellia banksiensis*: **A** habitat, with Laurie Consaul who described the species **B** inflorescence **C** habit, *Gillespie et al 8055*. Photographs by L.J. Gillespie (**A**), R.D. Bull (**B, C**).

Creek North Warning System site (abandoned DEW-line site) and coast, 68°44'35"N, 109°06'15"W, 20–70 m, 22 July 2008, *Gillespie, Saarela, Consaul & Bull 8240* (CAN-592705); Victoria Island, south of Sinclair Creek North Warning System site (abandoned DEW-line site), approximately 1 km N of coast, 22 July 2008, 68°43'14"N, 109°05'10"W, 10–20 m, *Gillespie, Saarela, Consaul & Bull 8261* (ALA, CAN-592689,

MT, O); Victoria Island, disturbed ground in the vicinity of the Sinclair Creek North Warning System site (abandoned DEW-line site), 68°45'5"N, 109°06'20"W, 75 m, 23 July 2008, *Gillespie, Saarela, Consaul & Bull 8339* (ALA, CAN-592707, MT, O, US).

Potamogetonaceae

***Stuckenia vaginata* (Turcz.) Holub**
Fig. 10

Potamogeton vaginatus Turcz.
Stuckenia subretusa (Hagstr.) Holub

Common name. Big-sheathed pondweed

Distribution. Circumboreal

Comments. This collection is the first record of this primarily boreal species for the CAA. The species has a scattered distribution across Canada north to treeline and reaches the Arctic in coastal Yukon, coastal mainland Northwest Territories, and south-eastern mainland Nunavut (Porsild and Cody 1980, Haynes and Hellquist 2000b, Saarela et al. 2013a). The nearest site on the mainland is in the Northwest Territories near the coast just northwest of the border with Nunavut (*Scotter & Zoltai 90-494*, DAO; Saarela et al. 2013a), some 440 km west-northwest of our site. A slightly closer record (ca. 400 km) was mapped from eastern Great Bear Lake in Porsild and Cody (1980) (presumably based on a specimen collected by A.E. Porsild housed at GH, as cited by Raup 1947, no collection number given). A probable duplicate at CAN (Great Bear Lake, N shore of McTavish Arm, Black Rock, Laurentian, about 66°20'N, 118°30'W, 6 August 1928, *Porsild & Porsild 6186*, CAN-7215, det. *P. vaginatus* by M. Fernald) was re-determined as *Coleogeton filiformis* subsp. *occidentalis* (J.W. Robbins) Les & R.R. Haynes (= S. *filiformis* subsp. *occidentalis* (J.W. Robbins) R.R. Haynes, Les & M. Král) by C.B. Hellquist, and the site was not mapped for *S. vaginata* in Haynes and Hellquist (2000b).

Following the treatment by Kaplan (2008) *S. vaginata* may be distinguished by its open leaf sheaths from *S. filiformis* (Pers.) Börner, the only species of the family known to occur in the CAA prior to this collection. Although *S. vaginata* is generally more robust in habit with wider leaf sheaths and more numerous whorls of flowers on the inflorescence (usually 7–9 versus 3–6 in *S. filiformis*), our collection from the northern edge of its range was somewhat intermediate in size with few young inflorescences (and no fruit) having 5–7 whorls of flowers.

The taxonomy of *Stuckenia* Borner is complex and there are several conflicting taxonomic treatments (e.g., Tolmachev et al. 1995, Haynes and Hellquist 2000b, Kaplan 2008; see discussion in Elven et al. 2011). Our collection was initially identified by R. Elven in 2009 as *S. subretusa* (Hagstr.) Holub, a primarily Russian Arctic species, based on its retuse or subretuse leaf apices. Although included in the Panarctic Flora, Elven et

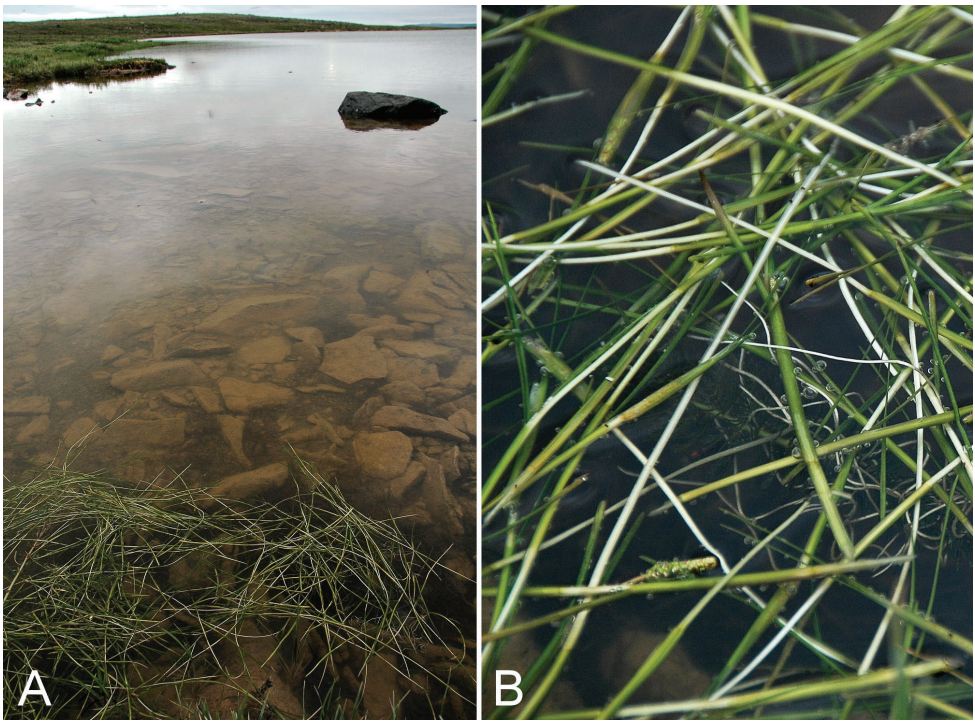

Figure 10. *Stuckenia vaginata*: **A** habitat **B** habit, *Gillespie et al. 8048*. Photographs by R.D. Bull.

al. (2011) were not fully convinced that it should be treated as distinct and suggested a possible alternative treatment within a variable *S. filiformis*. Tolmachev et al. (1995) recognized *S. subretusa* in their treatment for the Russian Arctic, but suggested it might be an arctic race of *S. vaginata*. Kaplan (2008) in his revision of Asian *Stuckenia* treated *S. subretusa* as a synonym of *S. vaginata* (both have open leaf sheaths contrasting with the fused leaf sheaths of *S. filiformis*); he found leaf apex shape to vary within specimens and (sub)retuse leaf apices on collections from across the range of *S. vaginata*. Saarela et al. (2013b) in their barcode study of Canadian Arctic Island vascular plant species found that the *rbcL* and *matK* sequences of our collection (as *S. subretusa*) were identical to those of *S. vaginata*, and different from *S. filiformis*, consistent with Kaplan's (2008) treatment. Here we follow Kaplan (2008) in treating *S. subretusa* as a synonym of *S. vaginata*, but also recognize that the species complex in North America is in need of further study. If *S. subretusa* is considered a distinct species, our collection would represent the first record for Canada (and is the one referred to in Elven et al. (2011) documenting presence of the species on Victoria Island and in Canada). If treated within *S. filiformis*, our collection would represent the first record for the western CAA.

Specimens examined. Canada. Nunavut: Victoria Island, Kitikmeot Region, Johansen Bay, 18 km ENE of airstrip, Nakoyoktok River at outflow of large unnamed lake, 68°39'25"N, 110°42'30"W, 20–30 m, 18 July 2008, *Gillespie, Saarela, Consaul & Bull 8048* (ALA, ALTA, BABY, CAN-592375, MT, O, UBC, US).

EUDICOTS
Amaranthaceae

***Suaeda calceoliformis* (Hook.) Moq.**
Fig. 11

Common name. Horned sea-blite

Distribution. North America

Comments. This species was first recorded as occurring at Johansen Bay along southern Victoria Island by Thannheiser et al. (2001; voucher at TROM, not seen); however, the species was not included in Aiken et al. (2007) and we thus report it here. We collected *S. calceoliformis* at five sites on Victoria Island: three on southern Victoria Island (Nunavut), and two in the vicinity of Minto Inlet on north-western Victoria Island (Northwest Territories). These are the first records for this family, genus and species in the CAA. We initially mis-identified our collections as the annual *Koenigia islandica* (Polygonaceae), a superficially similar species known from the adjacent mainland and the eastern Arctic Islands (Aiken et al. 2007, Porsild and Cody 1980). The true identity of our material was revealed upon collection of DNA barcode data (Saarela et al. 2013b), which placed them with other *Suaeda* individuals and distinct from *Koenigia*. Re-examination of the very small specimens confirmed their identity as *S. calceoliformis*.

This species is found in saline and disturbed environments in the western and mid-western United States north to south-western Yukon, along southern James Bay and coastal areas of eastern Canada and north-eastern United States (Bassett and Compton 1978, Cody 2000, Riley 2003, Ferren Jr. and Schenk 2004). It is also known from one sub-Arctic site on the northern side of Great Bear Lake and four areas in the western mainland Arctic: Tuktoyaktuk Peninsula; Rae River mouth, Kugluktuk area; Walker Bay, Kent Peninsula; and Paulatuk and Lower Brock Lagoon (Bassett and Compton 1978, Cody et al. 2003, Ferren Jr. and Schenk 2004, Porsild and Cody 1980; specimen citations given in Saarela et al. 2013a). The species was treated as a rare plant for the Canadian Arctic (McJannet et al. 1993). Our five collections from Victoria Island double the number of known sites for this species in the Canadian Arctic. It has probably been overlooked by collectors in its Arctic range, as it is very small and has fairly specialized habitat requirements.

Suaeda calceoliformis displays a wide degree of phenotypic plasticity throughout its range; for example, its height ranges from 5 cm to 1 m in continental Canada (Ferren Jr. and Schenk 2004). Our collections range from 1–4 cm, with the smallest plants often only possessing a single inflorescence. Habitats on Victoria Island include saline depressions inland and coastal saline flats, and the species was typically found growing in association with *Puccinellia arctica* (Hook.) Fernald & Weath. and *P. phryganodes* (Trin.) Scribn. & Merr.

Specimens examined. Canada. Nunavut: Kitikmeot Region, Victoria Island, Oterkvik Point vicinity, ca. 8 km N of Coronation Gulf coast, 11 km N of point,

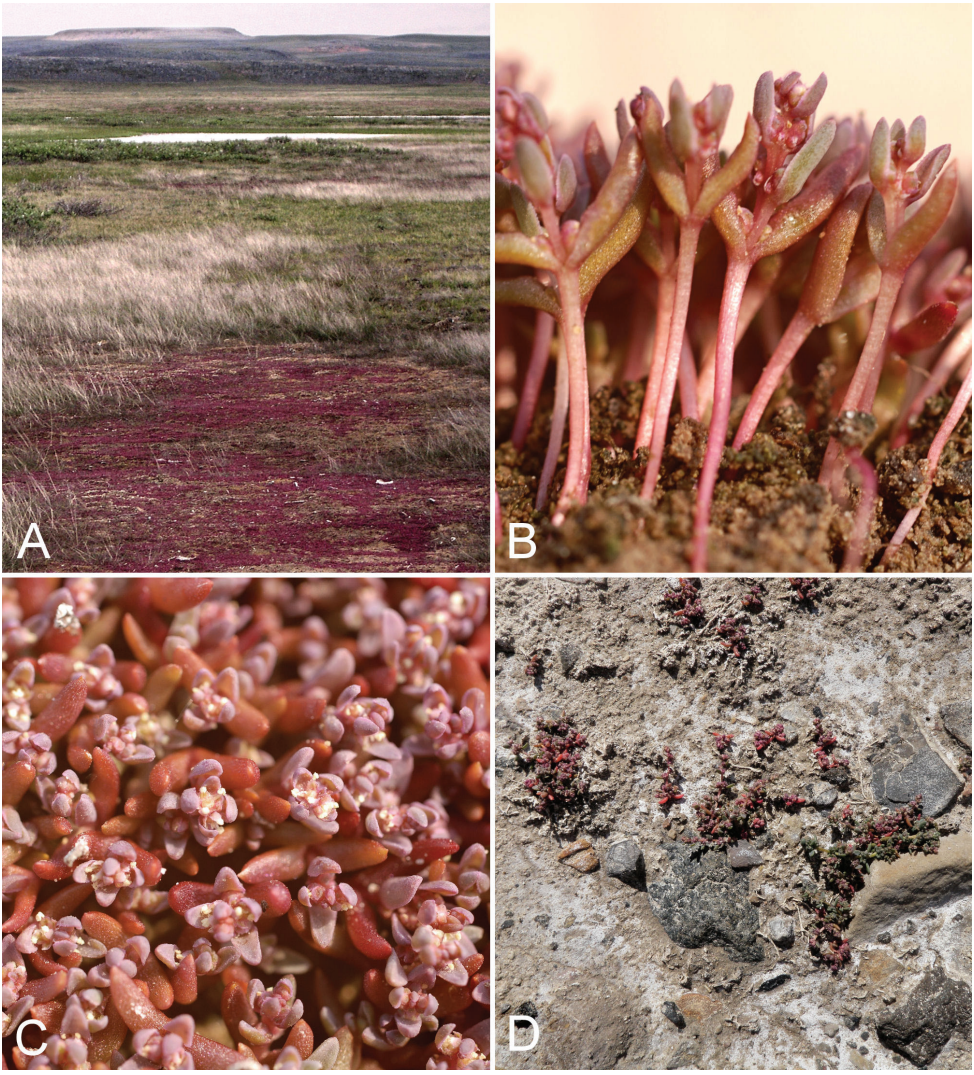

Figure 11. *Suaeda calceoliformis*: **A** habitat **B** habit, profile **C** inflorescences, *Gillespie et al. 8068* **D** habit, *Gillespie et al. 10243*. Photographs by R.D. Bull (**A, B, C**), L.J. Gillespie (**D**).

68°34'32"N, 112°36'57"W, 25–35 m, 5 July 2008, *Gillespie, Saarela, Consaul & Bull 7570* (ALA, CAN-592376, O); Kitikmeot Region, Victoria Island, vicinity of Nakoyoktok River, 1.5–2 km southwest of outflow of river from large unnamed lake, ca. 18 km ENE of Johansen Bay, 68°38'37"N, 110°42'22"W, 20–30 m, 19 July 2008, *Gillespie, Saarela, Consaul & Bull 8068* (ALA, CAN-593265, MT, O, UBC); Kitikmeot Region, Victoria Island, W end of Johansen Bay at mouth of Mackenzie Creek, 68°36'4"N, 111°21'7"W, 0–20 m, 20 July 2008, *Gillespie, Saarela, Consaul & Bull 8137* (ALTA, BABY, CAN-593267). **Northwest Territories:** Inuvik Region, Victoria Island, NE corner of Boot Inlet, frost boils in *Dryas-Arctagrostis* tundra above

rocky seashore, 71°28'14.5"N, 117°21'36.7"W, 5 m, 10 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 9662* (CAN-598332, O); Inuvik Region, Victoria Island, head of Minto Inlet, end of easternmost inlet (N arm), coastal saline flat, 71°31'6.5"N, 115°6'30.4"W, 1–10 m, 25 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 10243* (CAN-598331).

Caryophyllaceae

Arenaria humifusa Wahl.

Fig. 12

Common name. Creeping sandwort

Distribution. Arctic North America–amphi-Atlantic

Comments. Our collections from the Minto Inlet area of Victoria Island represent the first record of the species from the western CAA. Plants were matted, often large, forming loose circular cushions and were found growing on inland sand dunes. Although the species is primarily distributed in the eastern Canadian Arctic and sub-Arctic (south to Nova Scotia) and around Hudson Bay, it is also found scattered on the Northwest Territories and Nunavut mainland south of Victoria Island (specimens at CAN). Porsild and Cody (1980) treated *A. humifusa* in the broad sense including *A. longipedunculata* (see below) and the distribution shown for Alaska, Yukon, and part of the Northwest Territories is that of the latter species. Neither species has previously been recorded for the western Arctic Islands (Porsild and Cody 1980, Aiken et al. 2007). Our Minto Inlet collections have short pedicels (0.5–4 mm long) with mostly very short retrorse hairs (and few scattered glandular hairs), flowers not exserted above the leaves, glabrous sepals and smooth leaf margins, all characteristics of *A. humifusa* s.s.

Specimen examined. Canada. Northwest Territories: Inuvik Region, Victoria Island, Sand dunes east of Kuujjua River, 2 km south of lower Kuujjua River, 71°10'4.8"N, 116°27'54"W, 110 m, 16 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 9882* (ALA, CAN-599149, O); Inuvik Region, Victoria Island, Sand dunes east of Kuujjua River, 2 km south of lower Kuujjua River, 71°10'4.8"N, 116°27'54"W, 110 m, 16 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 9893* (ALA, CAN-599166, O); Inuvik Region, Victoria Island, sandy bank of Kuujjua River, south of "Fish Lake", 71°6'43.2"N, 116°6'21.2"W, 74 m, 17 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 9971* (CAN-599167).

Arenaria longipedunculata Hultén

Common name. Long-stemmed sandwort

Distribution. Arctic-alpine amphi-Beringia–North America

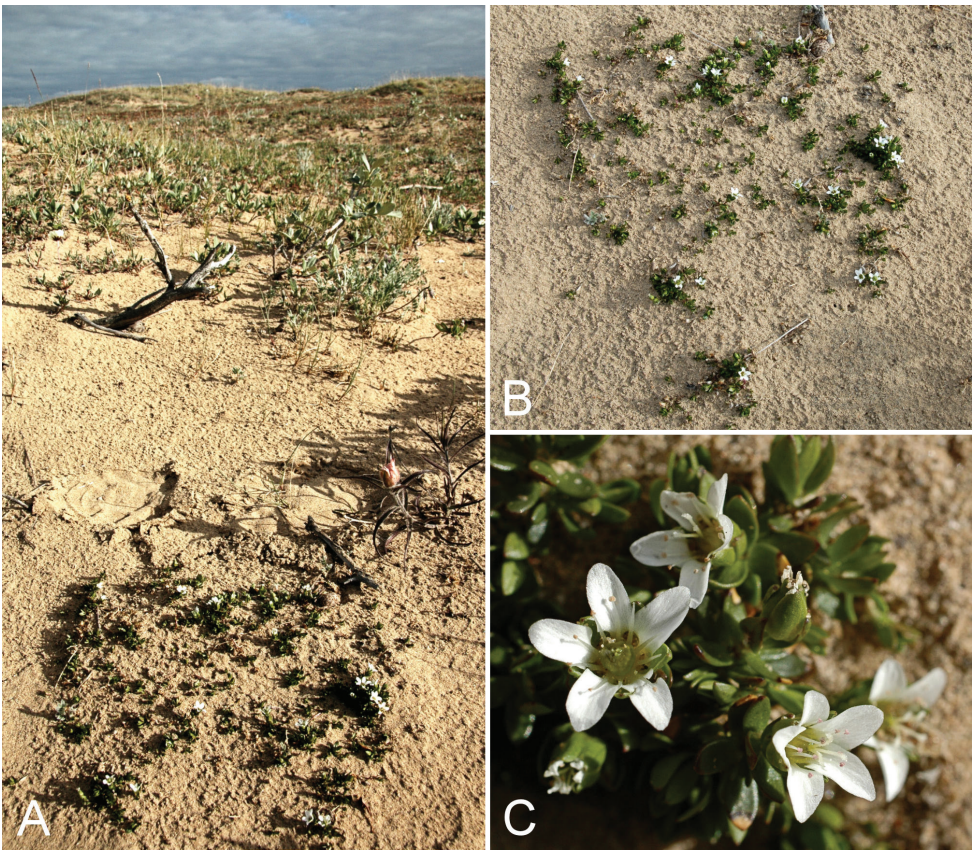

Figure 12. *Arenaria humifusa*: **A** habitat **B** habit **C** flowers, *Gillespie et al. 9882*. Photographs by L.J. Gillespie.

Comments. Our collections are the first records of the species for the CAA and Nunavut. Described by Hultén (1966) from Arctic Alaska, this species was considered conspecific with *Arenaria humifusa* by Porsild and Cody (1980), but has most recently been treated as a separate species (Cody 2000, Hartman et al. 2005, Elven et al. 2011). While considered to have an amphi-Beringian distribution, Elven et al. (2011) suggested that the species may also be present in the CAA and Greenland based on the results of a phylogeographical analysis of AFLP data (Westergaard et al. 2011), a hypothesis supported here. Our collections from southeastern Victoria Island (det. R. Elven) and Baffin Island were identified as this species based on the character combination of long pedicels (10–20 mm) with glandular villous pubescence (not very short retrorse), flowers long-exserted above the leaves, sepals glandular villous basally, and leaf blade margins ciliate proximally (at least sparsely) (Hartman et al. 2005). We found that pedicel length varied among collections and was sometimes shorter than the range given for *A. longipedunculata* (10–20 mm) in Hartman et al. (2005); however, other characters were consistent with our identification. Pedicels are 10–20 mm (*Saarela et*

al. 2776) and 5–10 mm long (*Saarela et al. 2477*) on the Baffin Island collections, and 9–12 mm long (*Gillespie et al. 7721*) on the Victoria Island collection (flowers were still in bud with pedicels up to 6 mm long on *Gillespie et al. 8136*). Plants were small and tufted, and were growing in moss on moist to wet riparian meadows on Victoria Island and in mossy tundra at base of slopes or cliffs on Baffin Island.

The ranges of *A. longipedunculata* and *A. humifusa* overlap in the Arctic Islands; indeed we collected both species in the Soper River-Kimmirut area on Baffin Island, and both on Victoria Island but in different localities. In northern Quebec and Newfoundland some large specimens identified as *A. humifusa* appear to approach *A. longipedunculata* in some characters; these robust matted plants have elongate stems with long internodes and pedicels. Further study of this species complex is needed to determine more precisely species boundaries and distributions and to determine if hybrid or introgressed populations exist in the Canadian Arctic.

Specimens examined. Canada. Nunavut: Kitikmeot Region, Victoria Island, vicinity of river flowing into Clauston Bay, 3–4 km from river mouth, 69°2'39"N, 113°25'15"W, 10–20 m, 8 July 2008, *Gillespie, Saarela, Consaul & Bull 7721* (CAN-592340); Kitikmeot Region, Victoria Island W end of Johansen Bay at mouth of Mackenzie Creek, 68°36'4"N, 111°21'7"W, 0–20 m, 20 July 2008, *Gillespie, Saarela, Consaul & Bull 8136* (CAN-593142); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River, 18.5 km downstream (south) of its confluence with the Livingstone River, 2 km south of Emergency Cabin #8, west side of river, 62°59'20"N, 69°43'41"W, 36 m, 15 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2477* (CAN-601731); Qikiqtaaluk Region, Baffin Island, Kimmirut, west end of Fundo Lake, ca. 2 km west of hamlet, 62°50'44"N, 69°54'6"W, 40 m, 22 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2776* (CAN-601732).

***Sabulina stricta* (Sw.) Rchb.**

Minuartia stricta (Sw.) Hiern

Common name. Bog stitchwort

Distribution. Circumpolar-alpine

Comments. This species was first recorded for the western CAA, on southern Victoria Island, by Thannheiser et al. (2001; no voucher collection located), and is confirmed by our collection. The species is known from Baffin, Southampton, and Coats Islands in the eastern Arctic Islands, and has a scattered distribution across the low Arctic (and north-west alpine areas) from Alaska to Labrador and Greenland. On mainland Nunavut it is currently known only from the Hudson Bay area, and in the Northwest Territories from the vicinity of Great Bear Lake and the Hornaday River (Porsild and Cody 1980, Saarela et al. 2013a). The Victoria Island collections represent a range extension of ca. 400 km northeast of the Northwest Territories populations and ca. 1000 km west of the closest Nunavut population.

This species was previously known as *Minuartia stricta* (Sw.) Hiern (e.g., Porsild and Cody 1980, Rabeler et al. 2005, Aiken et al. 2007) (the name *Sabulina stricta* (Michx.) Small ex Rydb., based on *Arenaria stricta* Michx. [=*Sabulina michauxii* (Fenzl) Dillenb. & Kadereit, a non-Arctic species], is an illegitimate homonym). Recent molecular studies have determined *Minuartia* to be polyphyletic (Harbaugh-Reynaud et al. 2010, Greenberg and Donoghue 2011, Saarela et al. 2013b, Dillenberger and Kadereit 2014). The most comprehensive sampling of the genus was conducted by Dillenberger and Kadereit (2014), who proposed a new classification of the group. The clade to which *M. stricta* belongs ("clade 10") has been segregated as a distinct genus, *Sabulina* Rchb., with 65 species. *Sabulina* includes four other Canadian Arctic species: *S. dawsonensis* (Britton) Rydb. [syn. *Minuartia dawsonensis* (Britton) House], *S. elegans* (Cham. & Schltdl.) Dillenb. & Kadereit [syn. *M. elegans* (Cham. & Schltdl.) Schischk], *S. rossii* (R.Br.) Dillenb. & Kadereit [syn. *M. rossii* (R.Br.) Graebn.], *S. rubella* (Wahlenb.) Dillenb. & Kadereit [syn. *M. rubella* (Wahlenb.) Hiern.]. Four Canadian Arctic species, *Minuartia biflora* (L.) Schinz & Thell., *M. arctica* (Steven ex Ser.) Graebn., *M. obtusiloba* (Rydb.) House, and *M. yukonensis* Hultén, are part of "clade 6" in Dillenberger and Kadereit (2014), which they recognize as the genus *Cherleria* L., with some 19 species. Combinations for these species in *Cherleria* are not available; we assume they will be published in a revision of *Cherleria* that is noted to be in preparation (Dillenberger and Kadereit 2014, see their Appendix S3). *Cherleria* is distinguished from *Sabulina* by sepals obtuse and oblong (versus acute and linear-lanceolate) (Dillenberger and Kadereit 2014). *Minuartia macrocarpa* (Pursh) Ostenfeld (= *Pseudocherleria macrocarpa* (Pursh) Dillenb. & Kadereit) is part of "clade 3", which is recognized as the new genus *Pseudocherleria* Dillenb. & Kadereit, with ca. 12 species. *Pseudocherleria* has obtuse sepals, but differs in its long acute multicellular hairs (Dillenberger and Kadereit 2014). *Minuartia groenlandica* (Retzius) Ostenfeld (= *Mononeuria groenlandica* (Retzius) Dillenb. & Kadereit) is part of "clade 5", recognized as the genus *Mononeuria* Rchb., characterized by an annual or biennial habit and emarginate petals (sometimes absent) twice as long as the sepals (Dillenberger and Kadereit 2014). There are no species of *Minuartia* s.s. in the Canadian Arctic. Of the above species only *Sabulina elegans*, *S. rossii*, *S. rubella*, *S. stricta*, and *Minuartia biflora* occur in the CAA.

Sabulina stricta may be distinguished from the closely related and largely sympatric *Sabulina rossii–S. elegans* species complex by the presence of branched flowering stems bearing two or more flowers (versus always unbranched and 1-flowered in the latter). Recent molecular evidence suggests that *S. stricta* may be part of this species complex and not easily separable from the genetically diverse species *S. elegans* (Saarela et al. 2013b, S. Leung and L.J. Gillespie, unpubl. data).

