Antarctic Science page 1 of 4 *(2024)*
doi:10.1017/S0954102024000014

Mosses of Cockburn Island plateau, Antarctica

AGUSTINA CELESTE COTTET [1], MARÍA INÉS MESSUTI [1], MARTÍN ANSALDO [2] and LAURA PATRICIA DOPCHIZ [2]

[1] *Instituto de Investigaciones en Biodiversidad y Medioambiente (INIBIOMA) and Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Universidad Nacional del Comahue (UNComahue), Quintral, Río Negro, Argentina*
[2] *Laboratorio de Ecofisiología y Ecotoxicología, Instituto Antártico Argentino (IAA), Campus Miguelete, San Martín, Buenos Aires, Argentina*
agustina.c.cottet@gmail.com

Abstract: Located east of the Antarctic Peninsula, Cockburn Island is a small island in the James Ross Archipelago. Studies of mosses on the island are scarce. The oldest studies date from the first half of the nineteenth century to the most recent in 1993. The number of records of mosses is very small due to the difficulty of accessing the area. Here, we report an updated composition of the moss flora of the plateau, in which four new records have been found: *Bryoerythrophyllum antarcticum*, *Ceratodon purpureus*, *Pohlia wilsonii* and *Schistidium lewis-smithii*. The occurrence of these species on the plateau shows that the ranges of these species have expanded from the Antarctic Peninsula to the east. This collection highlights the need for further research into the dynamics of moss flora in the context of climate change.

Received 5 September 2022, accepted 26 December 2023

Key words: *Bryoerythrophyllum*, Bryophyta, *Ceratodon*, *Pohlia*, *Schistidium*

Introduction

Cockburn Island, a small island that is part of the James Ross Archipelago, is located 5 km north of Marambio (Seymour) Island (64°13' S, 56°50' W), in the east of the Antarctic Peninsula. Cockburn Island was formed by volcanic activity and was one of the first places in Antarctica to be explored during the first half of the nineteenth century. It consists of an area of ~4 km^2 and measures 2.8 × 1.8 km (Stilwell 2002). The archipelago to which the island belongs represents a transitional region between marine and continental Antarctica. Bryophytes and lichens are the two main floral components of the island. There are three lineages of bryophytes: hornworts, liverworts and mosses, with only the latter of which being represented on the island.

The moss flora of Antarctica has a relatively short history compared to in other parts of the world, especially tropical and temperate regions (Putzke *et al.* 2015). The earliest data on the study of mosses on Cockburn Island date from Hooker's expeditions, from which five species were documented and mentioned by Lewis Smith (1993). This author also presented a survey of vegetal diversity at different levels on the island (coast, plateau and cone) and an inventory of the moss flora. More recently, Ochyra *et al.* (2008) reported six moss species on Cockburn Island. The present study aimed to survey the moss flora of Cockburn Island.

Knowledge of the moss flora present on Cockburn Island will provide a baseline for monitoring vegetation in the region. From this foundation, it will be possible to assess the impacts of climate change and establish mechanisms for biodiversity conservation of Antarctic moss flora. The present study aimed to survey the moss flora of the Cockburn Island plateau.

Materials and methods

As part of the 2021–2022 summer Antarctic campaign, the Instituto Antártico Argentino (IAA), Dirección Nacional del Antártico (DNA), Argentina, carried out plant collections on Cockburn Island. Sampling was only carried out on the depressed side of the plateau (north-east), which is the most favourable area for the presence of vegetation due to the humid conditions caused by the accumulation of snowdrifts (Roman *et al.* 2019), solar radiation and the fact that it is relatively protected from the wind (mainly from the south-west; Fig. 1).