Specimens examined. Canada. Nunavut: Kitikmeot Region, Victoria Island, rocky hills S of large unnamed lake ca. 18 km ENE of Johansen Bay airstrip, 68°38'43"N, 110°40'9"W, 50–80 m, 14 July 2008, *Gillespie, Saarela, Consaul & Bull 7966* (ALA, CAN-592334, MT, O).

Ericaceae

***Andromeda polifolia* L.**
Fig. 13

Common name. Bog rosemary

Distribution. Circumboreal-polar

Comments. This species was first reported from the Arctic Islands by Thannheiser et al. (2001; no voucher collection located for confirmation), at Johansen Bay on the southern coast of Victoria Island; however, it was not included in Aiken et al. (2007). We collected it at Johansen Bay, confirming its presence there, and along the Soper River on southern Baffin Island, extending the range of this boreal species northwards across the low Arctic islands.

Andromeda polifolia has a broad circumboreal-polar distribution, and occurs from Alaska across much of Canada and northern United States to western Greenland (Fabijan 2009). Numerous collections have been reported from the mainland Arctic (Porsild and Cody 1980, Saarela et al. 2013a), including sites south of Coronation Gulf across from our collection site on Victoria Island. On Victoria Island we encountered a single, large population of the species growing in dense moss-sedge mats along the sides of hummocks and polygon ridges in a hummocky, moist to wet sedge meadow on a gentle west-facing slope, in association with *Dryas integrifolia*, *Arctous rubra*, *Vaccinium uliginosum*, *Rhododendron tomentosum* subsp. *decumbens*, *Salix reticulata*, *Cassiope tetragona* and *Carex* spp. We collected the species in the Soper River valley, Baffin Island, in a large, wet and hummocky sedge meadow, growing in association with *Carex rariflora*, *Betula glandulosa*, *Salix arctophila*, and *Luzula wahlenbergii*. We observed three patches at this location, one 3 × 2 m, and two smaller ones along the edge of a pond. Our collection in this area was made on the east side of the Soper River; we also observed the species in the area on the west side of the river, but did not collect it there.

Elven et al. (2011) provisionally treat *Andromeda polifolia* as two subspecies—the Eurasian *A. polifolia* subsp. *polifolia* and the widespread *A. polifolia* subsp. *pumila* V.M. Vinogr. However, due to difficulties in circumscribing diagnostic characters this division is difficult to quantify, and they call for an in depth investigation of this taxon. Fabijan (2009) treats the species as possessing two varieties: the northern boreal-Arctic var. *polifolia*, and the more southern and eastern var. *latifolia* Aiton. Our collections would be considered as *A. polifolia* var. *polifolia* following this treatment.

Specimens examined. Canada. Nunavut: Kitikmeot Region, Victoria Island, slope at S end of unnamed lake, ca. 20 km ENE of Johansen Bay airstrip, 68°36'27"N, 110°40'35"W, 30–50 m, 16 July 2008, *Gillespie, Saarela, Consaul & Bull 8002* (ALA, BABY, CAN-592360, MT, O, UBC); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River valley, E bank, large sedge meadow with several small ponds ca. 12.5 km south of Mount Joy, 0.5 km south of Group/Warden Cabin #7, 63°9'35"N, 69°40'3"W, 41 m, 7 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2186* (ALA, CAN-601935, MO, MT, O, US, WIN).

Figure 13. *Andromeda polifolia*: **A** habitat **B** habit, *Saarela et al. 2186*. Photographs by P.C. Sokoloff.

***Orthilia secunda* subsp. *obtusata* (Turcz.) Böcher**

Pyrola secunda var. *obtusata* Turcz.

Common names. One-sided wintergreen, nodding wintergreen

Distribution. Disjunct circumpolar (excluding Europe)

Comments. This is the first collection of the species from the eastern CAA; previously it had been collected in the western Arctic Islands at two localities on Victoria Island (Aiken et al. 2007), where we also collected it from a third locality, and one on Banks Island (Porsild and Cody 1980; not mapped in Aiken et al. 2007). In the eastern North American Arctic, this species is known from western Greenland (Böcher et al. 1968) and Ungava Bay, Quebec (Porsild and Cody 1980), thus our collection fills in a distributional gap in the general area between these sites, extending the range to southern Baffin Island. Our collection on Baffin Island comes from a single population encountered along the Soper River. This small population was found growing abundantly in a wet snowbed community with *Cassiope tetragona*, *Vaccinium uliginosum*, and *Salix reticulata*. On Victoria Island, we found this species growing in a similar habitat: a wet sedge meadow formed by a drainage between two lakes, associated with *Carex aquatilis* var. *minor*, *Eriophorum angustifolium*, *Dryas integrifolia*, *Salix reticulata*, *S. glauca*, and *Pedicularis albolabiata* (Hultén) Kozhevn.

Elven et al. (2011) recognize this taxon at the species level as *Orthilia obtusata* (Turcz.) H. Hara, a circumpolar plant distinct from the mostly circumboreal *O. secunda* (L.) House. Freeman (2009) treats North American material as widely variable, and synonymises subsp. *obtusata* under *Orthilia secunda*. As there are distinctions between the taxa, most pronounced in Eurasia, we follow Aiken et al. (2007), and treat the Arctic taxon as *O. secunda* subsp. *obtusata*, an approach intermediate to those of Elven et al. (2011) and Freeman (2009).

Specimen examined. Canada. Nunavut: Kitikmeot Region, Victoria Island, Johansen Bay, 18 km ENE of airstrip, Nakoyoktok River at outflow of large unnamed lake, 62°39'25"N, 110°42'30"W, 20–30 m, 18 July 2008, *Gillespie, Saarela, Consaul & Bull 8036* (ALA, CAN-592359); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River, 18.5 km downstream (S) of its confluence with the Livingstone River, 2 km S of Emergency Cabin #8, W side of river, 62°59'28"N, 69°43'30"W, 67 m, 15 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2489* (CAN-601915).

Fabaceae

***Oxytropis deflexa* subsp. *foliolosa* (Hook.) Cody**

Fig. 14

Common name. Pendant-pod oxytrope, pendant-pod locoweed

Distribution. Arctic-alpine North America

Comments. This is the first record of this taxon from the western CAA—the only populations known on the islands previously occur on southeastern Baffin Island near Kimmirut, Iqaluit, and on the Hall Peninsula (Aiken et al. 2007), and we made four additional collections in Katannilik Territorial Park on southern Baffin Island. On the mainland Arctic, this taxon has been collected in the vicinity of Coronation Gulf south of Victoria Island (67°45'N, 111°57'W) (Macoun and Holm 1921). Subspecies *foliolosa* is common in the boreal forest of Yukon and Alaska, extends south along the Rocky Mountains to Colorado, and occurs along the coast in northern Ontario and Quebec (Welsh 1974, Porsild and Cody 1980, Blondeau and Cayouette 2002). A collection (*Baldwin 1997*, CAN-203476) from the vicinity of Longstaff Bluff (68°58'N, 47°57'W) on the west coast of Baffin Island is included in the range map for this species in Porsild (1957). However, Porsild re-identified this collection to *Astragalus alpinus* L. in 1959 (a determination with which we agree) and, while the dot on the map is erroneously reproduced in Porsild and Cody (1980), it is correctly omitted from the map in Aiken et al. (2007). We encountered only one small population on Victoria Island, consisting of six individuals growing on a rocky river flat at the edge of a low thicket of *Salix alaxensis* (Andersson) Coville, associated with *Chamerion latifolium*, *Astragalus alpinus*, *Castilleja elegans* Malte and *Saxifraga tricuspidata* Rottb. This collection extends the range of this species north by approximately 300 kilometers from Coronation Gulf, where J. Cox collected it during the Canadian Arctic Expedition 1913–1918 (Macoun and Holm 1921, Polunin 1940).

Figure 14. *Oxytropis deflexa* subsp. *foliolosa*: **A** fruits **B** habitat **C** habit, *Gillespie et al. 10129*. Photographs by R.D. Bull (**A**), L.J. Gillespie (**B**), P.C. Sokoloff (**C**).

Isely (1998) synonymized this taxon (as var. *foliolosa* (Hook.) Barneby) under var. *deflexa*, but did so only taking into account material from continental United States, excluding Alaska. Here we follow Cody (1994) and Aiken et al. (2007) and recognize subsp. *foliolosa* as a discrete taxon in North America. In a pan-Arctic context, Elven et al. (2011) suggested that this taxon may be synonymous with the Russian *O. deflexa* subsp. *dezhnevii* (Jurtz.) Jurtz. Further work is needed to clarify

the statuses of these taxa, but the Russian name would have priority if these taxa were synonymized.

Specimens examined. Canada. Northwest Territories: Inuvik Region, Victoria Island, River valley at N head of Minto Inlet, ca. 3 km from inlet, 71°33'46.7"N, 115°22'45.1"W, 24 m, 23 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 10129* (CAN-598345). **Nunavut:** Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River, west side, ca. 44.5 km south of Mount Joy along river, ca. 17 km south of confluence with Livingstone River, 62°57'51"N, 69°47'53"W, 33 m, *Saarela, Gillespie, Sokoloff & Bull 2504* (ALA, ALTA, CAN-601898, MO, NFM, UTC, UTU, US, UVIC, WIN); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper Falls, south side of Soper Lake, just southeast of Soper Falls, 62°54'8"N, 69°50'42"W, 6 m, 17 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2530* (ALA, CAN-601901); Qikiqtaaluk Region, Baffin Island, Kimmirut, north end of Fundo Lake below Taqaiqsirvik Territorial Park, 62°50'50"N, 69°53'40"W, 35 m, 20 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2658* (CAN-601900); Qikiqtaaluk Region, Baffin Island, Pleasant Inlet, ca. 10 km south of Reversing Falls at end of Soper Lake, west of Kimmirut, west side of inlet 62°47'22"N, 69°59'51"W, 10–25 m, 21 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2714* (ALA, CAN-601899, MT, O, UBC).

Lentibulariaceae

***Pinguicula vulgaris* L.**
Fig. 15

Common name. Butterwort

Distribution. Nearly circumboreal-polar

Comments. This species was first reported from the western Arctic Islands by Thannheiser et al. (2001; no voucher collection located for confirmation) at Johansen Bay on Victoria Island (they incorrectly considered their record as the first for the whole CAA). We collected this species at Johansen Bay and Clauston Bay on southwestern Victoria Island and from three sites in the Minto Inlet area on northwestern Victoria Island, extending the northern range of this low Arctic species. On Victoria Island the species was sometimes locally common and populations were scattered mostly in moist to wet meadows on river flats. Two nearby populations were discovered in rocky tundra on the top of a plateau south of Minto Inlet; the larger population (*Gillespie et al. 9967*) comprised about 50 plants scattered in a moist depression in a boulder field adjacent to an *Eriophorum* meadow above the head of a canyon. The species was previously known in the CAA based on four collections from southeastern Baffin Island (Porsild 1957, Porsild and Cody 1980, Aiken et al. 2007). We collected it at six sites there, in the vicinity of Kimmirut (where previously known) and from five sites along the Soper River (one previous collection known).

Figure 15. *Pinguicula vulgaris*: **A** habitat, *Gillespie et al. 7718* **B** habit, *Gillespie et al. 8983b* **C** leaves, *Gillespie et al. 7718* **D** flower, *Gillespie et al. 8983b*. Photographs by R.D. Bull.

Specimens examined. Canada. Nunavut: Kitikmeot Region, Victoria Island, vicinity of river flowing into Clauston Bay, 3–4 km from river mouth, 69°2'39"N, 113°25'15"W, 10–20 m, 8 July 2008, *Gillespie, Saarela, Consaul, & Bull 7718* (ALA, CAN-592385, MT, O); Kitikmeot Region, Victoria Island, W end of Johansen Bay at mouth of Mackenzie Creek, 68°36'4"N, 111°21'7"W, 0–20 m, 20 July 2008, *Gillespie, Saarela, Consaul & Bull 8132* (CAN-592384); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River, west bank, near con-

fluence with Livingstone River, crystalline limestone ridge just north of confluence, 63°6'38"N, 69°44'14"W, 100m, 10 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2264* (CAN-601974); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Livingstone River (major tributary of Soper River), north side, near confluence with Soper River, ca. 0.5 km northwest of Livingstone Falls, 63°6'32"N, 69°44'38"W, 141m, 12 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2381* (CAN-601972, MO); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River, 18.5 km downstream (south) of its confluence with the Livingstone River, 2 km south of Emergency Cabin #8, west side of river, 62°59'17"N, 69°43'47"W, 60m, 15 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2478* (ALA, CAN-601970, WIN); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper Falls, south side of Soper Lake, just southeast of Soper Falls, 62°54'1"N, 69°50'48"W, 6 m, 17 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2531* (CAN-601973); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper Falls, north side of Soper River, 62°54'35"N, 69°50'43"W, 20m, 18 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2565* (CAN-601975); Qikiqtaaluk Region, Baffin Island, Kimmirut, northwest end of Fundo Lake, ca. 2 km west of hamlet, 62°50'36"N, 64°54'10"W, 30m, 22 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2787* (CAN-601971). **Northwest Territories:** Inuvik Region, Victoria Island, plateau above head of enclosed valley S of "Fish Lake" on lower Kuujjua River, 71°10'44.3"N, 116°27'11.9"W, 120 m, 16 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 9878* (CAN-599229); Inuvik Region, Victoria Island, wet rocky tundra on plateau above head of enclosed valley S of "Fish Lake" on lower Kuujjua River, 71°10'14.2"N, 116°27'29.1"W, 100 m, 16 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 9880* (CAN-599258); Inuvik Region, Victoria Island, sandy bank of Kuujjua River S of "Fish Lake", 71°6'43.2"N, 116°6'21.2"W, 70 m, 17 July 2010, *Gillespie, Saarela, Doubt, Bull & Sokoloff 9967* (CAN-599230, O).

***Utricularia ochroleuca* R.W. Hartm.**
Fig. 16

Common name. Yellowish-white bladderwort

Distribution. Circumboreal

Comments. This is the first collection of this genus and species for the CAA, and the first record of the species for Nunavut. Although broadly distributed across boreal Canada (Porsild and Cody 1980) and reported from nine states (NatureServe 2014), the species is rare in North America, with only 25 localities known prior to this collection (G. Crow, pers. comm. 2014). This uncommon plant has previously been collected at two Arctic localities in Canada: Richards Island, Mackenzie Delta, Northwest Territories (*Porsild 7076*, CAN-99617) and along the eastern coast of Hudson Bay in northern Quebec (Porsild and Cody 1980). The species is also present in west Greenland (Elven et al. 2011). Despite previous reports (Taylor 1989), this

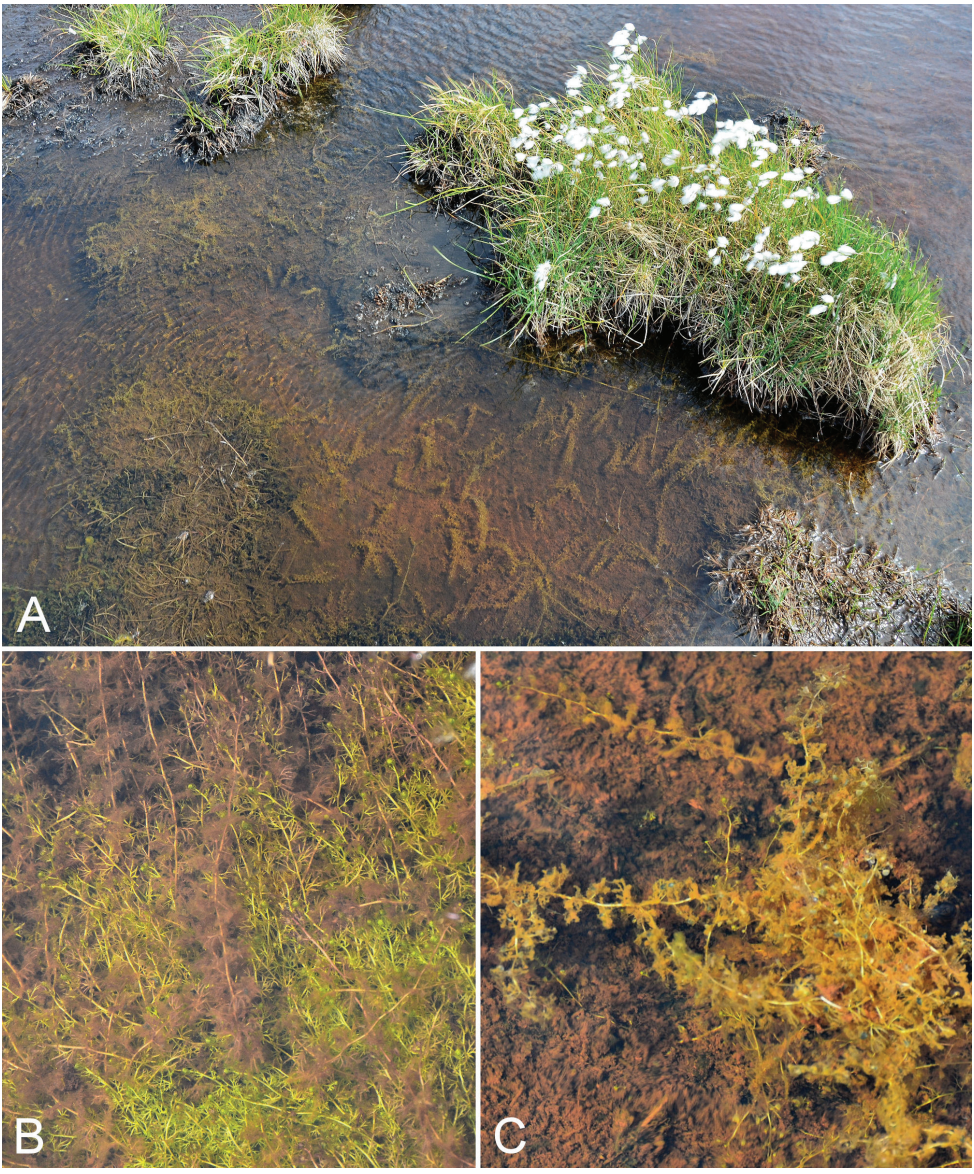

Figure 16. *Utricularia ochroleuca*: **A** habitat **B** habit **C** habit showing branches with bladders, *Saarela et al. 2464*. Photographs by R.D. Bull.

taxon has recently been excluded from the flora of Alaska (Alaska Natural Heritage Program 2014).

We encountered a single population of *U. ochroleuca* on southern Baffin Island, forming a dense floating mat along the bottom of a shallow muddy pond in a wet sedge meadow comprised of *Carex bigelowii* Torr. ex Schwein., *C. chordorrhiza* Ehrh. ex

L. f., *C. holostoma*, *Betula glandulosa*, *Arctagrostis latifolia* subsp. *latifolia*, *Eriophorum vaginatum* L. and *E. scheuchzeri* subsp. *scheuchzeri*. This population was uniformly sterile—no conspicuous emergent flowers were seen. This pattern is seen in many species of *Utricularia* above the treeline (Porsild and Cody 1980), particularly *U. ochroleuca* (G. Crow, pers. comm. 2014). This species may be more common in the low Arctic than herbarium records suggest and should be looked for carefully.

Specimens examined. Canada. Nunavut: Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River, 18.5 km downstream (S) of its confluence with the Livingstone River, 1.5 km S of Emergency Cabin #8, E bank of river, 62°58'45"N, 69°43'1"W, 23 m, 15 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2464* (ALA, ALTA, CAN-601976, MT, O, NY, UBC, US, WIN).

Primulaceae

***Primula egaliksensis* Wormsk.**
Fig. 17

Common name. Greenland primrose

Distribution. Arctic-alpine amphi-Beringia–North America

Comments. Our collections are the first for this species in the CAA. This species commonly occurs along lakeshores and riverbeds in tundra and alpine regions of Canada, Greenland and the United States (Porsild and Cody 1980, Kelso 2009), and is known from both Ungava Bay to the south and Greenland to the west of southeastern Baffin Island where our collections were made. One population collected was found in a moist mossy depression among rocks in a disturbed site near the Kimmirut boat landing on Soper Lake, associated with *Chamerion latifolium*, *Bistorta vivipara* and *Cardamine pratensis* subsp. *angustifolia* (Hook.) O.E. Schultz. The second population was on moist mossy ground among rocky outcrops on a small island, with *Leymus mollis*, *Juncus arcticus*, *Dupontia fisheri*, *Puccinellia phryganodes*, *Potentilla anserina* subsp. *egedei* (Wormsk. ex Hornem.) Hiitonen and *Saxifraga caespitosa* L. Similar in size and appearance to *P. stricta* Hornem., a largely sympatric species that is found in the CAA on Banks Island and Victoria Island, *P. egaliksensis* is distinguished by its non-farinose flowering stem (versus farinose at least at the apex), abruptly petiolate leaves, and calyx base that is less prominently saccate and never auriculate (Kelso 2009, Saarela et al. 2013a).

Specimens examined. Canada. Nunavut: Qikiqtaaluk Region, Baffin Island, Soper Lake, SE corner, Kimmirut boat landing, 62°51'45"N, 69°52'56"W, 16 m, 19 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2606* (CAN-601987, COCO); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, small unnamed island on Soper Lake (Eider duck colony), 62°53'6"N, 69°53'18"W, 9 m, 19 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2640* (CAN-601986).

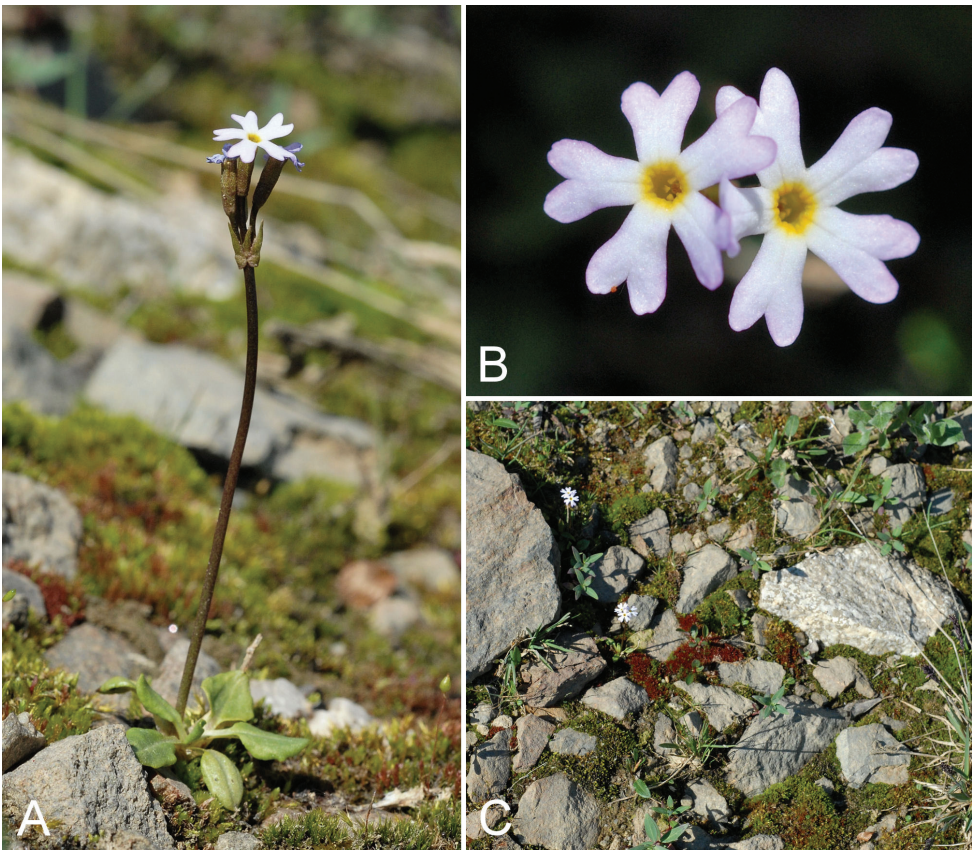

Figure 17. *Primula egaliksensis*: **A** habit **B** inflorescence **C** habitat, *Saarela et al. 2606*. Photographs by L.J. Gillespie.

Ranunculaceae

***Coptidium* × *spitsbergense* (Hadač) Luferov & Prob.**
Fig. 18

Ranunculus × *spitsbergensis* Hadač

Common name. Spitzbergen buttercup

Distribution. Disjunct circumpolar

Comments. Our collections are the first of this species for the CAA. The species is considered to be a sterile triploid hybrid between *Coptidium lapponicum* (L.) Rydb. and *C. pallasii* (Schltdl.) Tzvelev, and exhibits an intermediate morphology and habitat preference (Cody et al. 1988, Elven and Murray 2008). All three species were previously treated within *Ranunculus* L. (Porsild 1957, Porsild and Cody 1980, Cody et al. 1988, Whittemore 1997, Aiken et al. 2007), but they differ both genetically

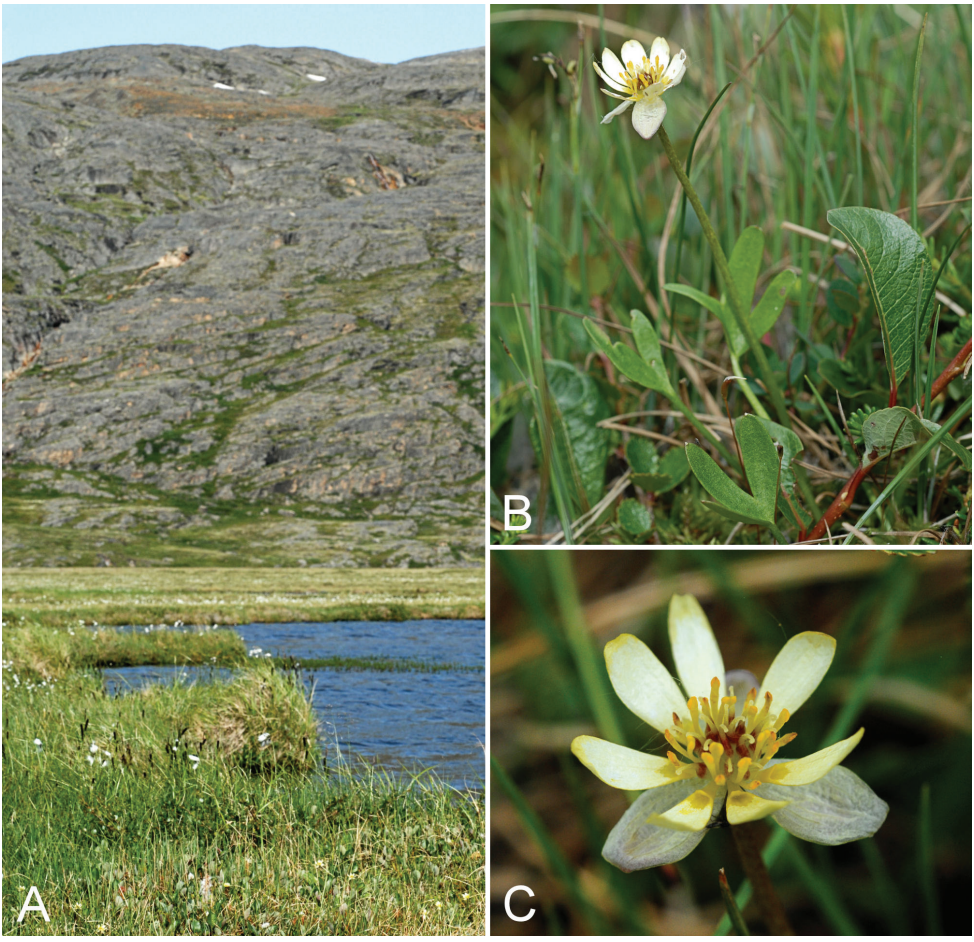

Figure 18. *Coptidium* × *spitsbergense*: **A** habitat **B** habit **C** flower, *Saarela et al. 2419*. Photographs by L.J. Gillespie.

and morphologically (presence of thick white underground stems, fragrant flowers, three sepals, spongy tissue in achene) from other members of the genus (Hörandl et al. 2005). *Coptidium* × *spitsbergense*, also known from Svalbard and the Russian Arctic, was first recorded in North America by Cody et al. (1988) from one site in southern mainland Nunavut, and four sites in northwestern Arctic Quebec. The hybrid is most similar in habit and leaf morphology to *C. pallasii*, but differs in its smaller, pale yellow flowers. The taxon was not treated by Whittemore (1997) for North America.

Coptidium × *spitsbergense* was found at two sites in the Soper River valley growing in sedge meadows, in wet moss adjacent to ponds. Associates at the first site (*Saarela et al. 2194*) include *Carex bigelowii* and *Salix arctophila*, at the second site *Betula glandulosa*, *Empetrum nigrum*, *Eriophorum angustifolium*, *E. scheuchzeri*, *Rhododendron tomentosum* subsp. *decumbens*, *Carex* spp. and *Salix* sp. Only one parent, *C. lapponicum*, was found

nearby at the *Saarela et al. 2419* site (parents were not looked for at the other site), growing scattered in moist mossy tundra. The other parent, *C. pallasii*, has not been collected in the Soper River valley and was not observed during our fieldwork there, but one older collection is known from the vicinity of Kimmirut (*Polunin 1173*, CAN; Aiken et al. 2007). Elsewhere the hybrid species is also often found in the absence of one (usually *C. pallasii*) or even both parents. In Svalbard it is more common than either parent and occurs in large stands usually in the absence of one or both parents (Elven and Murray 2008, http://svalbardflora.no/). Cody et al. (1988) recorded *C. lapponicum* as present at all five sites in Canada, and *C. pallasii* as present at only two sites, both in northern Quebec.

Throughout its range fruiting specimens have not been observed. Plants are assumed to be spread mainly by bird dispersal of stem-shoot fragments (Elven and Murray 2008, Elven et al. 2011). However, Cody et al. (1988) considered there to be no evidence for long distance dispersal and suggested that separate hybridization events occurred at each locality sometime in the past.

Specimens examined. Canada. Nunavut: Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River valley, W bank, ca. 12 km S of Mount Joy, meadow along river opposite Group/Warden Cabin #7, 63°9'50"N, 69°39'55"W, 40 m, 8 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2194* (ALA, CAN-602059, O); Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Soper River, 18.5 km downstream (S) of its confluence with the Livingstone River, 2 km S of Emergency Cabin #8, E bank of river, 62°59'2"N, 69°43'1"W, 20 m, 14 July 2012, *Saarela, Gillespie, Sokoloff & Bull 2419* (ALA, CAN-602060, MT, O, WIN).

Salicaceae

Salix arctophila Cockerell ex A. Heller

Common name. Northern willow

Distribution. Arctic North America

Comments. This is the first record of this species for the western CAA. This sub-Arctic–low Arctic species is distributed from northeastern Alaska to Greenland and south to Maine in the alpine zone (Argus 2007). Its range on the Northwest Territories mainland extends to the coast immediately adjacent to where we collected it at Oterkvik Point (Porsild and Cody 1980, Argus 2007). Previous collections in the Arctic Islands have only been made on Baffin Island and Southampton Island in the eastern CAA (Aiken et al. 2007).

Specimen examined. Canada. Nunavut: Kitikmeot Region, Victoria Island, Oterkvik Point vicinity, 9–10 km N of Coronation Gulf coast, 12–13 km N of point, 68°36'23"N, 112°34'7"W, 50–60 m, 4 July 2008, *Gillespie*, *Saarela, Consaul & Bull 7511* (CAN-592250, O, ALA, MT).

***Salix fuscescens* Andersson**

Common name. Alaska bog willow

Distribution. Arctic Asia (NE)–amphi-Beringia–North America

Comments. Our collections are the first records for the eastern CAA. Aiken et al. (2007) reported the species in the CAA from a single collection on Victoria Island (*Lambert s.n.*, CAN-52349). Argus (2007) mapped the species as occurring in the low Arctic from Alaska to western Hudson Bay, including southern Victoria Island, King William Island and the lower Boothia Peninsula. Our collections represent an eastern range extension of some 900 km for the species, with respect to the map in Argus (2007).

Specimens examined. Canada. Nunavut: Qikiqtaaluk Region, Baffin Island, Katannilik Territorial Park Reserve, Livingstone River (major tributary of Soper River), north side, near confluence with Soper River, 63°06'30"N, 69°44'02"W, 50 m, 12 July 2012, *Saarela, Gillespie, Sokoloff, Bull 2361* (CAN-601675), *2362* (CAN-601674).

Saxifragaceae

***Saxifraga eschscholtzii* Sternb.**

Common name. Eschscholtz's saxifrage

Distribution. Amphi-Beringia

Comments: Collected on Bathurst Island by S. Edlund in 1975, this is only the second collection of this species from the CAA, and the first record from Nunavut. Edlund's collection was shelved in the backlog of the National Herbarium of Canada for nearly 40 years, and was only recently uncovered. However, its significance as a new record was noted on the newsprint accompanying the specimen, indicating its importance was apparent to the collector.

Though long known from the alpine tundra of northern Yukon and Alaska (Cody 2000), the 1968 collection on Prince Patrick Island (mapped in Porsild and Cody 1980 and Aiken et al. 2007)—the first record for the Arctic Islands—extended the range of this species northeastwards by over 1000 km. The second collection on Bathurst Island pushes this species a further 500 km east in the CAA. The apparent gaps in this species distribution may be explained by its habit: when not in flower, it can resemble either the very common *Saxifraga oppositifolia* L. or a lichen (Aiken et al. 2007); either scenario could account for the paucity of collections from the CAA.

Specimens examined. Canada. Northwest Territories: Inuvik Region, Prince Patrick Island, Green Bay, gravelly slopes with northern exposure, 76°33'46"N, 118°51'28"W, 7 July 1968, *Kuc s.n.* (CAN-385465). **Nunavut:** Qikiqtaaluk Region, Bathurst Island, Bracebridge Inlet, GSC [Geological Survey of Canada] Site, 75°35'N, 101°00'W, 1 July 1975, *Edlund 41* (CAN-605793).

Saxifraga rivularis subsp. *arctolitoralis* (Jurtz. & V.V. Petrovsky) M.H. Jørg. & Elven

Common name. Alpine brook saxifrage

Distribution. Arctic amphi-Beringia–North America

Comments. This collection (det. R. Elven and L.J. Gillespie) represents the first record of *S. rivularis* L. as currently circumscribed from the western CAA and the first record of *S. rivularis* subsp. *arctolitoralis* from the CAA. Porsild (1957) and Porsild and Cody (1980) previously treated the species in a broader sense and included plants now treated under *S. hyperborea* R.Br., a circum-Arctic species (all collections of *S. rivularis* s.l. mapped by them from the western Arctic Islands are now considered *S. hyperborea*). As treated by Aiken et al. (2007), *S. rivularis* is restricted to the eastern CAA, while *S. hyperborea* is widespread across the CAA; the two species are easily distinguished by the presence of stolons only in *S. rivularis*. Our collection fills in a distribution gap in the widely disjunct amphi-Atlantic–amphi-Beringian distribution of *S. rivularis*.

Two subspecies have recently been recognized in *S. rivularis*: subsp. *rivularis* with an amphi-Atlantic distribution (and widespread in the eastern CAA) and subsp. *arctolitoralis* with an amphi-Beringian distribution (Jørgensen et al. 2006, Brouillet and Elvander 2009, Elven et al. 2011). Jørgensen et al. (2006), Aiken et al. (2007) and Brouillet and Elvander (2009) considered subsp. *arctolitoralis* as present in Alaska, but not known from Canada. More recently, Westergaard et al. (2010) presented molecular evidence for the presence of subsp. *arctolitoralis* on southeastern Baffin Island and Greenland, suggesting long distance dispersal from Beringia in the post-glacial period. Elven et al. (2011) consider subsp. *arctolitoralis* as present also in the Yukon and the Mackenzie Delta area of the Northwest Territories and mention that there are also plants from Hudson Bay and northern Quebec and Labrador conforming in both DNA and morphology to the subspecies. The two subspecies may be distinguished by the following key (adapted from Jørgensen et al. 2006 and Brouillet and Elvander 2009):

1 Hypanthium densely covered with long stipitate glandular hairs, 0.3–0.6 mm long; flowering stem glabrous or sparsely hairy ..... ***Saxifraga rivularis* subsp. *arctolitoralis***

– Hypanthium sparsely covered with short stipitate glandular hairs, 0.1–0.3 mm long; flowering stem sparsely to densely hairy ..... ***Saxifraga rivularis* subsp. *rivularis***

Specimens examined. Canada. Nunavut: Kitikmeot Region, Victoria Island, Murray Point, W side of Wilbank Bay, 68°35'34"N, 110°18'24"W, 20–30 m, 21 July 2008, *Gillespie, Saarela, Consaul & Bull 8174* (ALA, ALTA, BABY, CAN-592397, MT, O, UBC).

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Appendix

CAN accession number	Taxon, collector and collector no.	URL
CAN-601315	*Cryptogramma stelleri. Saarela, Gillespie, Sokoloff & Bull 2774.*	http://dx.doi.org/10.6084/m9.figshare.1408637
CAN-592505	*Carex bicolor. Gillespie, Saarela, Consaul & Bull 8118.*	http://dx.doi.org/10.6084/m9.figshare.1408638
CAN-601449	*Carex brunnescens* subsp. *brunnescens. Saarela, Gillespie, Sokoloff & Bull 2232.*	http://dx.doi.org/10.6084/m9.figshare.1408636
CAN-601450	*Carex brunnescens* subsp. *brunnescens. Saarela, Gillespie, Sokoloff & Bull 2346.*	http://dx.doi.org/10.6084/m9.figshare.1408639
CAN-601451	*Carex brunnescens* subsp. *brunnescens. Saarela, Gillespie, Sokoloff & Bull 2407.*	http://dx.doi.org/10.6084/m9.figshare.1408640
CAN-598595	*Eriophorum brachyantherum. Gillespie, Saarela, Doubt, Bull & Sokoloff 9485.*	http://dx.doi.org/10.6084/m9.figshare.1408555
CAN-598605	*Eriophorum brachyantherum. Gillespie, Saarela, Doubt, Bull & Sokoloff 9673.*	http://dx.doi.org/10.6084/m9.figshare.1408553
CAN-598607	*Eriophorum brachyantherum. Gillespie, Saarela, Doubt, Bull & Sokoloff 9899.*	http://dx.doi.org/10.6084/m9.figshare.1408554
CAN-598924	*Eriophorum brachyantherum. Gillespie, Saarela, Doubt, Bull & Sokoloff 9982.*	http://dx.doi.org/10.6084/m9.figshare.1408557
CAN-598596	*Eriophorum brachyantherum. Gillespie, Saarela, Doubt, Bull & Sokoloff 10091.*	http://dx.doi.org/10.6084/m9.figshare.1408556
CAN-598910	*Eriophorum brachyantherum. Gillespie, Saarela, Doubt, Bull & Sokoloff 10102.*	http://dx.doi.org/10.6084/m9.figshare.1408558
CAN-598598	*Eriophorum brachyantherum. Gillespie, Saarela, Doubt, Bull & Sokoloff 10305.*	http://dx.doi.org/10.6084/m9.figshare.1408561
CAN-592326	*Luzula wahlenbergii. Gillespie, Saarela, Consaul & Bull 8170.*	http://dx.doi.org/10.6084/m9.figshare.1408559
CAN-601427	*Triglochin palustris. Saarela, Gillespie, Sokoloff & Bull 2535.*	http://dx.doi.org/10.6084/m9.figshare.1408560
CAN-601426	*Triglochin palustris. Saarela, Gillespie, Sokoloff & Bull 2652.*	http://dx.doi.org/10.6084/m9.figshare.1408562
CAN-592381	*Corallorhiza trifida. Gillespie, Saarela, Consaul & Bull 8093.*	http://dx.doi.org/10.6084/m9.figshare.1408563
CAN-601648	*Corallorhiza trifida. Saarela, Gillespie, Sokoloff & Bull 1970.*	http://dx.doi.org/10.6084/m9.figshare.1408564
CAN-601649	*Corallorhiza trifida. Saarela, Gillespie, Sokoloff & Bull 2036.*	http://dx.doi.org/10.6084/m9.figshare.1408565
CAN-601650	*Corallorhiza trifida. Saarela, Gillespie, Sokoloff & Bull 2415.*	http://dx.doi.org/10.6084/m9.figshare.1408567
CAN-601651	*Platanthera obtusata* subsp. *obtusata. Saarela, Gillespie, Sokoloff & Bull 2197.*	http://dx.doi.org/10.6084/m9.figshare.1408568
CAN-601276	*Platanthera obtusata* subsp. *obtusata. Saarela, Gillespie, Sokoloff & Bull 2209.*	http://dx.doi.org/10.6084/m9.figshare.1408566
CAN-601652	*Platanthera obtusata* subsp. *obtusata. Saarela, Gillespie, Sokoloff & Bull 2488.*	http://dx.doi.org/10.6084/m9.figshare.1408570
CAN-601348	*Calamagrostis stricta* subsp. *groenlandica. Saarela, Gillespie, Sokoloff & Bull 2191.*	http://dx.doi.org/10.6084/m9.figshare.1408569

CAN accession number	Taxon, collector and collector no.	URL
CAN-601345	*Calamagrostis stricta* subsp. *groenlandica. Saarela, Gillespie, Sokoloff & Bull 2255.*	http://dx.doi.org/10.6084/m9.figshare.1408571
CAN-601347	*Calamagrostis stricta* subsp. *groenlandica. Saarela, Gillespie, Sokoloff & Bull 2398.*	http://dx.doi.org/10.6084/m9.figshare.1408572
CAN-601346	*Calamagrostis stricta* subsp. *groenlandica. Saarela, Gillespie, Sokoloff & Bull 2442.*	http://dx.doi.org/10.6084/m9.figshare.1408573
CAN-601344	*Calamagrostis stricta* subsp. *groenlandica. Saarela, Gillespie, Sokoloff & Bull 2576.*	http://dx.doi.org/10.6084/m9.figshare.1408575
CAN-601368	*Hordeum jubatum* subsp. *jubatum. Saarela, Gillespie, Sokoloff & Bull 2737.*	http://dx.doi.org/10.6084/m9.figshare.1408577
CAN-601369	*Hordeum jubatum* subsp. *jubatum. Saarela, Gillespie, Sokoloff & Bull 2755.*	http://dx.doi.org/10.6084/m9.figshare.1408576
CAN-432022	*Leymus innovatus* subsp. *velutinus. Kuc 405.*	http://dx.doi.org/10.6084/m9.figshare.1408579
CAN-432023	*Leymus innovatus* subsp. *velutinus. Kuc 405.*	http://dx.doi.org/10.6084/m9.figshare.1408580
CAN-601371	*Leymus mollis* subsp. *mollis. Saarela, Gillespie, Sokoloff & Bull 2529.*	http://dx.doi.org/10.6084/m9.figshare.1408581
CAN-600906	*Puccinellia banksiensis. Gillespie, Saarela, Consaul & Bull 7549.*	http://dx.doi.org/10.6084/m9.figshare.1408582
CAN-592678	*Puccinellia banksiensis. Gillespie, Saarela, Consaul & Bull 8055.*	http://dx.doi.org/10.6084/m9.figshare.1408585
CAN-592239	*Puccinellia banksiensis. Gillespie, Saarela, Consaul & Bull 8055-2.*	http://dx.doi.org/10.6084/m9.figshare.1408583
CAN-592679	*Puccinellia banksiensis. Gillespie, Saarela, Consaul & Bull 8077.*	http://dx.doi.org/10.6084/m9.figshare.1408586
CAN-592688	*Puccinellia banksiensis. Gillespie, Saarela, Consaul & Bull 8146-2.*	http://dx.doi.org/10.6084/m9.figshare.1408584
CAN-592705	*Puccinellia banksiensis. Gillespie, Saarela, Consaul & Bull 8240.*	http://dx.doi.org/10.6084/m9.figshare.1408589
CAN-592689	*Puccinellia banksiensis. Gillespie, Saarela, Consaul & Bull 8261.*	http://dx.doi.org/10.6084/m9.figshare.1408588
CAN-592707	*Puccinellia banksiensis. Gillespie, Saarela, Consaul & Bull 8339.*	http://dx.doi.org/10.6084/m9.figshare.1408587
CAN-592375	*Stuckenia vaginata. Gillespie, Saarela, Consaul & Bull 8048.*	http://dx.doi.org/10.6084/m9.figshare.1408591
CAN-592376	*Suaeda calceoliformis. Gillespie, Saarela, Consaul & Bull 7570.*	http://dx.doi.org/10.6084/m9.figshare.1408590
CAN-593265	*Suaeda calceoliformis. Gillespie, Saarela, Consaul & Bull 8068.*	http://dx.doi.org/10.6084/m9.figshare.1408592
CAN-593267	*Suaeda calceoliformis. Gillespie, Saarela, Consaul & Bull 8137.*	http://dx.doi.org/10.6084/m9.figshare.1408593
CAN-598332	*Suaeda calceoliformis. Gillespie, Saarela, Doubt, Bull & Sokoloff 9662.*	http://dx.doi.org/10.6084/m9.figshare.1408594
CAN-598331	*Suaeda calceoliformis. Gillespie, Saarela, Doubt, Bull & Sokoloff 10243.*	http://dx.doi.org/10.6084/m9.figshare.1408595
CAN-599149	*Arenaria humifusa. Gillespie, Saarela, Doubt, Bull & Sokoloff 9882.*	http://dx.doi.org/10.6084/m9.figshare.1408596
CAN-599166	*Arenaria humifusa. Gillespie, Saarela, Doubt, Bull & Sokoloff 9893.*	http://dx.doi.org/10.6084/m9.figshare.1408598

CAN accession number	Taxon, collector and collector no.	URL
CAN-599167	*Arenaria humifusa. Gillespie, Saarela, Doubt, Bull & Sokoloff 9971.*	http://dx.doi.org/10.6084/m9.figshare.1408597
CAN-592340	*Arenaria longipedunculata. Gillespie, Saarela, Consaul & Bull 7721.*	http://dx.doi.org/10.6084/m9.figshare.1408599
CAN-593142	*Arenaria longipedunculata. Gillespie, Saarela, Consaul & Bull 8136.*	http://dx.doi.org/10.6084/m9.figshare.1408602
CAN-601731	*Arenaria longipedunculata. Saarela, Gillespie, Sokoloff & Bull 2477.*	http://dx.doi.org/10.6084/m9.figshare.1408601
CAN-601732	*Arenaria longipedunculata. Saarela, Gillespie, Sokoloff & Bull 2776.*	http://dx.doi.org/10.6084/m9.figshare.1408600
CAN-592334	*Sabulina stricta. Gillespie, Saarela, Consaul & Bull 7966.*	http://dx.doi.org/10.6084/m9.figshare.1408604
CAN-592360	*Andromeda polifolia. Gillespie, Saarela, Consaul & Bull 8002.*	http://dx.doi.org/10.6084/m9.figshare.1408603
CAN-601935	*Andromeda polifolia. Saarela, Gillespie, Sokoloff & Bull 2186.*	http://dx.doi.org/10.6084/m9.figshare.1408605
CAN-592359	*Orthilia secunda* subsp. *obtusata. Gillespie, Saarela, Consaul & Bull 8036.*	http://dx.doi.org/10.6084/m9.figshare.1408606
CAN-601915	*Orthilia secunda* subsp. *obtusata. Saarela, Gillespie, Sokoloff & Bull 2489.*	http://dx.doi.org/10.6084/m9.figshare.1408608
CAN-598345	*Oxytropis deflexa* subsp. *foliolosa. Gillespie, Saarela, Doubt, Bull & Sokoloff 10129.*	http://dx.doi.org/10.6084/m9.figshare.1408607
CAN-601898	*Oxytropis deflexa* subsp. *foliolosa. Saarela, Gillespie, Sokoloff & Bull 2504.*	http://dx.doi.org/10.6084/m9.figshare.1408609
CAN-601901	*Oxytropis deflexa* subsp. *foliolosa. Saarela, Gillespie, Sokoloff & Bull 2530.*	http://dx.doi.org/10.6084/m9.figshare.1408611
CAN-601900	*Oxytropis deflexa* subsp. *foliolosa. Saarela, Gillespie, Sokoloff & Bull 2658.*	http://dx.doi.org/10.6084/m9.figshare.1408610
CAN-601899	*Oxytropis deflexa* subsp. *foliolosa. Saarela, Gillespie, Sokoloff & Bull 2714.*	http://dx.doi.org/10.6084/m9.figshare.1408612
CAN-592385	*Pinguicula vulgaris. Gillespie, Saarela, Consaul & Bull 7718.*	http://dx.doi.org/10.6084/m9.figshare.1408613
CAN-592384	*Pinguicula vulgaris. Gillespie, Saarela, Consaul & Bull 8132.*	http://dx.doi.org/10.6084/m9.figshare.1408614
CAN-601974	*Pinguicula vulgaris. Saarela, Gillespie, Sokoloff & Bull 2264.*	http://dx.doi.org/10.6084/m9.figshare.1408617
CAN-601972	*Pinguicula vulgaris. Saarela, Gillespie, Sokoloff & Bull 2381.*	http://dx.doi.org/10.6084/m9.figshare.1408615
CAN-601970	*Pinguicula vulgaris. Saarela, Gillespie, Sokoloff & Bull 2478.*	http://dx.doi.org/10.6084/m9.figshare.1408619
CAN-601973	*Pinguicula vulgaris. Saarela, Gillespie, Sokoloff & Bull 2531.*	http://dx.doi.org/10.6084/m9.figshare.1408618
CAN-601975	*Pinguicula vulgaris. Saarela, Gillespie, Sokoloff & Bull 2565.*	http://dx.doi.org/10.6084/m9.figshare.1408620
CAN-601971	*Pinguicula vulgaris. Saarela, Gillespie, Sokoloff & Bull 2787.*	http://dx.doi.org/10.6084/m9.figshare.1408621
CAN-599229	*Pinguicula vulgaris. Gillespie, Saarela, Doubt, Bull & Sokoloff 9878.*	http://dx.doi.org/10.6084/m9.figshare.1408623

CAN accession number	**Taxon, collector and collector no.**	**URL**
CAN-599258	*Pinguicula vulgaris. Gillespie, Saarela, Doubt, Bull & Sokoloff 9880.*	http://dx.doi.org/10.6084/m9.figshare.1408622
CAN-599230	*Pinguicula vulgaris. Gillespie, Saarela, Doubt, Bull & Sokoloff 9967.*	http://dx.doi.org/10.6084/m9.figshare.1408624
CAN-601976	*Utricularia ochroleuca. Saarela, Gillespie, Sokoloff & Bull 2464.*	http://dx.doi.org/10.6084/m9.figshare.1408625
CAN-601987	*Primula egaliksensis. Saarela, Gillespie, Sokoloff & Bull 2606.*	http://dx.doi.org/10.6084/m9.figshare.1408626
CAN-601986	*Primula egaliksensis. Saarela, Gillespie, Sokoloff & Bull 2640.*	http://dx.doi.org/10.6084/m9.figshare.1408629
CAN-602059	*Coptidium × spitsbergense. Saarela, Gillespie, Sokoloff & Bull 2194.*	http://dx.doi.org/10.6084/m9.figshare.1408627
CAN-602060	*Coptidium × spitsbergense. Saarela, Gillespie, Sokoloff & Bull 2419.*	http://dx.doi.org/10.6084/m9.figshare.1408628
CAN-592250	*Salix arctophila. Gillespie, Saarela, Consaul & Bull 7511.*	http://dx.doi.org/10.6084/m9.figshare.1408630
CAN-601675	*Salix fuscescens. Saarela, Gillespie, Sokoloff & Bull 2361.*	http://dx.doi.org/10.6084/m9.figshare.1408631
CAN-601674	*Salix fuscescens. Saarela, Gillespie, Sokoloff & Bull 2362.*	http://dx.doi.org/10.6084/m9.figshare.1408632
CAN-605793	*Saxifraga eschscholtzii. Edlund 41.*	http://dx.doi.org/10.6084/m9.figshare.1408633
CAN-592397	*Saxifraga rivularis* subsp. *arctolitoralis. Gillespie, Saarela, Consaul & Bull 8174.*	http://dx.doi.org/10.6084/m9.figshare.1408634

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RESEARCH ARTICLE

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Bolanthus turcicus (Caryophyllaceae), a new species from Turkey

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Abstract

A new species *Bolanthus turcicus* Koç & Hamzaoğlu, **sp. nov.** was discovered on Hasan Mountain (Turkey, Aksaray province) where it grows on volcanic stony slopes and alpine steppe. its description, images, chorology and ecology, and threat category are provided in this article. It was compared with a closely related species, *Bolanthus minuartioides* (Jaub. & Spach) Hub.-Mor., *B. huber-morathii* C.Simon, *B. spergulifolius* (Jaub. & Spach) Hub.-Mor., *B. frankenioides* (Boiss) Bark., *B. mevlanae* Aytaç based on its general morphology and seed micromorphology.

Keywords

Anatolia, new species, *Bolanthus*, taxonomy

Introduction

Bolanthus (Ser.) Reichb., in the family Caryophyllaceae, is one of the smallest genera of the family. This genus resembles especially the species of *Gypsophila* L. and *Acanthophyllum* C.A.Mey by its physical appearance. Nevertheless, it differs from *Gypsophila* in that *Bolanthus* are calyx tubular and do not include druses. Besides, it is different from the species of *Acanthophyllum* as its fruit is 8–28-seeded, dehiscing by valves

or teeth, leaves, bracts, and calyx never spiny, stamens included calyx. In addition, *Bolanthus* basically spreads across the Meditarranean Region, while *Acanthophyllum* is an Irano-Turanian genus (Bittrich 1993, Huber-Morath 1967, Huber-Morath et al. 1968, Davis et al. 1988).

Bolanthus consists of approximately 15 species and is mainly distributed in Greece, Palestine and Turkey (Bittrich 1993, Huber-Morath 1967, Davis et al. 1988). *Bolanthus* includes six species one of which is represented by 2 varieties in Flora of Turkey (Huber-Morath 1967, Huber-Morath et al. 1968). *Bolanthus* is represented by 8 species in Flora Europaea (Barkoudah and Akeroyd 1993), 1 species in Flora Palaestina (Zohary 1966). As a result of recent studies, 2 species (*B. huber-morathii* C.Simon, *B. mevlanae* Aytaç) and 1 subspecies (*B. creutzburgii* Greuter subsp. *zaffranii* Phitos, Turland & Bergmeier) have been added to this genus (Aytaç and Duman 2004, Özhatay et al. 2009, Phitos et al. 2011). As a result; the total taxa number of this genus has been increased to 20. Anatolia is a prominent centre for *Bolanthus* and 8 species grow in Turkey.