For the identification of the moss species present in each sample, the morphology and anatomy of the different structures, of the gametophyte (e.g. leaf or cells) and, when present, of the sporophyte (e.g. capsule, operculum or calyptra) were observed (Gradstein *et al.* 2001). The observations on general aspects were made using a stereoscopic microscope (Olympus BX50) in both dry and hydrated states. The cuts for anatomical study were made under a magnifying glass and free-handed using razor blades. Water was used for mounting fresh mounts (Frahm 2003). For the identification and distribution of the taxa, the following bibliography was used: Lewis Smith (1993), Sharp *et al.* (1994), Ochyra & Zander (2002), Ochyra *et al.* (2008) and Sollman (2015). The identified specimens were deposited in the repository of the IAA and duplicates were deposited at the Herbarium

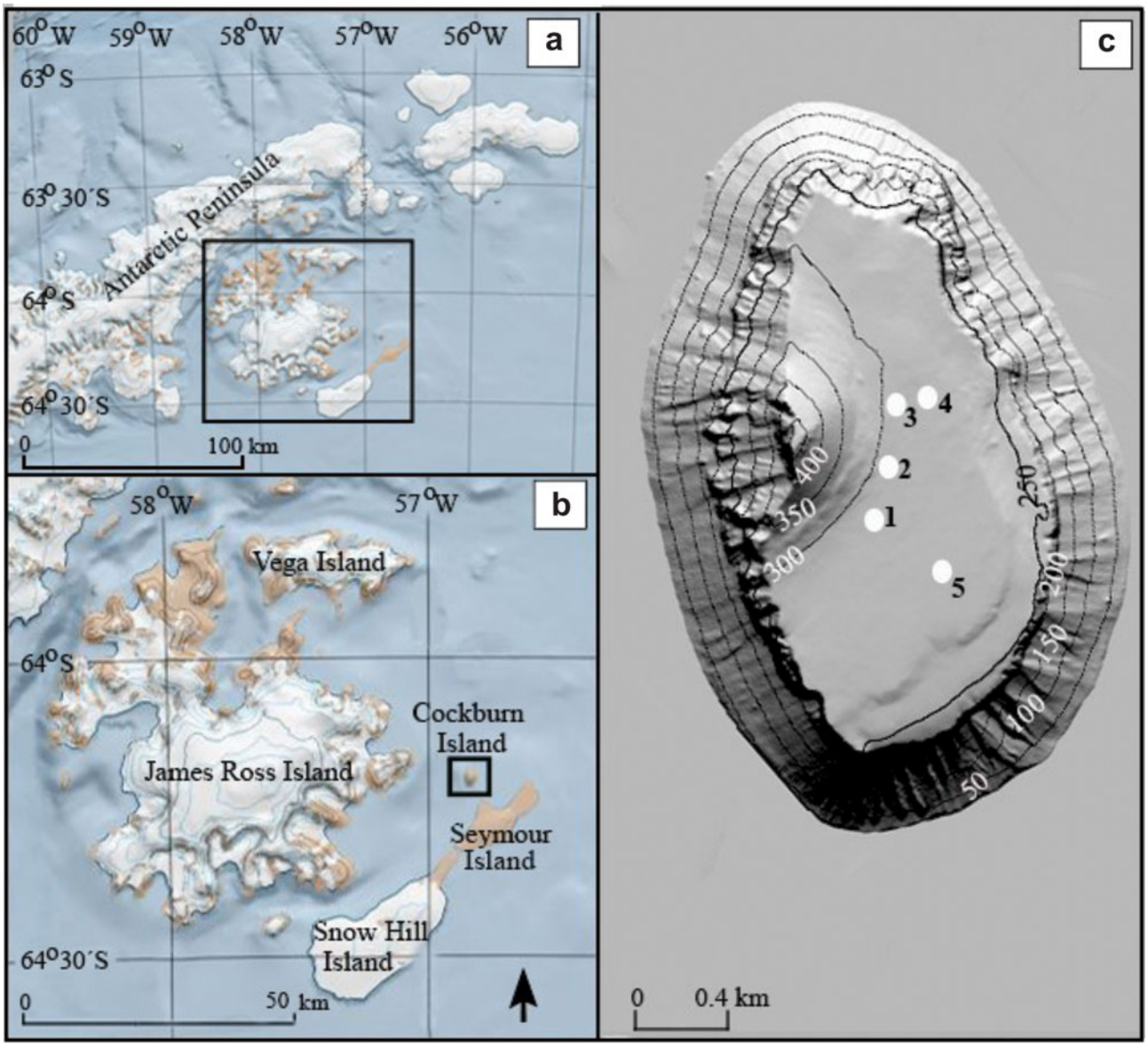

Figure 1. Location of the study area. **a.** Map of a portion of Antarctica showing the location of the northern Antarctic Peninsula and James Ross Archipelago (black box). **b.** Map of the James Ross Island group. The black box highlights Cockburn Island. **c.** Cockburn Island. White points show sampling sites. 1) 64°12'11,052" S; 56°50'28,607" W: *Bryoerythrophyllum antarcticum*, *Ceratodon purpureus*, *Syntrichia magellanica*. 2) 64°12'6,228" S; 56°50'35,016" W: *Bryoerythrophyllum antarcticum*, *Bryum argenteum*, *Syntrichia magellanica*. 3) 64°11'58,2" S; 56°50'31,343" W: *Bryum argenteum*, *Bryum pseudotriquetrum*, *Syntrichia magellanica*. 4) 64°11'57,804" S; 56°50'20,112" W: *Schistidium lewis-smithii*. 5) 64°12'16,92" S; 56°50'16,26" W: *Bryum argenteum*, *Pohlia wilsonii*.