Materials and methods

We came across some interesting *Bolanthus* specimens while conducting field work on the Hasan Mountain above Karkın town (Turkey, Aksaray province), as two authors actually having the goal of finding the *Minuartia* L. and *Dianthus* L.. These specimens were compared with related species in the herbarium of Biology Department of Bozok University, GAZI, K and with records in the literature (Barkoudah and Akeroyd 1993, Zohary 1966, Huber-Morath 1967, Huber-Morath et al. 1968, Davis et al. 1988, Bojňanský and Fargašová 2007). The images were taken using the Canon EOS 60D digital camera, and the seed surface micromorphology was visualized using the LEO 440 scanning electron microscope. Normal visualization of the specimens was carried out using the Olympus SZ61 microscope. The vegetative characters were measured using a ruler with 0.5-mm accuracy and the floral characters were determined using an ocular micrometer.

Taxonomic treatment

Bolanthus turcicus **Koç & Hamzaoğlu, sp. nov.**
urn:lsid:ipni.org:names:77148111-1
Figs 1, 2

Diagnosis. *Bolanthus turcicus* is related to *B. spergulifolius* (Jaub. & Spach) Hub.-Mor. It differs from the related taxa mainly by having it has leaves 3-veined (not 1-vained), linear (not subulate); calyx 3.5–4.5 mm long (not 4.5–5.5 mm long); petals 3.3–4.5 mm long and as long as calyx (not 5.5–6.5 mm long and 1.5 times longer than calyx).

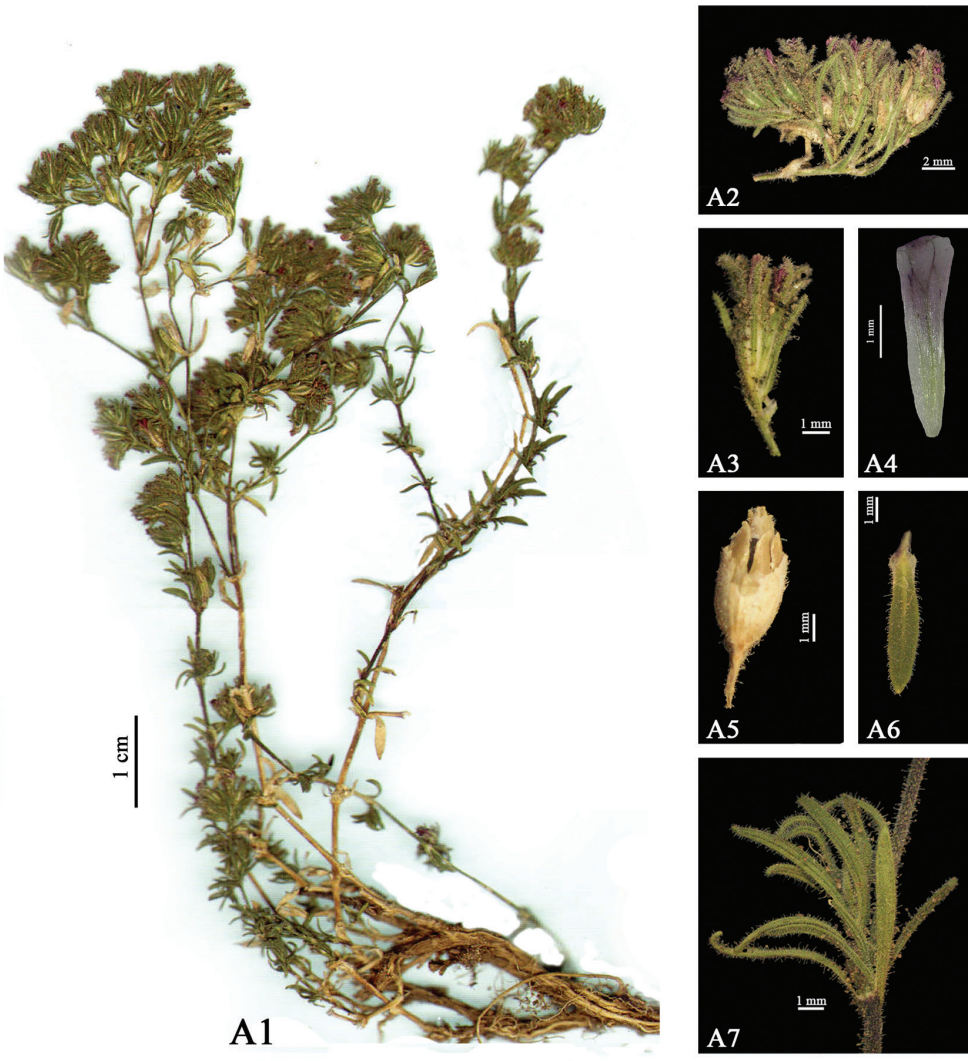

Figure 1. A: *Bolanthus turcicus* (EH 7110). **1** Habit **2** Inflorescence **3** Flower **4** Petal **5** Capsule **6** Leaf **7** Leaf axillary fascicles.

Type. TURKEY, Aksaray province, Hasan Mountain above Karkın town, Hamzaoğlu 7110 and Koç (holo GAZI, iso GAZI, ANK, Dept of Bozok Univ., Herbarium of Biology), 1950 m, volcanic stony slopes and alpine steppe, 18 June 2014.

Description. Perennial, completely glandular and eglandular hairs. Stems prostrate, 8–14 cm tall, 0.5–1 mm diameter. Leaves linear, margins ciliate and subscarious near base, apex acute; sterile shoot leaves similar but shorter than or equal to cauline leaves; cauline leaves linear, 5-8 × 0.5-0.7 mm, 3-veined, sheaths equal or slightly longer than wide; upper similar but smaller. Inflorescence cymose, subcapitate, 5–10-flowered; bracts similar cauline leaves, 3–5 × 0.4–0.6 mm; ± equalling calyx;

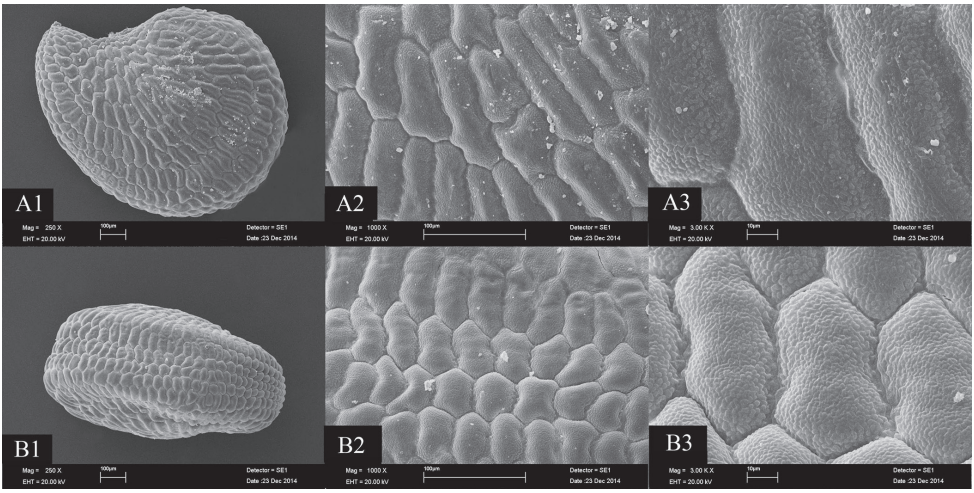

Figure 2. SEM photographs of the seed coat. *Bolanthus turcicus* – **A1–3** ventral surface **B1–3** dorsal surface (Scale bars 100 μm).

pedicels 1–2 mm or absent. Calyx tubular, 3.5–4.5 × 1–1.4 mm; tube 5-ribbed, herbaceous, commissures whitish, scarious; teeth narrowly triangular, 1–1.3 mm, apex acuminate. Petals linear-spathulate, 3.3–4.5 × 0.8–1.2 mm, emarginated, as long as calyx; limb whitish with transverse deep purple stripe near middle or base. Stamens 10. Styles 2. Capsule sessile, oblong-ovoid, including calyx, dehiscing by 4 teeth. Seeds black, comma-shaped, 0.8–1.1 × 0.5–0.7 mm, tuberculate. flowering in June and July, volcanic stony slopes and alpine steppe.

Seed micro-morphology. Seeds of *Bolanthus turcicus* are comma-shaped, 0.8–1.1 × 0.5–0.7 mm, granular; ventral surface with regular elongated rectangular cells, tuberculate, obscure teeth on each margin, teeth S-undulate; dorsal surface with regular rectangular cells, tuberculate, obscure teeth on each margin, teeth S-undulate. The seeds of *B. turcicus* aren't different than the seeds of *Bolanthus minuartioides* (Jaub. & Spach) Hub.-Mor., *B. huber-morathii*, *B. spergulifolius*, *B. frankenioides* (Boiss) Bark., *B. mevlanae* in terms of dorsal and ventral surfaces (Figure 2).

Chorology and ecology. *Bolanthus turcicus* grows on volcanic stony slopes and alpine steppe and Irano-Turanian phytogeographic regions (Davis 1965). Many plants in the alpine steppe have distinctive adaptations to the harsh environment. On mountain slopes in the alpine steppe, grasses decrease and forbs increase (Huang 1987). The species grows on volcanic stony slopes and alpine steppe together with *Scleranthus annus* L. subsp. *polycarpos* (L.) Thell., *Acantholimon acerosum* (Willd.) Boiss., *Bromus tomentellus* Boiss., *Festuca valesiaca* Schleich., *Alyssum pateri* Nyár. subsp. *pateri*, *Astragalus angustifolius* Lam., *Astragalus lineatus* Lam., *Phlomis armeniaca* Willd., *Phleum alpinum* L., *Stipa pulcherrima* K.Koch, *Minuartia juniperina* (L.) Maire & Petitm., *Sedum pallidum* M.Bieb.

Conservation status. *Bolanthus turcicus* is an endemic species known only from the type gathered in the Hasan Mountain (Aksaray province). Informal grazing and land-use changes could have a detrimental impact in the future. For this reason this species should be classified as "Critically Endangered" (CR-B1a) according to the World Conservation Union categories (IUCN 2014).

Results

The specimens introduced as the new species in this study were collected from Aksaray province, Hasan Mountain above Karkın town. All the 20 taxa, which spreads across the world as well, exist in the Meditarranean Region; however, this taxon exists in the Irano-Turanian phytogeographic region. Firstly collected specimens resemble *Bolanthus spergulifolius* and *Bolanthus huber-morathii* at first glance. Yet, comprehensive studies that were subsequently carried out revealed that they belonged to a new species.

Distinction from other taxa

Bolanthus is represented by 8 species in the flora in Turkey. Three species (*B. cherlerioides* (Bornm.) Bark., *B. thymoides* Hub.-Mor., *B. stenopetalus* Hartving & Strid) among them differs from the others as these three have tight cushion-shaped, leaves that have intensive imbricates and their internodes are scarcely visible. Therefore, *Bolanthus turcicus* is similar to the other 5 species (*B. minuartioides*, *B. huber-morathii*, *B. spergulifolius*, *B. frankenioides*, *B. mevlanae*) as it branches loosely, its leaves do not imbricate and the gaps between the internodes are wide. Each of these species has its own character by its pedal color, shape of leaves and pubescence. According to the examined specimens and the Flora of Turkey and the East Aegean Islands, *Bolanthus turcicus* differs from the species of *B. frankenioides* and *B. mevlanae* with its loose branching, wide distance internodes, shapes and vein number of leaves, length of petal and ratio of petal-calyx. The increases in differences suspend it from these taxa while approximating to *Bolanthus minuartioides*, *B. spergulifolius*, *B. huber-morathii*. However, *B. huber-morathii* is a distinctive species, whose its glabrous stems, shape of leaves, rate of bracts to calyx and loose inflorescence,. On the other hand, *B. minuartioides* is a distinctive one as well with its petal colour, length of calyx-teeth and inflorescence shape. Thus *Bolanthus turcicus* resembles *B. spergulifolius* with its stems hairy, length of leaves, rate of bracts-calyx, type of inflorescence and color of petal. Despite these similarities, there are several distinctive differences between *B. turcicus* and *B. spergulifolius* in terms of leaves vein number, shape of leaves, rate of bracts-calyx, length of calyx, length of petal, rate of petal-calyx. A key-hart showing the discrimination between the related sprecies and tale showing the characteristics of the species are provided below. (Table 1, Figure 1).

Table 1. Diagnostic characters *Bolanthus frankenioides*, *B. mevlanae*, *B. huber-morathii*, *B. minuartioides*, *B. spergulifolius* and *B. turcicus*.

Characters	*B. frankenioides*	*B. mevlanae*	*B. huber-morathii*	*B. minuartioides*	*B. spergulifolius*	*B. turcicus*
Plants	loosely tufted	loosely tufted	many branched	many branched	many branched	many branched
Stems	2–15 cm	3–5 cm	8–15 cm	3–15 cm	5–15 cm	8–14 cm
	densely covered with glandular and eglandular hairs	puberulent	glabrous	long eglandular hairs	densely glandular and eglandular hairs	densely glandular and eglandular hairs
Leaves	2–7 mm	2–5 mm	5–8 mm	3–7 mm	5–10 mm	6–10 mm
	linear-setaceous	setaceous	subulate-setaceous	subulate	subulate	linear
	1-veined	1-veined	1-veined	1-veined	1-veined	3-veined
Bracts	2/3 or as long as calyx	2/3 or as long as calyx	up to 1/2 as long as calyx	2/3 or as long as calyx	2/3 or as long as calyx	2/3 or as long as calyx
Flowers	1–3-flowered	5–10-flowered	5–15-flowered	(5-)10–25-flowered	5–15-flowered	5–10-flowered
Inflorescence	Solitary in the axils or loose few flowered dichasial	dense dichasial subcapitate subsessil clusters	lax dichasial clusters	dense dichasial subcapitate subsessil clusters	dense dichasial subcapitate subsessil clusters	dense dichasial subcapitate subsessil clusters
Calyx	3–3.5 mm	4–5 mm	4.5–6 mm	4–5 mm	4.5–5.5 mm	3.5–4.5 mm
Calyx teeth	0.5–0.7 mm	1.5–2 mm	0.7–1 mm	0.7–1 mm	1–1.5 mm	1–1.5 mm
Petals	linear-cuneate	linear-oblong	linear-spatulate	linear-lanceolate	linear-oblong	linear-spatulate
	5–7 mm	5.5–6 mm	7–8 mm	5–7 mm	6.5 mm	3.3–4.5 mm
	white with purple veins	white with purple veins	white with purple veins	white without purple veins	white with purple veins	white with purple veins
	1.5 times longer than calyx	1.5 times longer than calyx	1.5 times longer than calyx	1.5 times longer than calyx	1.5 times longer than calyx	as long as calyx
Habitat	alpine meadows	steppe	serpantine	dry hills, limestone, mountain steppe	steppe, stony places fields	volcanic stony slopes and alpine steppe

Key to closely related *Bolanthus* species

1 Plants loosely tufted; leaves setaceous or linear-setaceous, internodes 1–5 mm
2 Stems densely covered with glandular and eglandular hairs, leaves linear- setaceous; calyx 3–3.5 mm, teeth 0.5–0.7 mm; inflorescence Solitary in the axils or loose few flowered dichasial. ..... ***B. frankenioides***
2' Stems puberulent, leaves setaceous; calyx 4–5 mm, teeth 1–1.5 mm; inflorescence dense dichasial subcapitate subsessil clusters ..... ***B. mevlanae***
1' Plants many branched, not tufted; leaves subulate, subulat-setaceous or linear, internodes 5–20 mm .....
3 Stems glabrous; bracts up to 1/2 as long as calyx; inflorescence lax dichasial clusters..... ***B. huber-morathii***
3' Stems glandular and eglandular hairy; bracts 2/3 or as long as calyx; inflorescence dense dichasial subcapitate subsessil clusters .....
4 Stems long eglandular hairs; calyx teeth 0.7–1 mm; petals white without purple veins..... ***B. minuartioides***
4' Stems densely glandular and eglandular hairs; calyx teeth 1–1.5 mm; petals white with purple veins.....
5 Leaves linear, 3-vained; calyx 3.5–4.5 mm long; petals 3.3–4.5 mm long, as long as calyx..... ***B. turcicus***
5' Leaves subulate, 1-vained; calyx 4.5–5.5 mm long; petals 5.5–6.5 mm long, 1.5 times longer than calyx ..... ***B. spergulifolius***

Specimens examined

TURKEY - ***B. mevlanae***, C3 Antalya: Between Akseki and Bozkır, 45 km, Gölcük, 1780 m, 16.07.1997, Aytaç 7733 (GAZI!); C3 Antalya: Between Bozkır and Akören, 1100 m, 18.06.2013, Hamzaoğlu 6765 and Koç (Bozok Univ. Herb.) - ***Bolanthus huber-morathii***, A2 Bursa: Soğukpınar-Keles 1 km nach soğukpınar, 900 m, 08.07.1979 (GAZI!); B2 Kütahya: Tavşanlı district, around Arifler town, Koç 1757 and Kocakaya (Bozok Univ. Herb.) - ***B. spergulifolius***, B2 Uşak: Alma Dagh, N of Uşak, 1300 m, 1857, Balansa 1294 (K-000725786 photo!) - ***B. minuartioides***, C3 Konya: Derebucak, Çamlık town, 1300 m, 30.05.2005, Hamzaoğlu 3640 (Bozok Univ. Herb.); C3 Isparta: Keçiborlu, NW of Keçiborlu, 1250 m, 16.06.2013 Hamzaoğlu 6748 and Koç (Bozok Univ. Herb.); B3 Afyon: between İscehisar and Seydiler, 1150 m, 30.06.2012, Hamzaoğlu 6394 and Koç (Bozok Univ. Herb.); B3 Afyon: between İscehisar and Seydiler, 1150 m, 30.06.2012, Hamzaoğlu 6394 and Koç (Bozok Univ. Herb.) - ***B. frankenioides***, B2 Kütahya: İscehisar, 1150 m, 05.08.2012, Hamzaoğlu 6585 and Koç (Bozok Univ. Herb.!); B3 Afyonkarahisar: between Bayat and Iscehisar, 1500 m, 01.07.2010, Koç 1209 and Hamzaoğlu (Bozok Univ. Herb.!).

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Verbascum kurdistanicum (Scrophulariaceae), a new species from Hakkâri, Turkey

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Abstract

Verbascum kurdistanicum Fırat (Scrophulariaceae), is described and illustrated as a new species that is located in Hakkâri, Turkey. In this study, diagnostic morphological characters of this and closely related species (*V. oreophilum* K.Koch and *V. pyramidatum* M. Bieb) are discussed. Furthermore, distribution maps for the three taxa are provided.

Keywords

New species, Hakkâri , Turkey, *Verbascum*

Introduction

Verbascum L. (Scrophulariaceae) includes about 360 species distributed throughout the world (Heywood 1993). This genus in Turkey includes about 245 species, 129 hybrids and 6 imperfectly known or doubtful records. Its endemism ratio is very high with 193 (79%) species restricted to Turkey (Huber-Morath 1978, Davis et al. 1988, Vural and Aydoğdu 1993, Karavelioğulları et al. 2004, 2006, 2008a, 2009a, 2009b, 2011, 2014, Karavelioğulları 2012, Sutorý 2001, 2004, Özhatay 2006, Kaynak et al. 2006, Yilmaz and Dane 2008, Bani et al. 2010).

Verbascum is divided into two sections (Murbeck 1933, Huber-Morath 1971): *Aulacospermae* Murb. and *Bothrospermae* (Murb.) Kamelin. The seed morphology of their members is the most important character which differentiates the sections. They are transversely corrugated and alveolate in sect. *Bothrospermae*, whereas the seeds are

longitudinally corrugated in sect. *Aulacospermae*. Section *Bothrospermae* includes all Turkish *Verbascum* species.

The first revision of Turkish *Verbascum* for *Flora of Turkey* was carried out by Huber-Morath (1978). Thirteen species and six hybrids were later described (Vural and Aydoğdu 1993, Karavelioğulları et al. 2004, 2006, 2008a, 2009a, 2011, 2014, Karavelioğulları 2012, Sutorý 2001, 2004, Özhatay 2006, Kaynak et al. 2006, Dane and Yılmaz 2009, Dane and Yılmaz 2005, Yilmaz and Dane 2008, Karavelioğulları 2009b).

Materials and methods

During field exploration in Hakkâri province, Turkey in 2011, an unusual population of *Verbascum* was discovered. At first glance, because of having corolla and capsule with branched eglandular hairs, glandular-hairy inflorescence and distinctly crenate lower leaves it seemed to be similar to *V. oreophilum* and *V. pyramidatum*. The specimens were cross-checked with the keys provided by Huber-Morath (1978, 1981) and the *Verbascum* accounts given in various relevant publications such as Fedchenko (1955), Feinbrun-Dothan (1978a, 1978b), Meikle (1985), Boulos (2009) and Ekim (2000). Herbarium specimens from VANF, GAZI, ANK, G and GB herbaria were also examined and compared. The threat category assessment of the new species was defined according to IUCN criteria (IUCN 2001).

Taxonomy

***Verbascum kurdistanicum* Fırat, sp. nov.**
urn:lsid:ipni.org:names:77148112-1
Figs 1–2

Type. TURKEY. **C9 Hakkâri**: Berçelan Plateau, 37°40’57”N, 043°43’21”E, 2600–2800 m, limestone rocks and steppe, 21 July 2011, *M. Fırat.* 27584. (Holotype: VANF, Isotype: ANK, GAZI, HUB, VANF, E).

Diagnosis. *Verbascum kurdistanicum* differs from *V. oreophilum* and *V. pyramidatum* by being biennial; having 8-30 (incl. petiole) × 2.5-4.5 cm, lanceolate, crenate basal leaves; linear-lanceolate calyx lobes; 4 stamens; two anterior filaments that are glabrous near apex; 10-15 × 6-8 mm, ovate to oblong capsule.

Description. Biennial, 35–170 cm, densely stellate below, sparsely stellate, densely stalked glandular above. Stem robust, terete, erect, branched. Basal leaves 8–30 (inc. petiole) × 2.5–4.5 cm, mostly congested at base, densely rosulate, lanceolate, entire, distinctly undulate, obtuse, gradually attenuate at base. Cauline leaves 2.5–4 × 0.5–1 cm, oblong-lanceolate, entire, acute, decreasing in size towards the inflorescence racemose, ascending-erect. Bracts 2–3 × 1–2 mm, ovate-lanceolate, entire, acute, each bract with a solitary flower. Pedicels 5–10 mm. Bracteoles absent. Calyx 3–10 mm,

Figure 1. *Verbascum kurdistanicum* Fırat: **a** habit **b** corolla **c** capsule.

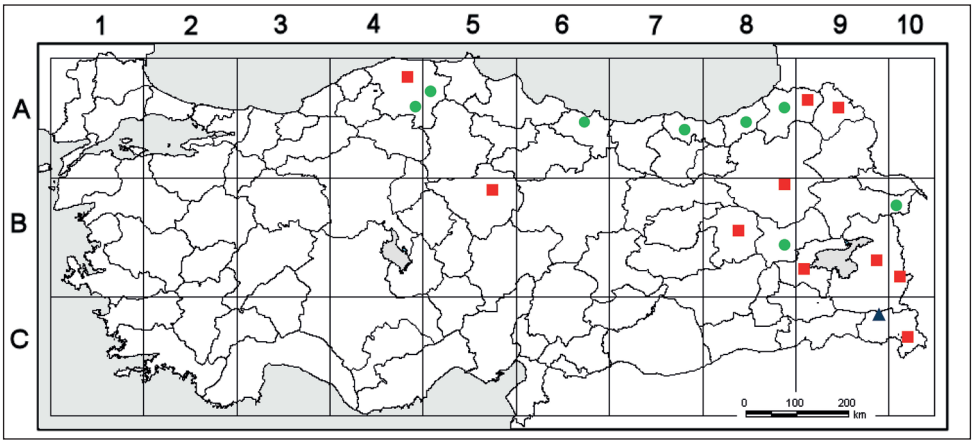

Figure 2. Distribution map of *V. kurdistanicum* (▲) and also closely related species *V. oreophilum* (■) and *V. pyramidatum* (●).

divided almost to base, with linear-lanceolate acute lobes. Corolla 20–30 mm diam, yellow, tube 1–2 mm, with unequal and orbicular lobes, without pellucid-punctate glands, with sparsely stalked glandular, stellate outside. Stamens 4, 6–8 mm, filaments 5–6 mm, with purple-violet wool, two anterior glabrous near apex, anthers 1–2 mm, reniform. Ovary ovate. Style 5–7 mm, filiform. Stigma spathulate. Capsule 10–15 × 6–8 mm, ovate, densely stellate hairs, rarely soon glabrescent.

Flowering time June-July and Fruiting time July-August, *limestone rocks and steppe,* 2600–2800 m.

Vernacular name. In Hakkâri Province, indigenous people use the name "Masî-jark" for *Verbascum* (Fırat 2013).

Examined representative specimens:

***Verbascum oreophilum*: Turkey. C10 Hakkari:** Van-Hakkâri 113. km, c. 2400 m, 19 July 1956, alpine meadow, *H.Birand & K.Karamanoğlu 471* (ANK).

Other herbarium materials of *Verbascum oreophilum* and *Verbascum pyramidatum* which were collected from Turkey have been examined. VANF, GAZI, ANK, G and GB herbarium have been visited for representative specimens.

Red list assessment: The extent of occurrence for *Verbascum kurdistanicum* was less than 100 km^2 (approximately between 10–20 km^2). 304 mature individuals have been counted. This species was found in a single location. It grows in limestone rocks and steppe. Its habitat continues to decline because of agricultural activities and other local uses. Hence, the threat category of *Verbascum kurdistanicum* is suggested as CR [B1ab (i, ii, iii) + 2ab (i, ii, iii)].

Results and discussion

Because of having 4 stamens, *Verbascum kurdistanicum* belongs to the group A according to the Flora of Turkey (Huber-Morath 1978, Davis et al. 1988). This group comprises 30 species with the addition of *Verbascum kurdistanicum*.

Verbascum kurdistanicum is morphologically similar to *V. oreophilum* and *V. pyramidatum* because of having the corolla and capsule with branched eglandular hairs; glandular-hairy inflorescence and distinctly crenate lower leaves, but differs from being biennial; having different basal leaves; stamen; flaments and capsule (Table 1).

Table 1. Diagnostic characters of *Verbascum kurdistanicum* compared with the related *V. oreophilum* and *V. pyramidatum*.

Characters	*V. kurdistanicum*	*V. oreophilum*	*V. pyramidatum*
Plant	Biennial, 35–160 cm	Perennial, 60–160 cm	Perenial, 45–150 cm
Basal leaves	8–30 (incl. petiole) × 2.5–4.5 cm, lanceolate, crenate	10–40 × 5–20 cm, lanceolate-oblong to ovate-elliptic coarsely crenate or bi crenate, more rarely dentate-lobed	7–40 × 3–15 cm, lanceolate-oblong to obovate, coarsely bicrenate, crenata-dentate or weakly lobed
Calyx	lobes linear-lanceolate	lobes oblong	lobes oblong
Stamens	4	4-rarely 5	5-rarely 4
Filaments	two anterior glabrous near apex	two anterior woolly to anthers or glabrous near apex	all woolly
Capsule	10–15 × 6–8 mm, ovate to oblong	4–6 × 3–5.5 mm, ellipsoid-ovate or subglobose	4–8 × 3–5 mm, broadly elliptic to ovate

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RESEARCH ARTICLE

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Rhizophora mucronata var. *alokii* – a new variety of mangrove species from the Andaman and Nicobar Islands, India (Rhizophoraceae)

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Abstract

Rhizophora mucronata var. *alokii* (Rhizophoraceae), a new variety of *Rhizophora* from the Andaman and Nicobar Islands, India, is described and illustrated. The new variety is remarkable in having four stamens, laterally folded leaves, a short peduncle, thick leathery petals, and a four-sided ovary with a sessile style. A key for the species of *Rhizophora* of the Andaman and Nicobar Islands is also provided.

Keywords

Rhizophoraceae, *Rhizophora mucronata* var. *alokii*, new variety, Andaman and Nicobar Islands, India

Introduction

The genus *Rhizophora* is the most common mangrove genus worldwide. Two species (*R. mangle* L. and *R. racemosa* G. Mey) and one natural hybrid (*R.* × *harrisonii* Leechm.) are restricted to the Atlantic-East Pacific Region, three species (*R. apiculata* Blume, *R. mucronata* Lam., and *R. stylosa* Griff.) and four named natural hybrids (*R.* × *annamalayana* Kathiresan, *R.* × *lamarckii* Montrouz, *R.* × *selala* (Salvoza) Toml., and *R.* × *tomlinsonii* Duke) are restricted to the Indo-West Pacific (IWP) region, and one species (*R. samoensis* (Hochr.) Salvosal) extends into both regions (Duke and Bunt 1979, Duke 1992, Duke et al. 1998, Duke 2002, Duke 2010). In addition, Ng et al. (2013) recognized an

unnamed hybrid between *R. mucronata* and *R. stylosa* through molecular studies. All the IWP taxa except *R. samoensis* and *R.* × *selala* are known from India (Ragavan et al. 2011).

The mangroves of the Andaman and Nicobar Islands (ANI) are denser and more diverse compared to other mangrove habitats in India (Mandal and Naskar 2008). According to the latest estimate by the Forest Survey of India (FSI 2013), the total mangrove area is approximately 4,628 km^2 in India, of which 604 km^2 occurs in the ANI. A total of 38 mangrove species has been recorded from the ANI. These include five *Rhizophora* taxa (*R. apiculata*, *R. mucronata*, *R. stylosa*, *R.* × *lamarckii* and *R.* × *annamalayana*; Ragavan et al. 2011).

During a recent botanical excursion, an interesting population of *Rhizophora* was encountered in the mangrove forest of Austin Creek, North Andaman. Specimens were collected and did not match any of the known species of the genus and hence have been described and illustrated here as new.

Materials and methods

To better assess the taxonomic placement and distinguishing characteristics of the new taxon, a morphometric analysis of the *Rhizophora* taxa present in ANI was performed. Seventeen attributes of leaves, inflorescences and flowers (Table 1) were examined for each taxon. The dataset was used for cluster analysis with Primer-e software (Version 6). Results of the cluster analysis were then used to select the taxon morphologically most similar to the new entity. T-tests were used to determine which attributes differed significantly between the two taxa. A key for the *Rhizophora* species of Andaman and Nicobar Islands has also been provided to facilitate identification.

Results

The morphometric analysis shows that *R. mucronata* var. *alokii* has closest similarity with *R. mucronata* than to other *Rhizophora* taxa (Fig. 1). However, attributes such as leaf length, length-width ratio, petiole length, peduncle length, number of flowers and stamen number are significantly different ($p < 0.05$) between the two taxa (Table 1).

Taxonomic treatment

***Rhizophora mucronata* var. *alokii* P.Ragavan, var. nov.**
urn:lsid:ipni.org:names:77148139-1

Material. India. North Andaman: Austin Creek, mangrove forest (Fig. 2A), 12°52'36.9"N, 92°50'40.2"E, 3 April 2014, leg. P. Ragavan, PBL 31001 and 31002 (holotype: PBL).

Table 1. Characters used for classification analysis of *Rhizophora* species of the ANI; average value (range) in cm for each taxon. Where no range is included, the values for the taxon showed no variation. Values that differ significantly ($p < 0.05$) between the varieties of R. mucronata are marked with an asterisk.

Characters	*R. apiculata*	*R. mucronata* var. *mucronata*	*R. mucronata* var. *alokii*	*R. stylosa*	*R.* × *annamalayana*	*R.* × *lamarckii*
Leaf length	13 (8.5–16.2)	13.55* (8.5–18)	11.29* (7–13)	11.1 (8–13)	12.39 (10–16)	13.08 (8–16)
Leaf width	5.9 (4–8.5)	8.47 (5.7–11.3)	6.71 (4–8.5)	5.68 (4–6.3)	7.4 (6–12)	6.45 (4.5–8.5)
Leaf length width ratio	2 (1.7–3.12)	1.6* (1.4–1.8)	1.69* (1.43–1.79)	2.02 (1.8–2.8)	1.67 1.4–1.7	2 (1.79–2.2)
Leaf mucro length	0.4 (0.4–0.5)	0.5 (0.4–0.6)	0.45 (0.4–0.5)	0.5 (0.4–0.6)	0.34 (0.3–0.5)	0.45 (0.4–0.5)
Petiole length	1.8 (1.4–2.5)	2.61* (1.5–3)	2.22* (1.5–3)	3.35 (2–3.5)	2.17 (1.8–2.5)	2.39 (1–3)
Petiole width	0.2 (0.2–0.3)	0.31 (0.3–0.5)	0.4 (0.3–0.5)	0.23 (0.3–0.4)	0.3 (0.3–0.4)	0.3 (0.3–0.4)
Number of flowers per inflorescences	2	5* (2–8)	4* (2–6)	5 (2–8)	2 (2–4)	2 (2–4)
Bud length	1.2 (1–1.6)	1.47 (1.2–1.6)	1.48 (1.4–1.6)	1 (0.7–1.2)	1.5 (1.4–1.6)	1.65 (1.5–1.7)
Bud width	1 (0.9–1)	0.8 (0.8–1)	0.79 (0.7–0.9)	0.43 (0.3–0.6)	1 (0.8–1.1)	0.8 (0.7–0.8)
Bud length width ratio	1.2 (0.9–14)	1.81 1.69–2.23	1.87 (1.74–2.28)	2.39 (1.81–2.51)	1.68 (1.2–1.81)	2.06 (1.79–2.32)
Peduncle length	1 (0.8–1)	3.15* (1.5–6)	2.72* (2–3.5)	3.9 (2.5–5.5)	1.3 (1.2–1.5)	1.85 (1–2.5)
Peduncle width	0.5 (0.4–0.6)	0.3 (0.3–0.5)	0.4 (0.3–0.5)	0.2 (0.2–0.3)	0.5 (0.4–0.5)	0.4 (0.3–0.4)
Petal length	0.8 (0.7–1)	0.8 (0.8–1)	1 (0.9–1.1)	0.8 (0.7–0.9)	1.2 (1–1.2)	1 (0.9–1.1)
Petal width	0.2 (0.2–0.3	0.3 (0.3–0.4)	0.4 (0.3–0.4)	0.3 (0.2–0.4)	0.4 (0.3–0.4)	0.3 (0.2–0.3)
Stamen number	12 (9–14)	8*	4*	8	12 (8–16)	12 (8 – 16)
Stamen length	0.8 (0.8–1.1)	0.7 (0.7–0.9)	0.7 (0.5–0.7)	0.5 (0.4–0.6)	0.8 (0.4–1)	0.6 (0.4–0.8)
Style length	0.1 (0.06–0.12)	0.1 (0.08–0.12)	0.1 (0.08–0.12)	0.4 (0.3–0.5)	0.12 (0.08–0.15)	0.3 (0.28–0.41)

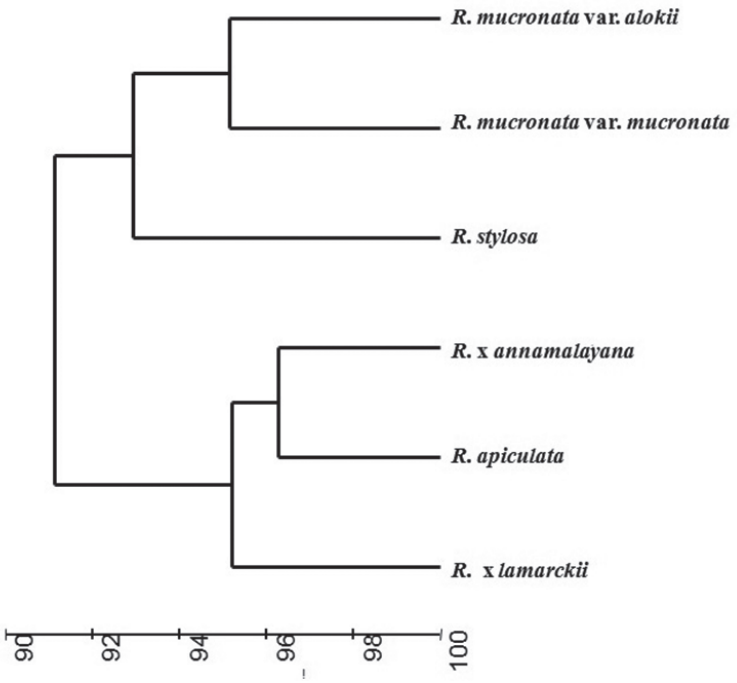

Figure 1. Cluster dendrogram (group average) showing similarity among the *Rhizophora* species of the ANI.

Tree: columnar to spreading, height to 20 m, evergreen (Fig. 2A). *Bark*: dark brown, friable, fissured horizontally (Fig. 2C). *Roots*: both stilt roots and aerial roots growing from lower branches, stilt roots are highly conspicuous arching above ground to 2 m (Fig. 2B). *Leaves*: simple, opposite, green to dark green, elliptical to broadly elliptical (Fig. 2D, E), laterally folded, underside with numerous dark spots, 7–13 × 4–8.5 cm, length to width ratio averaging 1.69 (not greater than 1.8), apex obtuse with pointed mucro, 0.4–0.5 cm long (Fig. 2F), base cuneate, margin entire; petiole green, 1.5–3 × 0.3–0.5 cm. *Inflorescences*: axillary, 2–6 flowered (Fig. 2G); bract and bracteoles minute (Fig. 2H); peduncle 2–3.5 × 0.3–0.5 cm; pedicel stout; *Mature flower*: ellipsoidal, creamy white (Fig. 2I), 1.4–1.6 × 0.7–0.9 cm, length to width ratio *ca*. 1.87, cross section slightly four-sided (Fig. 2J); calyx lobes 4, thicker than *R. mucronata*, yellowish white, apex acute; petals 4, thick, leathery, folded laterally, creamy white, velvety and hairy on the margin (Fig. 2L, N), 0.9–1.1 × 0.3–0.4 cm; stamens 4, 0.5–0.7cm long (Fig. 2M, N); style bilobed (Fig. 2O), 0.8–0.12 cm long, seated on four sided domed ovary (Fig. 2P). *Mature fruits*: pear-shaped, brown, 4–5 × 2.5–3.5 cm, calyx persistent with erect lobes (Fig. 2Q). *Mature hypocotyls*: 40–60 cm long, green, tip pointed, 1.5–1.7 cm wide at widest point (Fig. 2K); plumule green, 2–3 cm long.

Distribution. *Rhizophora mucronata* var. *alokii* is currently known only from Austin Creek, North Andaman, India.

Figure 2. *Rhizophora mucronata* var. *alokii* (**A**) habit (**B**) stem base with stilt roots (**C**) bark (**D**) branches (**E**) leafy branch end with flowers (**F**) leaf apex with mucro (**G**) inflorescence (**H**) minute bract at dichotomous inflorescence branch (**I**) mature bud with minute bracteole below calyx (**J**) cross section of bud (**K**) mature propagules (**L**) thick leathery petal (**M**) stamens (**N**) flower (**O**) pistil showing four-sided ovary (**P**) flower with one petal removed (**Q**) pear-shaped fruit (**R**) stamens with pollen.

Habitat and ecology. It grows in a mangrove forest along the banks in an intermediate estuarine position in association with *Rhizophora apiculata*, *R. mucronata* and *Ceriops tagal*.

Phenology. Flowering December to March; fruiting April to July.

Etymology. Named in honour of Dr. Alok Saxena (Principal Chief Conservator of Forests) for his inspiration and his outstanding contribution to mangrove conservation in the ANI.

Conservation status. *Rhizophora mucronata* var. *alokii* was collected only from Austin Creek (North Andaman Islands). At this site ca. 15 individuals were observed and hence it is assumed to be rare. At present, until further areas can be sampled the species can be accessed as "Data Deficient" (DD), using the criteria of IUCN (2001).

Discussion

Rhizophora species are very similar and can be difficult to distinguish (Lo 2003). The key distinguishing characters of *Rhizophora* spp. in the ANI are given in Table 2. The identification of *R. apiculata* is not problematic because it differs from the other species within its range in many characters, including having apiculate leaves with spinose mucronate tips, bi-flowered inflorescences borne on short peduncles below the leaves, short styles and a swollen, corky, brown bract below the calyx. However, dark spots are present on the leaf undersides of *R. apiculata* from India to southeast Asia and northern Papuasia; they are absent in southern Papuasia and northern Australia (Duke et al. 2002). The number of calyx lobes varies geographically; throughout most of the species range there are four lobes but in Australia there are three to six lobes (Duke et al. 2002).

Rhizophora hybrids are recognized by intermediate morphology and absence of advanced reproductive stages (Tomlinson 1986). Both *R.* × *lamarckii* and *R.* × *annamalayana* are distinguished from *R. apiculata* by their smooth green bract and 2-4 flowered inflorescences within the leaf axils. *Rhizophora* × *annamalayana* is distinguished from *R.* × *lamarckii* by its broader leaves (length: width ratio <1.8 *vs* >1.8), and shorter style (<1.5 mm *vs*. > 1.5 mm) and stamens in two whorls *vs*. usually in one single whorl.

Distinguishing *R. mucronata* and *R. stylosa* is often problematic. Style length is the main feature used to differentiate these taxa; Ragavan et al. (2011) showed that in *R. mucronata* the style is short and the ovary elongate and tapering, similar to that in *R. apiculata*, whereas in *R. stylosa* the style is long and ovary is short, although intermediates are found. The two species also differ in that *R. stylosa* has prominent, two-lobed bracts and bracteoles, smaller buds, obovate leaves, smaller fruits and shorter propagules.

All previously described *Rhizophora* species have eight or more stamens, whereas *R. mucronata* var. *alokii* has four stamens. *Rhizophora mucronata* var. *alokii* closely resembles *R. mucronata* var. *mucronata* in its minute bract and bracteoles, bark texture, and bud shape, but can be distinguished not only by stamen number but also by its dense foliage, laterally folded leaves, thick leathery petals with dense hairs, shorter peduncle,

Table 2. Diagnostic characters of *Rhizophora* species of the ANI. The hybrids do not produce seeds so hypocotyl characters are not present in them and therefore not included in the table.

Component	Attributes	*R. apiculata*	*R. mucronata* var. *mucronata*	*R. mucronata* var. *alokii*	*R. stylosa*	*R.* × *annamalayana*	*R.* × *lamarckii*
Leaves	Leaf shape	narrowly elliptic	ovate, broader at base	elliptic	narrowly obovate broader at apex	broadly elliptic	narrowly elliptic
	Leaf apex	acute	acute	obtuse	obtuse	acute	acute
	Leaf base	cuneate	broadly acute to rounded	cuneate	cuneate	cuneate	attenuate to cuneate
Inflorescences	Position relative to leaves	matures below	matures within	matures within	matures within	matures within	mature within
	Flower number	2	2–8	2–6	2–8	2–4	2–4
	Juncture number	1	1 to 3	1 to 3	1 to 3	1 to 2	1 to 2
	Bract condition	corky	smooth, minute	smooth, minute	smooth, conspicuous	smooth, swollen	smooth swollen
Mature flower bud(closed)	Bud length	1–1.6 cm	1.2–1.6 cm	1.4–1.6 cm	0.7–1.2 cm	1.4–1.6 cm	1.5–1.7 cm
	Bud width	0.9–1 cm	0.8–1 cm	0.7–0.9 cm	0.3–0.6 cm	0.8–1.1 cm	0.7–0.8 cm
	Shape x-section	rounded	rounded	slightly four- sided	rounded	four-sided	rounded
	Bud length /width ratio	1.2	1.81	1.87	2.39	1.68	2.06
	Petal x-section	flat	enclose stamens	thick folded	enclose stamens	curved	curved
	Petal margin	glabrous	Hairy	velvety hairy	hairy	slightly hairy	slightly hairy
	Style length	0.08–0.12 cm	0.08–0.12 cm	0.08–0.1 cm	0.3–0.4 cm	0.08–0.12 cm	0.2–0.4 cm
	Stamen number	9 to 14	8	4	8	8–16 in two whorls	8–16 in one whorls
Mature hypocotyls	Expanded fruit	cork -like	pear- like	pear- like	pear-like		
	Hypocotyl length	20–40 cm	50–80 cm	40–60 cm	21–35 cm		
	Distal shape	bluntly pointed	narrowly pointed	narrowly pointed	narrowly pointed		

and four-sided ovary. It can be difficult to distinguish var. *alokii* from var. *mucronata* without the presence of flowers. Differences in flowering time is likely to make this taxon reproductively isolated. A key to the ANI species of *Rhizophora* is given below.

Key to Rhizophora spp. of ANI

1 Peduncle shorter than petiole.....**2**
– Peduncle as long as or longer than petiole.....**4**
2 Mature flower bud and fruits below the leaves; inflorescences two-flowered; bract corky, brown; hypocotyl present ..... ***R. apiculata***
– Mature flower buds within the leaves; inflorescences 2-4-flowered; bract smooth and green; hypocotyls not present **3**
3 Leaves broadly elliptical; styles 0.8–1.2 mm long; stamens in two whorls, inner shorter; mature flower bud four-sided in cross-section ..... ***R.* × *annamalayana***
– Leaves narrowly elliptical; styles 2–3 mm long; stamens in one whorl; mature flower bud rounded in cross-section..... ***R.* × *lamarckii***
4 Stamens 4, petals thick and leathery, densely hairy ***R. mucronata* var. *alokii***
– Stamens 8; petals thin, hairy at margin **5**
5 Bract and bracteoles minute; style 1 mm long, seated on elongate, tapering ovary; hypocotyls 50–80 cm long ..... ***R. mucronata* var. *mucronata***
– Bract and bracteoles prominent, forming two-lobed, cup-like structure; style 3-4 mm, seated on short ovary; hypocotyls 20–40 cm long..... ***R. stylosa***

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RESEARCH ARTICLE

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A revision of infrageneric classification in *Astelia* Banks & Sol. ex R.Br. (Asteliaceae)

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Abstract

Systematic investigations and phylogenetic analyses have indicated that *Astelia*, as currently circumscribed, is paraphyletic, with *Collospermum* nested within it. Further, *A.* subgenus *Astelia* is polyphyletic, and *A.* subgenera *Asteliopsis* and *Tricella* are paraphyletic, as currently circumscribed. Revision of the subgeneric classification of *Astelia* is warranted to ensure classification accurately reflects the evolutionary history of these taxa. *Collospermum* is relegated to synonymy within *Astelia*. *Astelia* is dioecious or polygamodioecious, with a superior ovary, anthers dorsi- or basifixed, pistillodes or pistils that have a single short or poorly defined style, a 3 lobed stigma, and fleshy uni- or trilocular fruit with funicular hairs that are poorly to well developed. *Astelia* subgenus *Collospermum* (Skottsb.) Birch is described. A key to *Astelia* sections is provided. *Astelia hastata* Colenso, *A. montana* Seem., and *A. microsperma* Colenso *pro parte* are resurrected and the new combination *A. samoense* (Skottsb.) Birch, **comb. nov.** is made.

Keywords

Asparagales, Asteliaceae, Austral, Australia, dioecy, New Zealand, Pacific

Introduction

Astelia Banks & Sol. ex R.Br. is the largest genus in Asteliaceae Dumort., containing twenty-six species and three non-nominotypical varieties with an Austral-Pacific distribution. *Astelia* species exhibit a range of growth forms including low, cushion-forming and tall, clustered habits. *Astelia* species grow in a diverse range of habitats including

coastal, lowland wetlands, tropical and temperate lowland forests, tropical montane cloud forests, sub-alpine heath, alpine fellfields and grasslands, and bog habitats. Many *Astelia* species are facultatively epiphytic and three species are primarily epiphytic. *Collospermum* Skottsb. includes four species that occur in lowland forests and in lowland and tropical montane cloud forests in New Zealand, the Independent State of Samoa and the Republics of Fiji and Vanuatu. All species exhibit a tall, clustered habit and are primarily epiphytic, although plants that fall to the ground can persist for long periods.

Astelia and *Collospermum* share many morphological characters (Bayer et al. 1998, Rudall et al. 1998). All Asteliaceae genera have branched hairs that are otherwise uncommon in the Lilianae (Bayer et al. 1998) and those of *Astelia* and *Collospermum* are dense, at least in the young leaves of most species. The tomentum of *Astelia* and *Collospermum* consist of a multi-celled stalk, frayed unicellular filaments that form a basal wool adjacent to the stalk, and linear or ovate scales that are a single cell thick (McCarthy 1928, Skottsberg 1934, L. B. Moore 1980, Rudall et al. 1998). In *Astelia* the scales are linear, may be short or long, and the stalk is attached at the base of the scale. In *Collospermum*, the scales are ovate, short, and the stalk is peltate. Scales may be present on the adaxial and/or abaxial leaf surfaces, inflorescences, and flowers. On the leaves of *Astelia* species the scales may become fused to form a membranous pellicle over the leaf epidermis. *Astelia* and *Collospermum* have superior ovaries that are uni- or trilocular and trilocular, respectively. Published chromosome numbers for *Astelia* taxa range from $2n = 60$ to $2n = 210$ (Wheeler 1966, Dawson and Beuzenberg 2000, de Lange et al. 2004). Darlington and Wylie (1955) proposed a basic chromosome number for *Astelia* of $x = 8$, but Wheeler (1966) considered the basic chromosome number to be $x = 5$, 7, or 35. *Collospermum hastatum* and *C. microspermum* are the only *Collospermum* taxa for which chromosome numbers are known and both have a chromosome number of $n = 35$.

Skottsberg (1934) segregated *Collospermum* from *Astelia* based on the presence of simple lateral racemes, dimorphism of staminate and pistillate plants, basifixed anthers, long style papillae, and mucilaginous seed hairs of the former, which differ from the predominantly paniculate lateral racemes, versatile anthers, and poorly developed mucilaginous seed hairs of the latter (Birch unpublished PhD thesis 2011, Birch et al. 2012). However, morphological (Bayer et al. 1998, Birch unpublished PhD thesis 2011), cytological (Wheeler 1966, Moore 1980), and molecular (Birch unpublished PhD thesis 2011, Birch et al. 2012) data suggested a close evolutionary relationship between these genera. Moore (1980) considered that a re-evaluation of the circumscriptions of *Astelia* and *Collospermum* was warranted due to the production of viable progeny from intergeneric crosses. *Collospermum*, while monophyletic, was nested within *Astelia* in phylogenetic reconstructions based on combined chloroplast and nuclear sequence data applying Bayesian inference, maximum likelihood, and maximum parsimony criteria (Birch unpublished PhD thesis 2011, Birch et al. 2012). As a result, those authors recognized a broadly circumscribed *Astelia s.l.*, including *Collospermum*.

Within *Astelia*, Skottsberg (1934) recognized three subgenera (*A.* subg. *Astelia* Skottsb., *A.* subg. *Asteliopsis* Skottsb., and *A.* subg. *Tricella* Skottsb.) based on open or cushion-forming growth form, degree of tepal fusion, ovary division, and seed shape.

Within these subgenera, he recognized seven sections (*A.* sect. *Astelia* Skottsb., *A.* sect. *Desmoneuron* Skottsb., *A.* sect. *Isoneuron* Skottsb., *A.* sect. *Micrastelia* Skottsb., *A.* sect. *Palaeastelia* Skottsb., *A.* sect. *Periastelia* Skottsb., and *A.* sect. *Tricella* Skottsb.) based on leaf venation, pistillode size, seed surface features, and extent of funicle development. In phylogenetic analyses (Birch unpublished PhD thesis 2011, Birch et al. 2012), each of Skottsberg's (1934) sections, except *A.* sect. *Tricella*, were monophyletic, *A.* subg. *Astelia* and *A.* subg. *Asteliopsis* were polyphyletic, and *A.* subg. *Tricella* was paraphyletic. A revised circumscription of *Astelia* subgenera is proposed that accurately reflects the evolutionary relationships within the genus. *Collospermum* is relegated to synonomy under *Astelia*. Skottsberg's sections are retained as they are monophyletic and accurately capture the extensive morphological diversity that is present within the subgenera.

A revision based on recognition of monophyletic taxa is proposed here. Multiple characters support the proposed circumscription of *Astelia*. All taxa are dioecious or polygamodioecious, with a superior ovary, dorsi- or basifixed anthers, pistillodes or pistils that have a single short or poorly defined style, a 3 lobed stigma, and fleshy uni- or trilocular fruit with funicular hairs that are poorly to well developed.

Methods

Taxonomic sampling

All *Astelia* taxa, (twenty-six species and three non-nominotypical varieties) and all *Collospermum* (four species) were included in this study. Herbarium specimens were examined from the following herbaria: Auckland War Memorial Museum (AK), Herbarium Pacificum (BISH), Allan Herbarium (CHR), Harvard University (GH), Kew Royal Botanic Gardens (K), National Herbarium of Victoria (MEL), Missouri Botanical Garden (MO), Herbier National de Paris (P), National Tropical Botanical Garden (PTBG), United States National Herbarium (US), and Museum of New Zealand Te Papa Tongarewa (WELT). Type specimens were examined from AK, BISH, MEL, P, WELT and digital images of type specimens were examined from CHR and K (Herbarium abbreviations follow Index Herbariorum (Thiers continuously updated).

Morphological data and analyses

Morphological data were obtained for 410 herbarium specimens (Appendix 1). Data were obtained for ten specimens per species, including five staminate and five pistillate specimens for species with unisexual flowers. Measurements and scores were averaged across all specimens to give a mean value for each taxon. Flower and fruit color data were obtained from multiple sources including field observations, specimen label data, and taxon descriptions in national floras (Drake del Castillo 1893, L. B. Moore and Edgar 1976, Coode 1978, D. M. Moore 1983, Williams 1987, Wagner et al. 1999).