of the Centro Regional Universitario Bariloche (BCRU). Specific names have been updated according to the Missouri Botanical Garden database (Tropicos.org). The maps (Fig. 1) were made using *Antarctic Reference Elevation Model of Antarctica* (*REMA*) *Explorer* (https://livingatlas2.arcgis.com/antarcticdemexplorer/). The location maps in Fig. 1 were made using *Quantarctica* (Matsuoka *et al*. 2021). The detailed map of Cockburn Island is based upon REMA (Howat *et al*. 2022) with 50 m contour intervals extracted and digitalized in *Quantum GIS* (QGIS Development Team 2020).

Results

The collections resulted in 22 specimens belonging to seven species, all of which were georeferenced (Fig. 1). Based on the specimens examined, the list by Lewis Smith (1993) and the descriptions in Ochyra *et al*. (2008), an updated list of the species registered on Cockburn Island was produced. The species are presented with updated and valid names.

The following is the updated species list (asterisks mark new records for the Cockburn Island plateau):

https://doi.org/10.1017/S0954102024000014 Published online by Cambridge University Press

1) *Bryoerythrophyllum antarcticum* (L.I. Savicz & Smirnova) P. Sollman [Pottiaceae]*
2) *Bryum argenteum* Hedw. [Bryaceae]
3) *Bryum pseudotriquetrum* (Hedw.) Gaertn., Meyer *et* Scherb. [Bryaceae]
4) *Ceratodon purpureus* (Hedw.) Brid. [Ditrichaceae]*
5) *Didymodon brachyphyllus* (Sull.) R.H. Zander [Pottiaceae]
6) *Encalypta rhaptocarpa* Schwägr. [Encalyptaceae]
7) *Hennediella heimii* (Hedw.) R.H. Zander [Pottiaceae]
8) *Pohlia wilsonii* (Mitt.) Ochyra [Bryaceae]*
9) *Schistidium antarctici* (Cardot) L.I. Savicz & Smirnova [Grimmiaceae]
10) *Schistidium lewis-smithii* Ochyra [Grimmiaceae]*
11) *Syntrichia magellanica* (Mont.) R.H. Zander [Pottiaceae]
12) *Syntrichia sarconeurum* Ochyra & R.H. Zander [Pottiaceae]

An alphabetically annotated list of all 12 species recorded on the Cockburn Island plateau is presented in the Supplementary Appendix, with citations of descriptions and iconography, habitat and distribution, comments and examined material. The following species are reported for the first time for the plateau: *B. antarcticum*, *C. purpureus*, *P. wilsonii* and *S. lewis-smithii*.