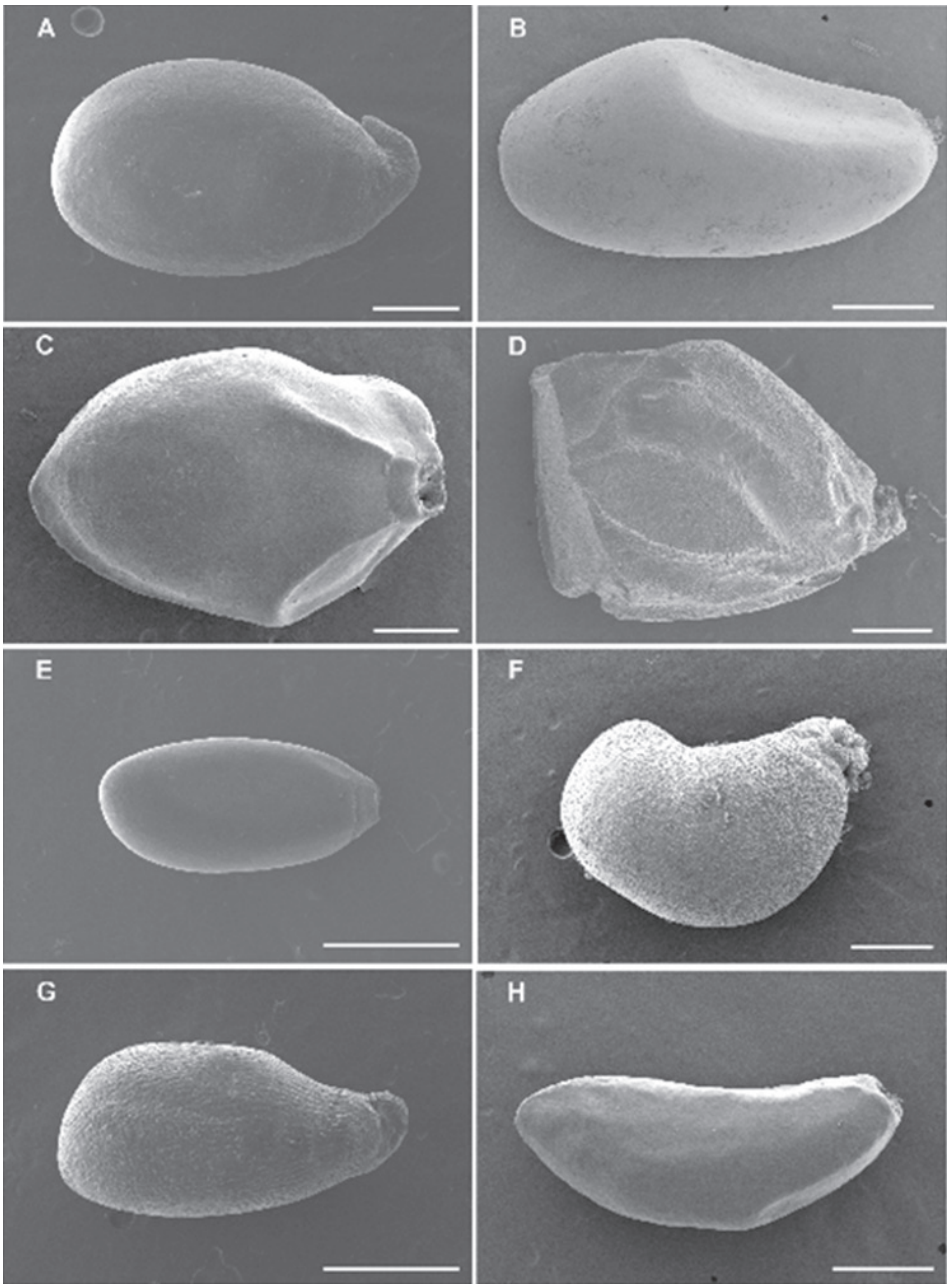

Figure 1. Scanning electron micrographs of *Astelia* seeds showing size, shape, and funicle characters. **A** *Astelia* (sect. *Astelia*) *linearis* var. *linearis*; ovoid, funicle long **B** *Astelia* (sect. *Tricella*) *petriei*; ovoid, funicle short **C** *Astelia* (sect. *Tricella*) *chathamica*; ovoid, funicle short **D** *Astelia* (sect. *Isoneuron*) *banksii*: polygonal-turbinate, funicle ribbed **E** *Astelia* (sect. *Micrastelia*) *pumila*; ovoid, funicle short **F** *Astelia* (sect. *Desmoneuron*) *solandri*; obovoid-reniform, funicle ribbed **G** *Astelia* (sect. *Isoneuron*) *neocaledonica*; obovoid, funicle ribbed **H** *Astelia* (sect. *Tricella*) *menziesiana*; fusiform, funicle short. Scale bars = 0.5 mm. SEM images created by J.L. Birch.

Morphological characters that varied at or below the genus rank were measured or scored for all *Astelia* and *Collospermum* taxa in the field and/or herbarium. Herbarium specimens were studied under a dissecting microscope and measurements obtained using digital calipers. Pollen and seed characters were examined directly from material obtained from herbarium specimens after coating with gold-palladium using a Hitachi S-4800 field emission scanning electron microscope (SEM) at the Biological Electron Microscope Facility, Pacific Biosciences Research Center of the University of Hawai'i at Mānoa. Images were digitally processed and the final plates were prepared in Photoshop 10.0.

Taxonomic treatment

Astelia Banks & Sol. ex R.Br.

Astelia Banks & Sol. ex R.Br., Prodr. 291. 1810. *nomen conservandum* (International Botanical Congress and JH Wiersema 2015). Type: *Astelia alpina* R.Br.

Funckia Willd., Mag. Neuesten Entdeck. Gesammten Naturk. Ges. Naturf. Freunde Berlin 2: 19. 1808, *nomen rejiciendum*. Type: *Funckia magellanica* Willdenow, *nomen illegitimum* (*Melanthium pumilum* G. Forster)

Hamelinia A.Rich., Voy. Astrolabe 1: 158. 1832. Type: *Hamelinia veratroides* A.Rich.

Note. Herbaceous perennials, terrestrial or epiphytic, often growing in clusters with three ramets in trigonal arrangement, some species turf-forming, rhizomatous, dioecious or polygamodioecious. Leaves: 3-ranked, linear, ensiform, or subulate; leaves usually keeled, margins erect or revolute; leaf sheath closed, with surface obscured by dense long white hairs; parallel venation, variously incrassate; tomentum composed of scales and lanate wool at base of scale stalk, scales with basal stalk or peltate. Inflorescence: a terminal panicle, sometimes reduced to a few flowers; lateral branches racemes or sub-panicles, subtended by foliaceous or membranous, linear or lanceolate spathes; peduncle tomentum composed of distinct, narrow scales with dense basal wool. Flowers: pedicillate; bracts membranous, linear or spathulate; perianth membranous or fleshy, 6 tepals in 2 series; connate at base into tube of variable length; outer tepals triangular to lanceolate, with three veins, scales present over entire surface; inner tepals linear with one midvein, scales present along midvein only. Staminate flowers: lobes recurved; stamens 6; filaments filamentous, adnate to tepals at base of tepal lobes; anthers elliptic or linear-hastate, dorsifixed and versatile or basifixed and immobile, latrorse; pistillode present, style undifferentiated or distinct; stigma not formed. Pistillate flowers: 6 reduced staminodes present, adnate to base of tepal lobes, filament filamentous, anthers flattened, sterile; ovary superior, uni- or trilocular, placentation parietal from three placentas or axile, with subapical placentas, ovules few to many; style distinct or undifferentiated, stigmas 3. Fruit: berry, stigma typically persistent. Seeds: black, obovoid, ellipsoid, fusiform, or polygonal; testa smooth or sculptured; funicle with mucilaginous funicular hairs poorly or well developed, funicle hairs surrounding the seeds and either adhering to the testa or not.

Astelia Banks & Sol. ex R.Br. subg. *Astelia*

Note. Flowers with a very short perianth tube (0.1–0.8 mm); anthers dorsifixed, versatile; ovary unilocular; seeds ovoid; funicle long, curved, with mucilaginous funicular hairs poorly developed that surround but do not adhere to the seed.

Remarks. Molecular (Birch et al. 2012) and morphology-based phylogenetic analyses (Birch unpublished PhD thesis 2011) indicate that *A.* subg. *Astelia*, as circumscribed by Skottsberg (1934), is polyphyletic. *Astelia* subg. *Astelia* is revised to include *A.* sect. *Palaeastelia* and *A.* sect. *Astelia*, which form a clade. *Astelia* sect. *Desmoneuron* is placed in a different clade and it is excluded from *A.* subg. *Astelia*.

Astelia sect. *Astelia*

Note. Low, compact, growth form (including cushion or turf forming taxa); leaves, linear, ensiform, or subulate; reduced inflorescences bearing few flowers; staminate flowers with short filaments (0.5–1.6 mm); pistillate flowers with long outer tepals (4.5–7.0 mm); ovary unilocular, long (4.3–8.3 mm); fruit ovoid or oblong; few or many seeds per fruit (< 25), seeds short and narrow (1.1–2.0 × 0.5–1.3 mm).

Included taxa and distribution. Australia *A. alpina* R.Br. var. *alpina*, *A. alpina* var. *novae-hollandiae* Skottsb. Indonesia (Papua Province), Papua New Guinea *A. papuana* Skottsb.. New Zealand *A. linearis* Hook.f. var. *linearis*, *A. linearis* var. *novaezelandiae* Skottsb., *A. subulata* Cheeseman

Habitat. Lowland (low latitudes) to sub-alpine (mid and higher latitudes) herbfields particularly on wet substrates (seeps, swamps etc.).

Astelia sect. *Palaeastelia* Skottsb.

Astelia sect. *Palaeastelia* Skottsb., Kongl. Svenska Vetenskapsakad. Handl. ser. 3, 14(2): 24. 1934.

Note. Open growth form; leaves linear; large inflorescences bearing many flowers; staminate flowers with intermediate length filaments (1.7–4.6 mm); pistillate flowers with short outer tepals (2.3–4.4 mm); ovary unilocular, intermediate length (3.2–4.2 mm); fruit ovoid, many seeds per fruit (< 20); seed intermediate length and narrow (2.4–2.9 × 1.2–1.3 mm). Type: *A. hemichrysa* (Lam.) Kunth.

Included species and distribution. Mascarene Islands, Réunion Island. *A. hemichrysa* (Lam.) Kunth

Habitat. Tropical forest.

Astelia subg. *Asteliopsis* Skottsb.

Astelia subg. *Asteliopsis* Skottsb., Kongl. Svenska Vetenskapsakad. Handl. ser. 3, 14(2): 46. 1934.

Note. Flowers with a short perianth tube (0.2–1.1 mm); anthers dorsifixed, versatile; ovary uni- (*A.* sect. *Desmoneuron*) or trilocular (*A.* sect. *Isoneuron*); seeds obovoid, obovoid-reniform, or turbinate-polygonal; funicle ribbed, mucilaginous funicular hairs well developed that surround but do not adhere to the seed; Type: *A. trinervia* Kirk, designated here.

Remarks. Phylogenetic analyses indicate that *A.* subg. *Asteliopsis*, as circumscribed by Skottsberg (1934), is polyphyletic (Birch unpublished PhD thesis 2011, Birch et al. 2012). *Astelia* subg. *Asteliopsis* is revised to include *A.* sect. *Isoneuron* and *A.* sect. *Desmoneuron*, which form a clade. But, as *A.* sect. *Periastelia*, is placed in a different clade, it is excluded from *A.* subg. *Asteliopsis.*

Astelia sect. *Desmoneuron* Skottsb.

Astelia sect. *Desmoneuron* Skottsb., Kongl. Svenska Vetenskapsakad. Handl. ser. 3, 14(2): 34. 1934.

Note. Open growth form; leaves linear with a group of three subequal lateral nerves conspicuous in lower half; inflorescences bearing many flowers; staminate flowers with short filaments (0.6–2.1 mm); pistillate flowers with short outer tepals (1.9–4.2 × 0.7–1.8 mm); ovary unilocular, short (1.3–2.8 mm); fruit ampulliform, many seeds per fruit (8–32); seeds short and narrow (1.4–1.8 × 0.5–1.0 mm). Type: *A. trinervia* Kirk, designated here.

Included species and distribution. New Zealand: *A. solandri* A.Cunn., *A. trinervia* Kirk. Society Islands, Tahiti: *A. nadeaudii* Drake & F.Br.

Habitat. Temperate forest (*A. solandri* and *A. trinervia*) and tropical montane cloud forest (*A. nadeaudii*).

Astelia sect. *Isoneuron* Skottsb.

Astelia sect. *Isoneuron* Skottsb., Kongl. Svenska Vetenskapsakad. Handl. ser. 3, 14(2): 51. 1934.

Note. Open growth form; leaves linear; inflorescences bearing many flowers; staminate flowers with short filaments (0.6–1.9 mm); pistillate flowers with short outer tepals (2.7–4.0 × 0.7–2.0 mm); ovary trilocular, intermediate length (2.2–4.4 mm); fruit ovoid, many seeds per fruit (11–18); seeds small and narrow (1.3–2.2 × 0.8–1.4 mm). Type: *A. banksii* A.Cunn., designated here.

Included species and distribution. New Caledonia: *A. banksii* A.Cunn., *A. neocaledonica* Schltr.

Habitat. Lowland coastal cliffs (*A. banksii*) and lowland tropical forest (*A. neocaledonica*).

Astelia subg. *Collospermum* (Skottsb.) Birch, stat. nov.

urn:lsid:ipni.org:names:77148154-1

Basionym: *Collospermum* Skottsb., Kongl. Svenska Vetensk. Acad. Handl. Ser. 3, 14(2): 72. 1934. Type: *Collospermum hastatum* (Colenso) Skottsb. [Lectotypified by Moore and Edgar (1976)].

Note. Open growth form; leaves linear or ensiform with dark coloration at base and peltate branched hairs; inflorescences bearing many flowers; flowers with a long perianth tube (1.3–3.1 mm); staminate flowers with long filaments (3.8–8.6 mm), anthers basifixed, immobile; pistillate flowers with long outer tepals (1.5–6.2 × 0.9–1.6 mm); ovary trilocular, intermediate length (2.1–4.8 mm); fruit globose or obpyriform, with few to many seeds per fruit (1–22); seeds ellipsoid or ovoid, small and narrow (1.3–2.1 × 0.1–1.1 mm); funicle short, truncate, with well-developed mucilaginous funicular hairs that adhere to the seed.

Remarks. Species published under *Collospermum* must be transferred as *Astelia* has nomenclatural priority. Synapomorphies recognized for the genus *Collospermum* (Skottsberg 1934) remain valid for *A.* subg. *Collospermum*.

Included species and distribution. New Zealand: *A. hastata* Colenso, *A. microsperma* Colenso *pro parte*. Republic of Fiji, Viti Levu, Vanua Levu, Kandavu; Republic of Vanuatu, Espiritu Santo, Tanna, Aneityum: *A. montana* Seem. Independent State of Samoa, Savai'i, Upolu: *A. samoense* (Skottsb.) Birch.

Habitat. Lowland temperate forest (*A. hastata* and *A. microsperma*) and montane tropical cloud forest (*A. montana* and *A. samoense*).

Astelia hastata Colenso

Astelia hastata Colenso, Trans. & Proc. New Zealand Inst. 19. 265. 1887.

Funckia hastata Kuntze, Revis. Gen. Pl. 2: 711. 1891, *nomen rejiciendum*.

Astelia furfuracea Banks et Solander MSS, *fide* C. Skottsberg, Kongl. Svenska Vetensk. Acad. Handl. Ser. 3, 14(2): 77. 1934.

Collospermum hastatum (Colenso) Skottsb., Kongl. Svenska Vetensk. Acad. Handl. Ser. 3, 14(2): 77. 1934; based on *A. hastata* Colenso.

Type. NEW ZEALAND. North Island. Hilly country north of Napier, County of Wairoa. January 1886, *A. Hamilton s.n.* (Lectotype: K [000524883, digital image!], staminate, designated by Skottsberg, 1934, 79; Isolectotypes: K [000524884, digital image!], staminate, pistillate; AK [3191!], staminate, pistillate).

Astelia microsperma* Colenso *pro parte

Astelia microsperma Colenso *pro parte*, Trans. & Proc. New Zealand Inst. 17: 251. 1885 (description of fruit only). Type: NEW ZEALAND. North Island. Seventy-mile Bush, between Norsewood and Danniverke, County of Waipawa. 1884, *W. Colenso s.n.* (Lectotype: K [000524879, digital image!], fruiting material in packet, designated by Skottsberg, 1934, 81).

Collospermum microspermum Skottsb., Kongl. Svenska Vetensk. Acad. Handl. Ser. 3, 14(2): 82. 1934; based on *A. microsperma* Colenso.

Funckia microsperma Kuntze, Revis. Gen. Pl. 2: 711. 1891, *nomen rejiciendum*.

Astelia albicans Colenso, Trans. & Proc. New Zealand Inst. 17: 252. 1885. Type: NEW ZEALAND. North Island. East slopes of Ruahine mountain range, county of Waipawa. Jan. 1884, *A. Hamilton s.n.* (Syntype: K [000524880, digital image!], staminate, pistillate). Skottsberg (1934, 88) identified a single specimen at K as the type material and the specimen in his plate 20 (K000524880) is consistent with the specimen described as the type. As *Astelia* is dioecious, the inclusion of one staminate and one pistillate inflorescence on the specimen means that it represents two distinct collections and each is rendered a syntype.

Funckia albicans Kuntze, Revis. Gen. Pl. 2: 711. 1891, *nomen rejiciendum*.

Astelia graminifolia Colenso, Trans. & Proc. New Zealand Inst. 19: 267. 1887. Type: NEW ZEALAND. North Island. Woods, hilly country north of Napier, County of Wairoa, 1886, *A. Hamilton s.n.* (Lectotype: K [000524881, digital image!], pistillate, designated by Skottsberg, 1934, 85).

Funckia graminifolia Kuntze, Revis. Gen. Pl. 2: 711. 1891, *nomen rejiciendum*.

Astelia planifolia Colenso Trans. & Proc. New Zealand Inst. 20: 209-210. 1888. Type: NEW ZEALAND. North Island, Pohue, hilly country west of Napier, Hawke's Bay. 1884. *A. Hamilton s.n.*; no specimens located.

Remarks. *Astelia microsperma* was described by Colenso based on a specimen at Kew that contained material from two species (Skottsberg 1934). The species description "referred to both, but mainly to the pistillate raceme in the envelope" (Skottsberg 1934, 82). Skottsberg (1934) lectotypified the fruiting material in the packet (K000524879) as the type material of *A. microsperma* (as syn. *C. microspermum*) and determined the remaining material on the specimen (K000524882) as *A. hastata* (as syn. *C. hastatum*).

Excluded species. *Astelia spicata* Colenso, Trans. & Proc. New Zealand Inst. 14: 335. 1882, *nomen illegitimum.* Type: NEW ZEALAND. North Island. In the forests about Kopua and Norsewood, *Colenso*. (Lectotype: K [000524878, digital image!], pistillate, designated by Skottsberg, 1934, 81). Moore (1966) regarded the type and other specimens examined to represent very small individuals of either *A. hastata* or *A. microsperma*.

Collospermum spicatum (Colenso) Skottsb., Kongl. Svenska Vetensk. Acad. Handl. Ser. 3, 14(2): 80. 1934; based on *A. spicata* Colenso *nomen illegitimum*.

Astelia nana Carse, Trans. & Proc. New Zealand Inst. 57: 91. 1926, *nomen illegitimum*. Type: NEW ZEALAND. North Island. Kaiaka (Mangonui County), Maungatapere (Whangarei County), Mauku (Franklin County), *H. Carse s.n.*; synonym of *A. spicata* Colenso *nomen illegitimum*. This is regarded by Skottsberg (1934) as a synonym of *Astelia spicata* Colenso *nomen illegitimum*. (Syntypes: CHR [328212, digital image!], staminate, pistillate; [328213, digital image!), pistillate; AK [3227!], pistillate; [3228!], pistillate; [222913!], staminate; [303282!], pistillate).

Funckia spicata Kuntze, Revis. Gen. Pl. 2: 711. 1891, *nomen rejiciendum*.

Astelia montana Seem.

Astelia montana Seem., Fl. Vit. [Seemann] 313, figs 1–6, pl. 95, 1865, non Reinecke 1898, nec Rechinger 1908. Type: FIJI ISLANDS. Kadavu, summit of Mbuke Levu mountain. *Seemann 641*. (Holotype: K [000524876, digital image!], pistillate; Isotypes: K [000524875, digital image!], vegetative; GH [00029835, digital image!], pistillate; BM [000990536, digital image!], pistillate).

Collospermum montanum (Seem.) Skottsb., Kongl. Svenska Vetensk. Acad. Handl. Ser. 3, 14(2): 73. 1934; based on *Astelia montana* Seem.

Funckia montana Kuntze, Revis. Gen. Pl. 2: 711. 1891, *nomen rejiciendum*.

Remarks. Seemann stated in the preface of *Flora Vitiensis* (1965, iv) that "the first set of specimens collected by me were deposited at the Royal Herbarium, Kew and from these the plates accompanying this work have chiefly been taken". The type material of *A. montana*, which was effectively published in *Flora Vitiensis*, can reasonably be expected to have been accessioned at Kew. Two sheets containing *Astelia montana* specimens collected by Seemann are accessioned at K. One sheet (K000524875) includes a vegetative plant collected at Mt. Mbuke Levu and a second sheet (K000524876) includes a leaf fragment annotated as collected at "Vuna, June 1860" and a pistillate inflorescence labeled as collected by Seemann (n. 641) in 1860. Sheet K000524876 includes the illustrations of the pistillate flower, staminode, berry and seed that appear in the plate that accompanies the protologue of *A. montana* (Seemann 1965).

The pistillate inflorescence labeled as Seemann's collection n. 641 on sheet K000524876 represents the holotype. According to Seemann's (1962, 1965) accounts of his field collections, he successfully ascended Mt. Mbuke Levu only once, on 6 September 1860. The vegetative specimen on sheet K000524875 was also collected by Seemann on "Buke Levu" [*sic*]. A type specimen can be mounted on multiple sheets "as long as the parts are clearly labeled as being part of that same specimen" (International Botanical Congress and JH Wiersema 2015); Article 8.3). Although it is likely that sheets K000524875 and K00524876 represent a single specimen that was mounted on separate sheets (Birch pers. comm., Smith 1979), they were not clearly labeled as such. Therefore, K000524875 is considered a duplicate. The leaf fragment

on sheet K000524876 annotated as collected in "Vuna June 1860" may represent a fragment of an earlier collection from Vuna on the island of Taveuni (Smith 1979) where Seemann spent time during June 1860 (Seemann 1962).

***Astelia samoense* (Skottsb.) Birch, comb. nov.**
urn:lsid:ipni.org:names:77148140-1

Basionym: *Collospermum samoënse* Skottsb., Kongl. Svenska Vetenskapsakad. Handl. ser. 3, 14(2): 75. 1934. Syntypes: SAMOA ISLANDS. Upolo, 7 July, 1905, *F. Vaupel n. 356* (staminate); Aug. 1905, *K. & L. Rechinger n. 4334* (pistillate).

Astelia montana ex Reinecke, Die Flora der Samoa-Inseln. in Bot. Jahrb. Syst. vol. 25. 595. 1898; based on *A. montana* Seem.

Astelia montana ex Rechinger, Vegetationsbilder, series 6, issue 1. tafel 6. 1908; based on *A. montana* Seem.

Remarks. Two specimens were identified by Skottsberg (1934) as types in the list of specimens examined. This included a staminate specimen (Vaupel 356 noted by Skottsberg (1934) as accessioned at HBG) and a pistillate specimen (K. and L. Rechinger n. 4334 noted by Skottsberg (1934) as accessioned at W). The pistillate specimen of Rechinger is not extant at W (pers. comm. A. Löckher, Department of Botany at Naturhistorisches Museum Wien). Efforts are underway to locate type material of *A. samoense* held in herbaria globally.

Diacritical signs, which should be suppressed in species names (International Botanical Congress and JH Wiersema 2015; Article 60.6) have not been transferred from *Collospermum samoënse*.

***Astelia* subg. *Tricella* Skottsb.**

Astelia subg. *Tricella* Skottsb., Kongl. Svenska Vetenskapsakad. Handl. ser. 3, 14(2): 58. 1934.

Note. Flowers with a short (*A.* sect. *Periastelia*) or long (*A.* sect. *Tricella*) perianth tube (0.3–3.5 mm); anthers dorsifixed, versatile; seeds ellipsoid, fusiform, or ovoid; funicle short, truncate, mucilaginous funicular hairs poorly developed; Type: *A. nervosa* Banks & Sol. ex Hook.f., designated here.

Remarks. *Astelia* subg. *Tricella* is revised to include both *A.* sect. *Tricella* and *A.* sect. *Periastelia*, which form a well supported clade in phylogenetic analyses (Birch unpublished PhD thesis 2011, Birch et al. 2012). *Astelia* sect. *Periastelia* is monophyletic; however *A.* sect. *Tricella* is present as a grade and relationships within each of these sections remain equivocal.

Astelia sect. *Tricella* Skottsb.

Astelia sect. *Tricella* Skottsb., Kongl. Svenska Vetenskapsakad. Handl. ser. 3, 14(2): 58. 1934.

Note. Compact to open growth form; leaves linear or ensiform; inflorescences bearing many flowers; staminate flowers with short or long filaments (0.8–3.5 mm); pistillate flowers with long outer tepals (2.3–5.3 × 1.2–2.6 mm); ovary trilocular, long (2.9–6.8 mm); fruit globose with few seeds per fruit (4–12); seeds long and wide (2.2–3.7 × 1.3–2.3 mm). Type: *A. nervosa* Banks & Sol. ex Hook.f., designated here.

Included taxa and distribution. Australia: *A. australiana* (J.H.Willis) L.B.Moore, *A. psychrocharis* F.Muell. New Zealand: *A. chathamica* (Skottsb.) L.B.Moore, *A. fragrans* Colenso, *A. graminea* L.B.Moore, *A. grandis* Hook.f. ex Kirk, *A. nivicola* Cockayne ex Cheeseman var. *nivicola*, *A.nivicola* var. *moriceae* L.B.Moore, *A. nervosa* Banks & Sol. ex Hook.f., *A. petriei* Cockayne, *A. skottsbergii* L.B.Moore.

Habitat. Lowland scrub (*A. chathamica*), temperate rainforest (*A. australiana*, *A. fragrans*, *A. grandis*, *A. nivicola* var. *moriceae*), sub-alpine and alpine herb-fields (*A. graminea*, *A. nervosa*, *A. nivicola* var. *nivicola*, *A. petriei*, *A. psychrocharis*, *A. skottsbergii*).

Astelia sect. *Periastelia* Skottsb.

Astelia sect. *Periastelia* Skottsb., Kongl. Svenska Vetenskapsakad. Handl. ser. 3, 14(2): 46. 1934.

Note. Open growth form; leaves linear or ensiform; inflorescences bearing many flowers; staminate flowers with short or long filaments (0.9–2.8 mm); pistillate flowers with long outer tepals (2.3–5.3 × 1.2–2.6 mm); ovary trilocular, intermediate length (1.8–4.6 mm); fruit globose, few seeds per fruit (4–12); seeds long and narrow (1.8–3.6 × 0.7–1.6 mm). Type: *A. argyrocoma* A.Heller & Skottsb., designated here.

Included species and distribution. Austral Islands, Rapa: *A. rapensis* Skottsb. Marquesas Islands, Ua Pou, Nuku Hiva: *A. tovii* F.Br. USA, Hawaii: *A. argyrocoma* A.Heller & Skottsb., *A. menziesiana* Sm., *A. waialealae* Wawra.

Habitat. Lowland mesic forest (*A. menziesiana*, *A. rapensis*), tropical montane cloud forest (*A. argyrocoma* and *A. menziesiana*) and alpine swamps (*A. menziesiana* and *A. waialealae*).

Incertae sedis

Astelia sect. *Micrastelia* Skottsb.

Astelia sect. *Micrastelia* Skottsb., Kongl. Svenska Vetenskapsakad. Handl. ser. 3, 14(2): 56. 1934.

Note. Low, compact, turf forming growth form; leaves caniculate; inflorescence bearing few flowers; staminate flowers with short filaments (0.6–1.9 mm); pistillate flowers with short outer tepals (2.6–3.8 × 0.8–1.3 mm); ovary trilocular, intermediate length (2.6–3.8 mm); fruit ellipsoid, many seeds per fruit (17–24); seeds short and narrow (1.1–1.7 × 0.5–0.8 mm). Type: *A. pumila* (Forst.) Gaudich.

Remarks. The relationships of *A.* sect. *Micrastelia* are poorly resolved, with alternate relationships with *A.* subg. *Asteliopsis* and the clade containing *A.* subg. *Tricella* and *Collospermum* (Birch unpublished PhD thesis 2011, Birch et al. 2012). *Astelia* sect. *Microastelia* contains a single species, *Astelia pumila*, which is a compact, turf-forming plant and dominant component of *Astelia* moorland in Chile, the Falkland Islands, and Tierra del Fuego. As a cushion-forming species, it differs morphologically from *A.* subg. *Asteliopsis*, which contains species with open, spreading growth form that are epiphytic or terrestrial and primarily found of the understory in lowland to montane forests. *Astelia pumila* does share morphological features with *A.* subg. *Asteliopsis* (e.g. short pistillode or pistil) and, alternatively, with *A.* subg. *Collospermum* and *A.* subg. *Tricella* (e.g. seeds with a short, truncate funicle). The subgeneric placement of *A.* sect. *Micrastelia* remains equivocal and the section is unplaced (*incertae sedis*).

Included species and distribution. Chile, Falkland Islands, Tierra del Fuego: *A. pumila* (Forst.) Gaudich.

Habitat. Lowland (low latitudes) to sub-alpine (mid and higher latitudes) herbfields particularly on wet substrates (seeps, swamps etc.).

Synoptic key

1 Leaf tomentum with scales with stalk attached at base; anthers versatile; pollen densely echinate; ovary/pistillode with weakly to moderately-developed mucilaginous hairs that do not adhere to seed surface on drying **2**

– Leaf tomentum with peltate scales; anthers immobile; pollen sparsely spinulous; ovary/pistillode with well-developed mucilaginous hairs that adhere to seed surface on drying ..... ***A.* subg. *Collospermum***

2 Ovary or pistillode unilocular, placentation parietal **3**

– Ovary or pistillode trilocular, placentation axile **5**

3 Plants <40 cm tall; leaves generally less than 30 cm long; compact growth form including cushion and turf forming plants; inflorescence panicle (very reduced in *A. subulata*) < 7 cm long, 1–few flowered ..... ***A.* sect. *Astelia***

– Plants > 40 cm tall; leaves generally greater than 30 cm long; open growth form; inflorescence panicle > 9 cm long, many flowered **4**

4 Leaves with acute apex; outer staminate tepals lanceolate, 5.0–6.4 mm long; pistillode bottle-shaped (lageniform); ovary ovoid; funicle long and curved .. .. ***A.* sect. *Palaeastelia***

– Leaves with long acuminate apex; outer staminate tepals ovate, 2.5–5.0 mm long; pistillode ovoid-conical; ovary ampulliform or obpyriform; funicle short and ribbed ..... ***A.* sect. *Desmoneuron***

5 Leaves generally < 10 cm long; compact turf forming growth form; inflorescence panicle < 7 cm long, 1-few flowered ..... ***A.* sect. *Micrastelia***

– Leaves generally > 10 cm long; compact or open growth form, but not turf forming; inflorescence panicle > 9 cm long, many flowered **6**

6 Pistillode ampulliform, < 1.2 mm long; pistillate flowers with short outer tepals (2.7–4.0 × 0.7–2.0 mm); fruit ovoid, white, pink or maroon; seeds 1.3-2.2 mm long, 11–18 seeds per fruit; funicle ribbed.... ***A.* sect. *Isoneuron***

– Pistillode ovoid, >1.0 mm, long; pistillate flowers with long outer tepals (2.3–5.3 × 1.2–2.6 mm); fruit globose, orange; seeds 2.0–3.6 mm long, 4–12 seeds per fruit; funicle not ribbed..... **7**

7 Perianth tube 0.8-4.0 mm long; ovary 1.6–4.6 mm; seeds fusiform and narrow (0.7–1.6 cm)..... ***A.* sect. *Tricella***

– Perianth tube 0.1-0.7 mm long, ovary 2.9–6.8 mm; seeds ovate and wide (1.3–2.3 cm)..... ***A.* sect. *Periastelia***

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Willdenow CL (1808) Nähere Bestimmung einiger Liliengewächse, besonders aber derjenigen, die zur sechsten Klasse und dritten Ordnung des Linnéschen Systems gehören. Magazin für die neuesten Entdeckungen in der gesammten Naturkunde, Gesellschaft Naturforschender Freunde zu Berlin. 1: 14–30.

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Appendix 1

Specimens examined for generation of morphological data. Herbarium abbreviations follow Index Herbariorum (Thiers [continuously updated]). For each specimen, the following data are provided: sampled taxa, voucher specimen information [collection location, date, collector, collection number, herbarium, and herbarium accession number]

Astelia argyrocoma A.Heller & Skottsb. - HAWAIIAN ISLANDS. Kauai: 10–16 Sept 1895, *A. A. Heller 2752* (BISH120976); Awaawaphui Trail, Honopu, 29 Dec 1956, *H. St. John 36004* (BISH413786); Kawaihau District, Lihue-Koloa Forest Reserve, Powerline trail from Wailua to Princeville, 27 Feb 1987, *T. Flynn 2063, R. Read, B. Read, D. Harder, and S. Weiss* (PTBG018401); Kawaihau District, north facing cliffs and forested slopes below Kekoiki, 9 Feb 1993, *K. R. Wood 2366, T. Flynn, D. Lorence, and S. Perlman* (PTBG014508); Na Pali-Kona Forest Reserve, Awaawapuhi Trail, 6 Dec 2007, *J. L. Birch 137, D. Lorence, K. Wood, and R. Aqurainja* (BISH751095); Na Pali-Kona Forest Reserve, Pihea Trail, 6 Dec 2007, *J. L. Birch 141, D. Lorence, K. Wood, and R. Aqurainja* (BISH751094); Koloa District, Lihue-Koloa Forest Reserve, Wahiawa Bog, 10 Apr 1987, *D. Lorence 5171, T. Flynn, R. DeLappe, W. H. Wagner, Jr. and F. Wagner* (PTBG018403); Koloa District, Lihue-Koloa Forest Reserve, Wahiawa Mountains, jeep road to microwave towers on Mt. Kahili, 2 Mar 1987, *D. Lorence 5105 and T. Flynn* (PTBG018404); Na Pali-Kona Forest Reserve, N. W. end of Alakai Swamp, 27 Dec 1930, *H. St. John 10768* (BISH120985); Pihea trail, on the flats above Lehua maka noe, 30 Jul 1963, *W. Takeuchi 140a* (BISH507424); Wahiawa Mts., Aug 1909, *C.N. Forbes 280K and J. M. Lydgate* (BISH120978); Waimea Drainage Basin, west side, 3-18 Jul 1917, *C.N. Forbes 849K* (BISH120969).

A. alpina R.Br. **var. *alpina*** - AUSTRALIA. Tasmania: 1844, *M. Verreaux s.n.* (P00614764); Table Mountain, *R. Brown 5652* (K000524938); *R. Brown s.n.* (P00614768); Table Mountain, *R. Brown s.n.* (MEL727772); *R. Brown s.n.* (P00614766); *F. v. Mueller s.n.* (K000524934); Mt. Field National Park, Mt Field East, 1876, *F. v. Mueller s.n.* (K00524936); 24 Jan 1983, *S. J. Forbes 1277* (MEL1523734); 14 Feb 1989, *N. G. Walsh 2300* (MEL1577414); Mt. Field National Park, Mt. Rodway tow, 8 Jan 2009, *J. L. Birch 369* (MEL); Mt. Field National Park, Mt. Rodway tow, 8 Jan 2009, *J. L. Birch 370* (MEL); Mt. Field National Park, Uraquat Trail, 8 Jan 2009, *J. L. Birch 372* (SP094921); Mt. Field National Park, Uraquat Trail, 8 Jan 2009, *J. L. Birch 373* (CHR, BISH751060); Cradle Mountain-Lake St. Clair National Park, Marian's Lookout trail, 11 Jan 2009, *J. L. Birch 379* (MEL); Southwest National Park, Mt. Eliza Plateau, 13 Jan 2009, *J. L. Birch 387 and A. Buchanan* (BISH751062); Tasmania: Southwest National Park, Mt. Eliza Plateau, 13 Jan 2009, *J. L. Birch 388A and A. Buchanan* (MEL); Southwest National Park, Mt. Eliza Plateau, 13 Jan 2009, *J. L. Birch 389 and A. M. Buchanan* (MEL); Southwest National Park, Mt. Eliza Plateau, 13 Jan 2009, *J. L. Birch 390 and A. M. Buchanan* (MEL).

A. alpina var. novae-hollandiae Skottsb. - AUSTRALIA. Victoria: Mt. Baw Baw, 1863, *B. F. v. Mueller s.n.* (P00614770); Mt. Baw Baw Alpine Resort, between summit t-bar and Painted Run t-bar, 18 Dec 2008, *J. L. Birch 343* (MEL); Mt. Baw Baw Alpine Resort, between summit t-bar and Painted Run t-bar, 18 Dec 2008, *J. L. Birch 344* (MEL); Mt. Baw Baw Alpine Resort, between summit t-bar and Painted Run t-bar, 18 Dec 2008, *J. L. Birch 345* (MEL); Mt. Baw Baw Alpine Resort, Village Trail, 18 Dec 2008, *J. L. Birch 346* (MEL); Mt. Buffalo National Park, Lyrebird Plains, 19 Dec 2008, *J. L. Birch 347* (MEL); Mt. Buffalo National Park, Bogong Plains, 19 Dec 2008, *J. L. Birch 348* (MEL); Mt. Buffalo National Park, Bogong Plains, 19 Dec 2008, *J. L. Birch 349* (MEL); Alpine National Park, Big River Fire trail, 20 Dec 2008, *J. L. Birch 350* (MEL); Alpine National Park, Big River Fire trail, 20 Dec 2008, *J. L. Birch 351* (BISH751063). New South Wales: Kosciuszko National Park, Kosciuszko summit trail, 30 Dec 2008, *J. L. Birch 357 and A. Beehag* (MEL).

A. australiana (J.H.Willis) L.B.Moore - AUSTRALIA. Victoria: Beenak, 20 Dec 1970, *A. C. Beaglehole and B. A. Fuhrer ACB38542* (MEL534348); Beenak, 10 May 1984, *N. G. Walsh 1244* (MEL662242); Eastern Highlands, 11 Jul 1981, *N. G. Walsh s.n.* (MEL599643−44); Eastern Highlands, 18 Mar 1967, *J. H. Willis s.n.* (MEL224481−3, MEL235432); Great Otway National Park, Brown Town Track, 22 Dec 2008, *J. L. Birch 352 and S. McDougall* (MEL); Otways, c. 150 m along Brown Town track from the Lavers Hill-Beech Forest road (just into State Forest on right hand side of Brown Town track), 6 Apr 1990, *R. Robinson s.n.* (MEL1581443−44); Otway Range, Browntown Road, Weeaproinah (head of a tributary of Youngs Creek), 22 Nov 1990, *G. Beilby s.n.* (MEL227997−8); Pioneer Creek, +/− 4 miles S.E. of Powelltown, 22 Nov 1969, *J. H. Willis s.n. and A. Morrison* (MEL224479); Yarra State Forest, 16 Dec 2008, *J. L. Birch 342 and* J. Downe (BISH751064).

A. banksii A.Cunn. - NEW ZEALAND. *E. Cosson s.n.* (P00614762-3). Little Barrier Island: South of Parihakoakoa Stream, base of cliffs above shore, *R. Melville 6573 and E. H. Godley* (CHR129107). North Island: Auckland, cliffs at Takapuna Beach, Apr 1887, *D. Petrie s.n.* (SP084324); Auckland, *T. Kirk s.n.* (MEL5315); Auckland Ecological Region, Awhitu Ecological District, Matakawau, end of Hatton Road, sandstone cliffs bordering Manakau Harbour, 20 Apr 2001, *P. A. Aspin s.n.* (AK253724); Omahu Islets, Eastern Northland and Islands Ecological Region and District, south end Oakura Bay, top E. side of W. islet, 26 Apr 2003, *E. K. Cameron 11668* (AK280946, AK280988); Opotiki, Hukutaia Domain, 15 Jun 1962, *N. Potts s.n.* (CHR132070); Waitakere Ranges, Piha Beach, low cliff adjacent to trailhead to Laird Thomson trail, 16 Dec 2007, *J. L. Birch 228* (BISH751076); Waitemata, *T. Kirk s.n.* (SP084485). Poor Knights Islands: Tawhiti Rahi Island, Whangarei County, near campsite in Landing Bay, 22 Mar 1984, *A. E. Wright 6337* (AK166389, AK166423). Rakitu (Arid) Island: Hauraki Gulf, west of Te Akau Point, 6 Jan 1981, *E. K. Cameron A183* (AK268645).

A. chathamica (Skottsb.) L.B.Moore - NEW ZEALAND. Chatham Islands: *J. D. Hector M.D. s.n.* (SP030867); Oct, *Travers 48* (MEL5298); F. v. Mueller (MEL5297); Chatham Island, *H. Travers s.n.* (SP034015A–B); *H. N. Travers s.n.* (SP033784); Chatham Islands source (cultivated at 17 Holmwood Road, Christchurch), 8 Apr 1966, L. B. Moore s.n. (CHR150989A–C); Chatham Islands source (cultivated at 17 Holmwood Road, Christchurch), 7 Nov 1967, L. B Moore s.n. (CHR181613A—D); *W. M. Martin s.n.* (SP080105A–B); Chatham Islands source (G. W. Ramsay) (cultivated in Botany division garden), 29 Feb 1972, *L. B. Moore s.n.* (CHR233293A–B). Chatham Island: 8 Sept 1966 (SP030867C,G,H); Tuku Valley, Timihunga, 19 Oct 1980, *A. M. Ringer s.n.* (AK170715). Pitt Island: Canister Cove, 5 Jan 1970, *N. C. Simpson s.n.* (SP0 42759).

A. fragrans Colenso - NEW ZEALAND. North Island: Bay of Islands County, Puketi Forest, side ridge south of Bramley's Ridge, north of Waikape Stream, 12 Oct 1984, *P. J. Bellingham s.n.* (AK170933); Kahikatea bush, Elsthorpe Scenic Reserve, Hawkes Bay (near Otane), 28 Oct 1963, *I. M. Morice 41* (CHR146207A–B); Egmont National Park, Curtis Falls Track, 11 Dec 2007, *J. L. Birch 205* (AK334003); Smith's Creek, Kaitoke, 19 Oct 1964, *L. B. Moore s.n.* (CHR141163); South Auckland Land District, Ikawhenua Ranges, Galatea, near Hikurangi Trig, 28 Dec 1993, *K. A. Ford 6/94* (CHR507187A–B). South Island: Haast side of Grassy Creek (ca. 2 miles), 3 Dec 1962, *I. M. Morice s.n.* (CHR133152A–C); Kahurangi National Park, Heaphy Track, 3 Jan 2008, *J. L. Birch 243 and K. E. Brown* (HAW); Karamea bluffs, Plot 2, 9 Jan 1985, *P. Wardle s.n.* (CHR419194A–C); Kohaihai River (1 mile south of river); Murchison, 12 Oct 1965, *L. B. Moore and J. Clarke s.n.* (CHR159055); Pelorus River Bridge, Marlborough, 12 Oct 1965, *J. B. Irwin s.n.* (CHR159046A–B), Resolution Bay, Marlborough Sounds, 18 Oct 1965, *J. B. Irwin s.n.* (CHR159046A–B); Taumarunui Co., Scenic Reserve at Moerangi, 21 Nov 1981, *R. O. Gardner 3165* (AK158745); W. Nelson, 1 Jan 1964, *I. M. Morice 81* (CHR146986A–E). Stewart Island: Northeastern Long Island, off Stewart Island, 8 Nov 1968, *J. Dugdale s.n.* (CHR188040).

A. graminea L.B.Moore - NEW ZEALAND. South Island: E Nelson, Bryant Range, 5 km. S. W. of Mt. Duppa, Nov 1982, *A. P. Druce* (CHR393919); Mt. Richmond Forest Park, Dun Saddle, Maungatapu Track, 18 Jan 2008, *J. L. Birch 271* (BISH751067); Mt. Richmond Forest Park, Dun Saddle, Maungatapu Track, 18 Jan 2008, *J. L. Birch 272* (SP094949). NW Nelson, Boulder Lake Basin, near Darby Pond and Owen Creek, 10 Apr 1966, *I. M. Morice 327* (CHR170909); NW Nelson, Douglas Range, Jan 1966, *K. H. Marshall s.n.* (CHR141454); NW Nelson, Gouland Downs, (grown in shade house at Lincoln), 26 Apr 1968, *J. Clarke s.n.* (CHR182561); NW Nelson, Mt. Arthur summit trail, 15 Jan 2008, *J. L. Birch 257, S. Courtney, and R. Gaskill* (BISH751070); NW Nelson, Mt. Arthur summit trail, New Zealand, 16 Jan 2008, *J. L. Birch 259, S. Courtney, and R. Gaskill* (CHR); Nelson, Granity Pass, Mt. Owen, 11 Jan 1983, *K. H. Platt s.n.*

(CHR520447); Nelson, Travers Range, Third Basin, 23 Apr 1962, *L. B. Moore s.n.* (CHR125634B); Nelson, Travers Range, Third Basin, 24 Apr 1962, *L. B. Moore s.n.* (CHR129010A-B).

Astelia grandis Hook.f. ex Kirk - NEW ZEALAND. North Island: Dairy flat, Waitemata Co. 16 Dec 1963, *C. Earwaker s.n.* (CHR146924A-B); Junction of Puketaha Road/Gordontown Road, Hamilton, 14 Dec 2007, *J. L. Birch* 223 (BISH751075); Egmont National Park, Potaema Track, 11 Dec 2007, *J. L. Birch* 201A–B (AK334001); North Cape, North Cape Scientific Reserve, Ngaroku Stream, 29 Dec 1986, *R. E. Beever 87003* (AK176615); Northland, Karikari, Tokerau Beach, Hector Busby property, 17 Oct 2006, *M. E. Young and L. J. Forster s.n.* (AK297667–70); South Auckland province, Whanganui, 15 Oct 1895 (SP084426); W Hokio, west of Levin, Oct 1967, *A. P. Druce s.n.* (CHR179566); Waitomo Co., Waitanguru, 15 Feb 1967, *R. Bell and N. Potts s.n.* (CHR174847A-B). South Island: Lake Ianthe (cultivated at Lincoln), 10 Nov 1966, *J. Clarke s.n.* (cultivated) (CHR566424A–B); Moeraki Valley, South Westland, 3 Apr 1978, *P. Wardle s.n.* (CHR321183A-C); Te Kinga near Lake Brunner, 14 Nov 1965, *N. Lambrechtsen s.n.* (CHR168155A–C).

A. hastata Colenso - NEW ZEALAND. 1875, *M. Filhol s.n.* (P00614792). North Island: Atuanui State Forest, 6 Apr 1969, *R. E and J. Beever 236* (CHR 195414A–B); Auckland Ecological Region, Awhitu Ecological District, Pollok, S off Barthow Road, Craig's Bush, lower part eastern end, 9 Jun 2005, *P. A. Aspin s.n.* (AK294016–7); Auckland Ecological Region, Hunua Ecological District, Hunua Range, Mangatangi Kauri area, 4 Feb 1971, *I. L. Barton* (AK208895); Egmont National Park, Stony River, May 1961, *A. P. Druce s.n.* (CHR129729); Rotorua County, Lake Rotoehu, 29 Jan 1963, *R. Mason 100059* (CHR140253A–C); South Manukau, Mauku, Jun 1901 (AK222913); Tainui Ecological Region, Kawhia Ecological District, Mount Pirongia, Ruapane, 13 Feb 1999, *P. J. de Lange 3801* (AK237952); Takaka, Rameka Gorge, 22 Feb 1964, *V. M. Scott s.n.* (CHR148397); Waikanae, Wellington, 5 Feb 1966, *I. M. Morice 312* (CHR150828A–D); Wairoa, Hawkes Bay, Jan 1886, *A. Hamilton s.n.* (AK3191); Whangarei, Maungatapere, Aug 1989, *H. Carse s.n.* (AK3228). Poor Knights Islands: Motukapiti Island, (summit) Nature Reserve, 20 Nov 1984, *A. Penniket s.n.* (CHR418304A-B).

A. hemichrysa (Lam.) Kunth - MASCARENE ISLANDS. Reunion Island: Forêt de Bébour, 26 Mar 1973, *D. H. Lorence* s.n. (MO2232208); Forêt de Bébour, 23 Feb 1979, *D. H. Lorence 2422* and *T. Cadet* (MO 2715190); Plateau de Belouve, 1956, *J. Bosser* 9462 (P00636603); Morne du Patates à Durand, 18 Mar 1974, *J. Bosser 21,643* (P00636604); *I. M. Morice P619* (CHR182114). Mauritius: Pétrin Nature Reserve, 3 Feb 1973, *D. Lorence M53* (MO222048); Pétrin Nature Reserve, 8 Oct 1978, *D. Lorence* 2100 (MO2715777).

A. linearis Hook.f. **var. *linearis*** - NEW ZEALAND. South Island: NW Nelson, Lake Sylvester, 28 Mar 1964, *L. B. Moore s.n.* (CHR148475); Lake Sylvester above Cobb Dam, 9 Jan 1961, *P. Hynes 70325* (AK70325); Boulder Lake, Jan 1957, *A. E. Esler s.n.* (AK216795); Southland, Longwood Range, Bald Hill, 22 Jan 2008, *J. L. Birch 279 and P. Michel* (HAW); Southland, Longwood Range, Bald Hill, 22 Jan 2008, *J. L. Birch 281 and P. Michel* (CHR); Southland, Longwood Range, Bald Hill, 22 Jan 2008, *J. L. Birch 276 and P. Michel* (BISH751078); Westland, 3 Nov 1985, *P. N. Johnson 469* and *P. Wardle* (CHR420097); Denniston, near Westport, 5 Aug 1942, *I. A. McNeur 25407* (CHR25407); Port Pegasus, Stewart Island, *G. M. Thomson s.n.* (SP084464).

A. linearis **var. *novae-zelandiae*** Skottsb. - NEW ZEALAND. North Island: *W. Colenso 1587* (K000524926); Wellington Land District, Southern Ruahine Range, Mar 1971. *A. P. Druce s.n.* (CHR245761). South Island: Southland, Longwood Range, Bald Hill, 21 Jan 2008. *J. L. Birch 280 and P. Michel* (HAW); Fiordland National Park, Borland Saddle/Mt. Burns track, 24 Jan 2008, *J. L. Birch 290 and P. Michel* (MEL); Fiordland National Park, Borland Saddle/Mt. Burns track, 24 Jan 2008, *J. L. Birch 289 and P. Michel* (AK334015); Westland Land District, S. W. of Lewis Pass, 27 Dec 1962, *D. R. Given s.n.* (CHR142821); Wilberg Range, 27 Apr 1993, *P. Wardle s.n.* (CHR499828); Mt. Davy. *W. R. B. Oliver s.n.* (SP010664). Stewart Island: Port Pegasus, Bald Cove, Apr 1981. *I. M. Ritchie s.n.* (CHR372824); Rakiura National Park, Mt. Anglem, 26 Jan 2008. *J. L. Birch s.n.* (HAW); Rakiura National Park, Mt. Anglem summit, 26 Jan 2008, *J. L. Birch 300 and J. Blythal* (P02141677).

A. menziesiana Sm. - HAWAIIAN ISLANDS. *J. F. Rock 8415* (BISH121100). Hawai'i Island: ca. 0.5 miles east of National Park Road junction, 04 Aug 1964, *M. R. Crosby and W. R. Anderson 1972* (BISH121099); Hawaii Volcanoes National Park, Kilauea Research Center, 13 Aug 2009, *J. L. Birch 391* (HAW); Kau Forest Reserve, near boundary of Kapapala Forest Reserve, 1 Jul 1981, *J. Davis 560* (BISH657788); Kealakekua Ranch, S. Kona, 2 Apr 1980, *J. Davis 274* (BISH656028); Saddle Road, Kipuka No. 9. 27 July 1983, *T. Flynn 494* (PTBG019408); Olaa Forest Reserve, road from Hilo to Kulani Prison, 31 Oct 1950, *W. H. Hatheway 441* (BISH121085); South Kohala District, Umipoho Gulch area above Koia sanctuary, 16 Oct 1995, *K.R. Wood 4676* (PTBG033654); Waiakea mauka, July 1986, *W. Takeuchi and K. Shimabukuro 2699* (BISH503251); East Maui: Haleakala, upper Keanae valley, 19 Jul 1927, *O. Degener 4057* (BISH121037); Hana District, Hana Forest Reserve, above N rim of Kipahulu, 1974, *B. Harrison 395* (BISH429287); Hana District, E Haleakala, 2 mi N. E. of Paliku Cabin, N facing slope above Wai Anapanapa, *J. Henrickson and R. Vogl 3556* (BISH35823); Rainforest SW of Kaunuohua, 20 May 1982, *J. Davis 759* (BISH657637); Ukulele, 1919, *C. N. Forbes s.n.* (BISH121031); West Maui: 20 Jul 1964, *M. R. Crosby and W. R. Anderson 1864* (BISH121024); Puu

Kukui Watershed Preserve, along boardwalk to summit at mile marker 2300, 31 Oct 2007, *J. L. Birch 154, R. Bartlett, D. Cole, L. Dunn, and D. Tanaka* (HAW); Puu Kukui Watershed Preserve, forest below bog, 31 Oct 2007, *J.L. Birch 158, R. Bartlett, D. Cole, L. Dunn, and D. Tanaka* (MEL); Puu Kukui Watershed Preserve, forest below bog, 31 Oct 2007, *J.L. Birch 159, R. Bartlett, D. Cole, L. Dunn, and D. Tanaka* (HAW); Molokai: Waikolu Valley, head of valley, 15 Mar 1952, *O. Degener 22160 and C. Tousley* (BISH10425); between Waikolu Valley and N. Puu Alii, 10 Apr 1928, *O. Degener 4065* (BISH121013); Pepeopae Bog, 25 m after end of boardwalk through bog, 22 Jun 2007, *J. L. Birch 149 and C. W. Morden* (BISH751101); ridge E of Mapulehu Valley, 29 Dec 1932, *H. St. John 12840* and F. Fosberg (BISH121017); Kawele, ridge to Pelekunu Pali, 17 Mar 1910, *J. F. Rock 6095* (BISH121053); Oahu. Waianae Range: Mt. Kaala, 14 Sept 2007, J. L. Birch 179 (HAW); Mt. Kaala summit trail (Waianae access), 26 Sept 2009, *J. L. Birch 393* (HAW); Mt. Kaala summit, 24 Nov 1929, *H. St. John 10071* (BISH121055); Kaukawahua gulch, N. fork, 15 May 1909, *J. F. Rock 4005* (BISH121110); Pukaloa gulch, above Schofield, off ridge trail to Puu Kalena, near Kumakalii, 16 Apr 1987, *S. Perlman 5640 and B. Hill* (BISH617222); Puu Hapapa, northeast ridge, 7 May 1939, *O. Degener 12382* (AK71043); Puu Hapapa, 16 Mar 1930, *E. Christopherson 1288B* (BISH121111); Puu Hapapa, 16 Mar 1930, *E. Christopherson 1288A* (BISH121113); Ridge between Puu Kanehoa and Puu Kaua, 23 Jun 1940, *O. Degener 12966* (BISH121146). Koolau Range: Kuliouou Valley, summit, 23 Jun 1935, O. Degener 10471, K. Park, and D. Topping (BISH121114); N Kaaawa, 12 Apr 1931, *E. P. Hume 189* (BISH121171).