Discussion

Since Lewis Smith's last visit to the island plateau in 1989 (Lewis Smith 1993), Cockburn Island has remained unvisited, mainly because of the difficulty of accessing the island. The studies carried out since then up to the present work are based on valuable collections held in various repositories. Our work contributes to knowledge of the island's diversity with the discovery of four new species present there. *B. antarcticum* has been reported at James Ross Island (Sollman 2015), so its presence at Cockburn Island is unsurprising. However, the presence of *P. wilsonii* was unexpected. This species was first reported from Antarctica in Enderby Land by Ochyra *et al*. (2008), and our finding at Cockburn Island is novel because this is the first mention of this species in the Antarctic Peninsula region. The morphological, anatomical and ecological features observed in the examined specimens of *P. wilsonii* are consistent with those described by Ochyra *et al*. (2008).

The finding on the plateau of *S. antarctici*, which is the most representative species of the genus, was predictable (Biersma *et al*. 2018), but *S. lewis-smithii* was not. The geographical range of *S. lewis-smithii* is currently restricted to the South Shetland Islands: 25 de Mayo Island (King George Island; Ochyra 2003), Livingston Island (Ochyra *et al*. 2008) and Ostrov Geologov Island (Câmara *et al.* 2021). In this paper, we present the first record of this species from the eastern Antarctic Peninsula. This species could be confused with *Schistidium falcatum* (Hook.f. & Wilson) B.Bremer due to the absence of a gymnosomal capsule (Ochyra *et al*. 2008), but the morphological differences of its leaves allow no room for confusion with the latter. They are certainly very similar, and molecular phylogenetic reconstructions show that the species are closely related. However, these reconstructions are based on a single specimen (Biersma *et al*. 2018), and so further studies are needed. On the other hand, the specimen reported by Lewis Smith (1993) as *Schistidium* cf. *chrysoneurum* is in fact *S. lewis-smithii*, and we consider it to be so.

The location of the mosses near the base of the cone, in the plateau (Fig. 1), can be explained by several factors: the protection it provides from the highly erosive south wind, the high degree of radiation that allows the snow to melt and the impermeability of the volcanic terrain that provides the necessary moisture for vegetation growth. According to Ochyra (2008), *C. purpureus* is rare on the coast of the Antarctic Peninsula, but it was mentioned as being present on James Ross Island. *D. brachyphyllus*, *H. heimii* and *S. sarconeurum* were found on the northern side of the island, above the Adélie penguin colony and between the base of the cliff and the Adélie penguin colony at 15–150 m (Ochyra *et al*. 2008). Nevertheless, these three species have not been registered on the Cockburn Island plateau area. These are the first records of them. *B. argenteum* and *B. pseudotriquetrum* had been previously reported in the plateau (Lewis Smith 1993). According to Ochyra *et al.* (2008), these two species were found together with *E. rhaptocarpa*, *S. magellanica* and *S. antarctici* at an altitude of 400 m. However, the plateau is at 250 m, so it is not clear exactly where they were found.

As mosses in Antarctica rarely produce sporophytes, their absence from our samples was unsurprising. However, Casanova-Katny *et al.* (2016) suggest that the production of fully mature sporophytes might be related to environmental conditions, such as elevated temperature, rather than being a physiological limitation or adaptive response. Their studies were conducted on 25 de Mayo Island (King George Island), within the 0°C isotherm. Cockburn Island's location at the -7°C isotherm, which, together with cold winds blowing from the Filchner-Ronne Ice Shelf, the ice-covered Weddell Sea and the mountains of the Antarctic Peninsula (Van Wessem *et al*. 2015), creates an environment that does not allow for sporophyte development in moss species.