A. microsperma Colenso - NEW ZEALAND. North Island: Auckland Ecological Region, Rodney Ecological District, Mt. Tamahunga, 28 Feb 1993, *M. E. Young s.n.* (AK212022); Blue Mountains, near Pinehaven, Hutt Valley, 1 Jan 1963, *I. M. Morice s.n.* (CHR132056A−C); Kaimai Mamaku Forest Park, Mt. Te Aroha, 13 Dec 2007, *J. L. Birch 248, C. Gemmill, E. Grove, and N. Wakefield* (SP094950); Mangonui County, Maungataniwha Range, Feb 1908, *H. Carse 516/1* (CHR328214 A−B); Mt. Egmont, near Puniho Hut, 20 Jan 1963, *I. M. Morice s.n.* (CHR132058); Ohakune, Mt. Road, 13−14 Dec 1962, *J. M. Wheeler s.n.* (CHR141652); Originally from Ruahine Range, west Tamaki River (cultivated in shade house at Lincoln), 2 Jan 1968, *J. Clarke s.n.* (CHR182141); Pureora State Forest Park, West Taupo, 26 Jan 1982, *J. E. Braggins 97* (AK270463); Tararua Forest Park, trail to Mt. Holdsworth, 12 Jan 2008, *J. L. Birch 244 and S. J. Birch* (BISH751080); Tongariro National Park, road between Ohakune and Turoa, 17 Mar 1999, *L. Perrie and L. Sheppard s.n.* (SP083500).

A. montana Seem. - VANUATU ISLANDS. Aneityum: crête du Nezwon Netounemla, 21 Jul 1971*, J. Raynal and M. Schmid RSNH 16129* (CHR 298987; P00636616); Mt. Inréro, peak south of mountain, 21 Jul 1971, *P. S. Green in RSNH 1149* (P00636643). Espiritu Santo: Mt. Tabwemasana, 17 Aug 1985, *P.*

Cabalion 2816 (P000636609); Mt Tabwemasana, 2–8 Sept 1971, *C. Wee-Lek RSNH 249* (P00636644). Tanna: Mt. Toukosméreu, 29 Jul 1971, *P. S. Green 1244* (P00636642). FIJIAN ISLANDS. Viti Levu: Water reserve near Suva, Jul 1965, *J. W. Dawson s.n.* (CHR170581, SP85966A–B). Vanua Levu: Thakaundrove, Natewa Peninsula, Uluingala, 15 Jun 1934, *A. C. Smith 1978* (P00636610). Kandavu: Mt. Mbuke Levu summit, 6 Sep 1860, *B. Seemann 641* (GH00029835).

A. nadeaudii Drake & F.Br. - SOCIETY ISLANDS. Tahiti: Mt. Aorai, 27 Apr 1858, *J. Nadeaud 250* (P0636625-28); Mt. Aorai, trail to summit from Fare Rau Ape, above Papeete on ridge east of Fautaua Valley, slopes of Rocher du Diable, 30 Mar 1973, *F. R. Fosberg 54,701 and M.-H. Sachet* (US2680616, US2680617); Mt. Aorai, 14 Dec 2006, *J. Meyers s.n.* (BISH751087); Mt. Aorai, sentier de l'Aorai, entre Fare Ata et le sommet, 15 Feb 1983, *J. Florence 4545* (P00636605); Mt. Marau, sentier du Pic. Vert., 28 Jan 1982, *J. Florence 2307* (P00636617, US3186926); Mt. Orohena, crête oust de la Papenoo, senteir de l'Orohena, 20 Oct 1982, *J. Florence 3992* (P00636618); Tahiti, 1847, *M. J. Lépine s.n.* (P00636635); Tahiti, *J. Nadeaud 250* (P00636622-24). Raiatea: Mt. Toomaru, Tevaitoa, crête sommitale N. du Mt. Toomaru, 27 Nov 1987, *J. Florence 8936* (P00636640).

A. neocaledonica Schltr. - NEW CALEDONIA. 1868-1870, *M. Balansa 950* (P00636652); 19 Apr 1910, *M and Mme Le Rat 2874* (P00636651); *I. Franc 3125* (MO977220, MEL600656). Grande Terre: Forêt de Sailles, 5 Dec 2001, *J. Muzinger 1244, B. Suprin and F. Carriconde* (MO5839966); Mt. Koghi, Mar 1929, *M. Franc 2325* (P00636650); Mt. Mandjélia, 24 May 1980, *J. W. Dawson s.n.* (SP085969); Mt. Mandjélia, below radio tower ca. 5 air-km of Pouébo, 11 Apr 1980, *G. McPherson 2531* (PTBG023027-8); Mt. Mandjélia, below radio tower ca. 5 air-km of Pouébo, 11 Apr 1980, *G. McPherson 2532* (MO2922540); Mt. Mau, crête sommitale, 21 Aug 1940, *M. R. Virot 284* (P0636648); Province Nord, Mont Görö Até, 19 Nov 2002, *F. Tronchet 469 and J. Munzinger, D. and I. Létocart, J.-P. Butin, A. Oddi, and A. Obry* (MO4781294); Province du Nord, upper Amoa River Valley, trail from Alain Obry property to Görö Até, 23 Apr 2002, *I. Létocart 5644, P. Lowry II, G. D. McPherson, F. Carriconde, and D. Létocart* (MO5666374).

A. nervosa Banks & Sol. ex Hook.f. - NEW ZEALAND. North Island: Coromandel County, Moehau summit, 2 Nov 1980, *R. O. Gardner 2763* (AK153040); Kokianga Co., Waima Forest, ridge between summit of Mount Misery and "highest point in Northland", 16 Jan 1990, *A. E. Wright 9684* (CHR192727); Egmont National Park, Ski field Road, 11 Dec 2007, *J. L. Birch 207* (CHR); Kaimai Mamaku Forest Park, Mt. Te Aroha, Waikato, 13 Dec 2007, *J. L. Birch 220*, *C. Gemmill, E. Grove, and N. Wakefield* (SP094947); Otorohanga County, Ranginui summit, Rangitoto Range, 16 Dec 1981, *R. O. Gardner 3209* (AK158716); Table Mountain, Kauaeranga Valley, Coromandel Range, 10 Apr 1971, *I. M. Morice*

484B (CHR208245); Thames County, Lookout rocks, inland from Taran, 10 Dec 1986, *R. O Gardner 5049* (CHR484212); Tongariro (grown in cultivation at Lincoln), 10 Nov 1966, *J. Clarke s.n.* (CHR566443A−B); Waitemata County, Albany Scenic Reserve, valley lying east of Lonely Track Road, Wright's Road intersection, 6 Oct 1979, *R. O. Gardner s.n.* (AK150794); Wellington District, Tongariro National Park, ca. 1.5 km N. W. of Chateau Tongariro, nr. road to Chateau, Whakapapanui Track, 24 Mar 1970, *P. J. Edwards 74* (AK129710). South Island: Marlborough Land District, Mt. Stokes, Marlborough Sounds, Mar 1977, *A.P. Druce s.n.* (CHR310138); Mt. Stokes, *T. Kirk s.n.* (SP030865); Mt. Stokes Scenic Reserve, Mt. Stokes summit, Marlborough Sounds, 14 Jan 2008, *J. L. Birch 251 and J. Little* (BISH751065); Mt. Stokes Scenic Reserve, Mt. Stokes summit, Marlborough Sounds, 14 Jan 2008, *J. L. Birch 252 and J. Little* (CHR); Nelson Land District, Nelson, Aniseed Valley Scenic Reserve, 1972, *G. C. and D. Kelly s.n.* (CHR230190). Arthur's Pass, Bealey Track near Margaret's Tarn, 29 Nov 1961, *R. Melville 5478* (CHR129127, AK156821); Kahurangi National Park, Heaphy Track, 31 Dec 2007, *J. L. Birch 237 and K. E. Brown* (HAW); Kahurangi National Park, Heaphy Track, 2 Jan 2008, *J. L. Birch 240 and K. E. Brown* (SP094946A/B); Kahurangi National Park, Heaphy Track, James Mackay Hutt, *2 Jan 2008, J. L. Birch 241 and K. E. Brown* (P02141675); Kahurangi National Park, Heaphy Track, trail to Gouland Downs Hut, ca. 1 mile from Percy Hut, 31 Dec 2007, *J. L. Birch 238 and K. E. Brown* (SP094945); NW Nelson, Mt. Arthur, 16 Jan 2008, *J. L. Birch 263* (BISH751073); Mt. Arthur, 16 Jan 2008, *J. L. Birch 267* (CHR); NW Nelson, Boulder Lake, Orater Creek, 11 Apr 1966, I. M. Morice 344 (CHR170919); Cobb Valley, Lake Sylvester, just above forest hut, 31 Mar 1964, *L. B. Moore s.n.* (CHR148498A−B); trail to Mt. Arthur, 15 Jan 2008, *J. L. Birch 258, S. Courtney, and R. Gaskill* (SP094941); Mt. Arthur trail to Gordon's Pyramid, 16 Jan 2008, *J. L. Birch 260* (BISH751068); Takaka Hill, on road to Canaan, 11 Jan 1964, *I. M. Morice 106* (CHR146995); Nelson Lakes National Park, Ridge to Mole Tops, 14 Feb 1964, *M. J. A. Simpson 4115* (CHR148394); North Canterbury, Upper Clarence Valley, Mt. St. Patrick, 14 Jan 1972 (CHR 228672); Canterbury Land District, Deer Spur Walk, Peel Forest Park, Stop 5, 29 Oct 1970, *B. P. J. Molloy* (CHR212134); West Coast, Paparoa Range, Croesus track, 19 Jan 2008, *J. L. Birch 274* (AK334012); Oparara Arch, 22 Jan 1985, *P. Wardle s.n.* (CHR574281); St. Arnaud Range, 11 Dec 1950, *W. R. B. Oliver s.n.* (SP010631). Fiordland, Dec 1966, *P. K. Dorizac s.n.* (CHR174065); Fiordland, Mt. Gray, 14 Feb 1959, *M. J. A. Simpson 1154* (CHR111751); Fiordland, Secretary Island, Feb 1967, *P. Wardle (3)* (CHR 566430); Fiordland National Park, Hollyford Valley, 31 Jul 1965, *K. Dorizac s.n.* (CHR141436); Homer, Dec 1943, *J. Salmon s.n. with R. Forster* (SP084347); Milford Sound, Sinbad Gulley, 27 Feb 1975, *P. N. Johnson s.n.* (CHR 261738); Pigeon Saddle, Oct 1957, *A. Esler s.n.* (SP085190); Track from Key Summit to road, 16 Dec 1962, *I. Morice s.n.* (CHR133242); Track from Key Summit to road, 16 Dec 1962, *I. Morice s.n.* (CHR133243).

A. nivicola Cockayne ex Cheeseman **var. *nivicola*** - NEW ZEALAND. South Island: Fiordland, Hunter Mts., east of summit of unnamed peak north of Green Lake, 9 Jan 1967, *D. Given 69043* (CHR193928); Fiordland, Key Summit, between upper bog and track upwards, *P. K. Dorizac (=IMM 474/2)* (CHR191766A−B); Fiordland National Park, Borland Saddle/Mt. Burns track, 24 Jan 2008, *J. L. Birch s.n. and P. Michel* (HAW); Marlborough, Richmond Range, Mt. Richmond, 23 Nov 1961, *J. I. Townsend s.n.* (CHR366690); Mt. Ollivier, Sealey Range, 12 Feb 1919, *L. Cockayne 1272* (AK3224); NW Nelson, Mt. Centre, Jan 1977, *A. P. Druce s.n.* (CHR310405, CHR310406); Nelson Land District, NW Nelson, Mt. Centre, Jan 1977, *A. P. Druce s.n.* (CHR310406); Southland, Longwood Range, Bald Hill, 21 Jan 2008, *J. L. Birch 277 and P. Michel* (CHR).

A. nivicola **var. *moriceae*** L.B.Moore - NEW ZEALAND. South Island: Collected from Wilmot Pass, (grown in Bot. Div. shadehouse), 5 May 1970, *L. B. Moore s.n.* (CHR199865); Fiordland, near Henry Saddle on George Sound track, 16 Jan 1966, *P. K. Dorizac s.n.* (CHR150752, CHR150753); Nelson, Flora track, head of Pearse River (type locality), 16 July 1964, *L. B. Moore s.n.* (CHR 151212); Nelson, Flora track, halfway between Flora saddle and Flora Hut, 26 Dec 1964, *D. R. Given 64410* (CHR144190A−B); Paparoa Range, above Roa Mine, 18 Dec 1965, *L. B. Moore, s.n., J. Clarke, and I. Robins* (CHR168145A−C); On E side 15 minutes from Wilmot Pass, 14 Dec 1962, *I. Morice s.n.* (CHR133164A−C); Track to Boulder Lake, The Pulpit, 6 Jan 1964, *I. M. Morice 92* (CHR146984A-C); Nelson, track to Mt. Arthur, 13 Apr 1963, *I. M. Morice* 12 (CHR 144249).

A. papuana Skottsb. - PAPUA NEW GUINEA. Central Highlands, Mt. Wilhelm, 25 Aug 2011, *W. R. and M. N. Philipson 3493* (CHR198540), Eastern Highlands province, Kainantu sub-province, Mt. Piora, 9 Jan 1975, *M. J. S. Sands 1604, G. A. Pattison, and J. J. Wood* (US3248428); Goilala sub-district, Mt. Dickson, 11 Feb 1964, *T. G. Hartley* 12985 (US3485933); Mt. Wilhelm, Lake Aunde, 22-26 Sep 1962, *F.W. Went 223* (MO1806059); South Highland district, Tari sub-district, Mt. Ambua, 29 July 1966, *W. Vink 17287* (MO2322009); Western Highlands district, Hagen sub-district, Mt. Hagen, 2 July 1967, *J. M. Wheeler ANU 6385* (US3321035); West Highlands, Mt. Kegum, 8 Apr 1977, *J. F. Veldkam 7598 and A. Vinas* (MO2682556); West Sepik district, Telefomin sub-district, Star Mountains, Mt. Scorpion, 25 May 1975, *J.R. Croft and G.S. Hope LAE 68018 (*US2895090); West Sepik district, Telefomin sub-district, Mt. Capella north of east summit, 18 Apr 1975, *W. R. Barker LAE 67438 and T. Umba* (MO3270313).

A. petriei Cockayne - NEW ZEALAND. South Island: Arthur's Pass, Temple Basin, 8 Dec 1963, *B. H. MacMillan 3* (CHR146933); Fiordland National Park, Gertrude Saddle track, 23 Jan 2008, *J. L. Birch 287 and P. Michel* (SP094956); Fiordland National Park, Gertrude Saddle track, 23 Jan 2008, *J. L. Birch 286 and P. Michel* (CHR); Fiordland National Park, Borland Saddle/Mt. Burns track, 24 Jan

2008, *J. L. Birch 291 and P. Michel* (SP094952); Molesworth Ecological Region, Balaclava Ecological District, Island Saddle just north of road summit, 4 Jan 2002, *E. K. Cameron 10684* (AK255636); N. Canterbury, Upper Clarence Valley, Mt. St. Patrick, 14 Jan 1972 (CHR228674); NW Nelson, Mt. Arthur, 15 Jan 2008, *J. L. Birch* 254, *S. Courtney, and R. Gaskill* (BISH751072); NW Nelson, Mt. Arthur, 15 Jan 2008, *J. L. Birch 255*, *S. Courtney, and R. Gaskill* (MEL); Otago Province, Lake Harris Saddle (cultivated in Dunedin), 1923, *W. A. Thomson s.n.* (SP085977); Westland National Park, Fox Glacier, Chancellor Hut, 2 Feb 1973, *P. Wardle s.n.* (CHR218793A–B).

A. psychrocharis F.Muell. - AUSTRALIA. New South Wales: Mt. Kosciuszko, 19 Feb 1990, *M. G. Corrick 10668* (MEL1578958); Mt. Kosciuszko, June 1901, *C. H. Grove s.n.* (MEL 2213620); Kosciuszko National Park, Mt. Kosciuszko, 30 Dec 2008, *J. L. Birch 359 and A. Beehag* (MEL); Kosciuszko National Park, Mt. Kosciuszko, 30 Dec 2008, *J. L. Birch* 360 *and A. Beehag* (MEL); Kosciuszko National Park, Mt. Kosciuszko, 31 Dec 2008, *J. L. Birch 361 and A. Beehag* (MEL); Kosciuszko National Park, Mt. Kosciuszko, 31 Dec 2008, *J. L. Birch 362 and A. Beehag* (BISH751056); Kosciuszko National Park, Southern Tablelands, near end of Mt. Blue Cow, "Snowtube", 31 Jan 1990, *J. H. Willis s.n.* (MEL 2117076).

A. pumila (Forst.) Gaudich. - ARGENTINA. Tierra del Fuego: Isla de los Estados, Bahia San Antonio, Puerto Hoppner, 8 Nov 1971, *T. R. Dudley, R. N. P. Goodall, and G. Crow 1596* (MO2300439); Northwest side of Bahia Thetis, 14 Nov 1969, *R. N. P. Goodall 2248* (US2626023). CHILE. Chiloé Island: River Toigoi, Chepu, 26 Oct 1958, *E. J. Godley 349a* (CHR 547077B); River Toigoi, Chepu, 26 Oct 1958, *E. J. Godley 348* (CHR 55303). Magallenes y de la Antártica Chilena: Churucca, 30 Jan 1879, *Lud Savatier 189* (P00614743); Détroit de Magellan-Port Famine. *M. le Guiillou 188* (P00614753). Riesco Island: Peninsula Cordova, Pto. Condor, 29 Aug 1970, *E. Pisano V. 2639* (MO2384477). FALKLAND ISLANDS. [Iles Maclovian] 1825, *Gaudichaud s.n.* (P00614740); [Iles Maclovianl 1825, *Gaudichaud s.n.* (P00614741).

A. rapensis Skottsb. - AUSTRAL ISLANDS. Rapa: Kaimaru, south ridge of Mt. Perahu, 13 Jul 1934, *H. St. John and J. Maireau 15,513* (BISH509590, P00636647).

A. samoense (Skottsb.) Birch - SAMOAN ISLANDS. Savai'i: Cloud forest near Mt. Silisili, 17 June 1992, *A. Whistler 8861* (housed at HAW); Mata-ole-afi cinder cone, 29 May 1975, *A. Whistler W2492* (housed at HAW); Matavanu Crater, 24 July 1931, *E. Christophersen and E. Hume 2130* (MO1631444); Mt. Silisili, 30 May 1975, *A. Whistler W2518* (housed at HAW). Upolu: 22 Nov 1973, *A. Whistler AW1172* (housed at HAW); between Mt. Lepu'e and Mt. Fito, 15 Oct 2008, *A. Whistler 12035* (housed at HAW); Lake Lano, 6 Aug 1971, *A. Whistler W270* (housed at HAW); Laka Lanoto'o, 15 Aug 1970, *A. Whistler W2177* (housed at

HAW); Mt. Siga'ele, 19 July 1973, *A. Whistler W358* (housed at HAW); Mt. Lepu'e east of Tiavi, 7 Dec 1973, *A. Whistler W1251* (housed at HAW).

A. skottsbergii L.B.Moore - NEW ZEALAND. South Island: Douglas Range, 15 May 1963, *K. H. Marshall s.n.* (CHR146875A–D); NW Nelson, Boulder Lake, Brown Cow Saddle, 12 Apr 1966, *I. M. Morice 350* (CHR170925); NW Nelson, Douglas Range, 1 Jun 1964, *K. Marshall s.n.* (CHR151057); NW Nelson, Mt. Domett, Jan 1977, *A. P. Druce s.n.* (CHR311624); NW Nelson, Mt. Goul, 19 Jan 1973, *M. J. A. Simpson 7215* (CHR278243); Mt. Arthur Plateau, Gordon's Pyramid, 26 Feb 1965, *R. Macfarlane s.n.* (CHR141321); Kahurangi National Park, Mt. Arthur, 16 Jan 2008, *J. L. Birch 261* (BISH751069); Kahurangi National Park, Mt. Arthur, 16 Jan 2008, *J. L. Birch 262* (CHR); Waingaro Peak, where Douglas and Lockett Ranges meet, on North facing slope, 16 Jan 1970, *I. M. Morice s.n.* (CHR199791); Wangapeka, Mt. Luna, 23 Jan 1971, *I. M. Moore s.n.* (CHR215917A–B).

A. solandri A.Cunn. - NEW ZEALAND. Little Barrier Island: North Auckland Land District, 24 Oct 1965, *R. Melville 6672* (CHR129112). North Island: Anatoki Valley, 9 Jan 1964, *I. M. Morice 100* (CHR147598); Auckland, 1875, *M. Filhol s.n.* (P00614785); Auckland Ecological Region, Awhitu Ecological District, Matakawau Reserve, south of Matakawau Road, 23 Apr 2001, *P. A. Aspin s.n.* (AK253912, AK254486); Coromandel, Dec 1905, *D. Petrie s.n.* (SP85958); Egmont Ecological Region and District, Mt. Egmont, Aug 1958, *A. E. Esler s.n.* (AK219600); Hunua, Dec 1868, *T. Kirk s.n.* (SP84518); Hunua, Dec 1868, *T. Kirk s.n.* (SP084519); Kaimai Mamaku Forest Park, Mt. Te Aroha summit trail, 13 Dec 2007, *J. L. Birch 219, C. Gemmill, E. Grove, and N. Wakefield* (SP094962); Mauku, Franklin County, 5 May 1901, *H. Carse s.n.* (CHR328230); Egmont National Park, Potaema Track, 11 Dec 2007, *J. L. Birch 202* (SP094922); Egmont National Park, road below Dawson Falls, 20 Jan 1964, *I. M. Morice 119* (CHR148342); Mt. Wellington lava fields near Auckland, Apr 1897, *D. Petrie s.n.* (SP084507); Mt. Wellington, Auckland, 4 Apr 1922, *H. Carse s.n.* (CHR292211); North Tararua Range, Makotukutuku St. near Mt. Kaiparoro, Jan 1977, *C. Ogle s.n.* (CHR286974); Orotere, south of Kaeo, 26 Aug 1965, *R. Cooper s.n.* (AK118465); Tararua Forest Park, Mt. Holdsworth, 12 Jan 2008, *J. L. Birch 250 and S. J. Birch* (BISH751081). South Island: Nelson (SP08453). Poor Knights Islands: Whangarei County, Aorangi Island, 31 Aug 1984, *A. E. Wright 6564* (AK169414). Rangitoto Island: North Auckland Land District, 13 Feb 1965, *I. M. Morice s.n.* (CHR 566383).

A. subulata Cheeseman - NEW ZEALAND. Campbell Island: Homestead Ridge, 26 Dec 1998, *C. D. Meurk s.n.* (CHR537469); Tucker Cove, 14 Jan 1947, *W. B. Brockie* s.n. (CHR223725). South Island: Paparoa Range, Westland, 14 Jan 1967, *L. B. Moore s.n and J. Clarke* (CHR174718). Stewart Island: Table Hill, 12 Jan

1940, *L. B. Moore* s.n. (CHR24184); Rakiura National Park, Mt. Anglem, 26 Jan 2008, *J. L. Birch s.n. and J. Blythal*, (HAW); Rakiura National Park, Mt. Anglem, 26 Jan 2008, *J. L. Birch 299 and J. Blythal*, (CHR); Rakiura National Park, Mt. Anglem, 26 Jan 2008, *J. L. Birch 301 and J. Blythal* (BISH751079).

A. tovii F.Br. - MARQUESAS ISLANDS. Nuku Hiva: Summit of the ridge south of Tekao, between the new airport road at peak #1227 M. and Tekao, the main ridge above Toovii, 25 Sept 1995, *S. Perlman 15,055* (BISH660310, MO5601362, PTBG021995); Mt. Tapuaooa, about 2 km. from the Tapuaooa shelter and 3 km. W of Mt. Ooumu, 10 Jul 1970, *G. W. Gillett 2166* (US 3485393, P00636646); Toovii, épaulement SE du Mt. Tekao, 28 May 1984, *J. Florence 6818* (P00636614); Tovii, ridge above L'Economie Rurale to Ooumu, 17 Jul 1988, *W. L. Wagner, D. Lorence, J. Florence, and S. Perlman 6119* (MO4330721, PTBG008791, P00636608, US3206556); Toovii Plateau, trail behind L'Économie Rurale toward Ooumu peak, near summit crest, 16 Jul 1988, *S. Perlman 10,127* (PTBG008286).

A. trinervia Kirk - NEW ZEALAND. North Island: Auckland Ecological Region, Awhitu Ecological District, Matakawau Reserve, south of Matakawau Road, 23 Apr 2001, *P. A. Aspin s.n.* (AK253912); Eastern Northland Ecological Region, Eastern Northland & Islands Ecological District, Orotere, south of Kaeo, 26 Aug 1965, *R. C. Cooper s.n.* (AK118465); North Auckland Land District, Franklin Co., Mauku, 5 May 1901, *H. Carse s.n.* (CHR328230); North Auckland, Hunua, Wairoa [Hunua] Falls, Dec 1868, *T. Kirk s.n.* (SP084519); North Auckland Land District, Mt. Wellington, Auckland, lava field, 4 Apr 1922, *H. Carse s.n.* (CHR292211); North Auckland, Auckland City, Mt. Wellington lavafield, Apr 1897, *D. Petrie s.n.* (SP084507). Little Barrier Island: North Auckland Land District, summit, 9 Mar 1962, *R. Melville 6672* (CHR129112). Rangitoto Island: North Auckland Land District, 13 Feb 1965, *I. M. Morice s.n.* (CHR 566383).

A. waialealae Wawra - HAWAIIAN ISLANDS. Kaua'i: Alakai Swamp, transect across Sincock Bog, Bog 1, 13 Feb 1989, *S. Perlman 10,641, T. Pratt, and J. Lepson* (PTBG011706); Alakai Swamp, 1 Sep 1977, *P. van Royen 11716 and J. Davis, S. Perlman* (BISH419748A); Waialealae, 23 Sep 1909, *J. F. Rock 5041* (BISH121147); Waialealae, 20 Oct 1911, *J. F. Rock 8878* (BISH121150); Waimea District, Sincock Bog, Halehaha area, *S. Perlman and K. Wood 3395* (PTBG019596).