Despite the scarce and sporadic reports, slow colonization events could occur with the establishment of new species from spores transported long distances by the wind from more northerly latitudes (Lewis Smith 2005). This observation is also supported by the absence of birds in the area. Most floristic studies of the

https://doi.org/10.1017/S0954102024000014 Published online by Cambridge University Press

archipelago have focused on James Ross and Vega islands (Ochyra 1999, Barták *et al.* 2015, Goga *et al.* 2018). This underscores the necessity of continued monitoring on this difficult-to-access volcanic island.

The increase in the number of moss species on Cockburn Island highlights the ongoing need to study the dynamics of the flora at this site, as these plants are potentially good proxies of Antarctic climate change (Singh *et al.* 2018).

Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S0954102024000014.

Acknowledgements

All of the authors thank the crew of Marambio Station and the logistical support provided by Instituto Antártico Argentino. A.C. Cottet and M.I. Messuti thank Consejo Nacional de Investigaciones Científicas y Técnicas and Universidad Nacional del Comahue for funding their research. We thank C.R. Amenabar and A. Zakrajsek, who helped with the preparation of the maps, and J.M. Lirio for his advice on Cockburn Island's topography. This work was wholly funded by Instituto Antártico Argentino (PICTA 0091). L.P. Dopchiz and M. Ansaldo are the managers of the project to which the present work belongs.

Author contributions

The material was collected by A.C. Cottet and L.P. Dopchiz. The identifications were made by A.C. Cottet. All authors commented on and edited previous versions of the manuscript. All authors approved the final version for publication.

Competing interests

The authors declare none.

References

Barták, M., Váczi, P., Stachoň, Z. & Kubešová, S. 2015. Vegetation mapping of moss-dominated areas of northern part of James Ross Island (Antarctica) and a suggestion of protective measures. *Czech Polar Reports*, **5**, 10.5817/CPR2015-1-8.

Biersma, E.M., Jackson, J.A., Stech, M., Griffiths, H., Linse, K. & Convey, P. 2018. Molecular data suggest long-term *in situ* Antarctic persistence within Antarctica's most speciose plant genus, *Schistidium*. *Frontiers in Ecology and Evolution*, **6**, 374284.

Câmara, P.E., Carvalho-Silva, M. & Stech, M. 2021. Antarctic bryophyte research - current state and future directions. *Bryophyte Diversity and Evolution*, **43**, 221–233.

Casanova-Katny, A., Torres-Mellado, G.A. & Eppley, S.M. 2016. Reproductive output of mosses under experimental warming on Fildes Peninsula, King George Island, Maritime Antarctica. *Revista chilena de historia natural*, **89**, 1–9.

Frahm, J.P. 2003. Manual of tropical bryology. *Tropical Bryology*, **23**, 1–200.

Gallego, M.T., Cano, M.J. & Guerra, J. 2011. New records, synonyms and one combination in the genus *Syntrichia* (Pottiaceae) from South America. *Bryologist*, **114**, 10.2307/41289812.

Goga, M., Sabovljević, M.S., Lang, I. & Bačkor, M. 2018. Contribution to the bryophyte flora of Antarctica: the James Ross Island moss inventory and the new records. *Czech Polar Reports*, **8**, 10.5817/CPR2018-1-3.

Gradstein, S.R., Churchill, S.P. & Salazar-Allen, N. 2001. *Guide to the bryophytes of tropical America*. New York: New York Botanical Garden Press, 577 pp.

Howat, I., Porter, C., Smith, B.E., Noh, M.J. & Morin, P. 2022. The Reference Elevation Model of Antarctica - Mosaics, Version 2. Harvard Dataverse, V1 [Antarctic REMA Explorer]. Retrieved from https://doi.org/10.7910/DVN/EBW8UC

Lewis Smith, R.I. 1993. The vegetation of Cockburn Island, Antarctica. *Polar Biology*, **13**, 10.1007/BF00236395.

Lewis Smith, R.I. 2005. Bryophyte diversity and ecology of two geologically contrasting Antarctic Islands. *Journal of Bryology*, **27**, 10.1179/174328205X69940.

Matsuoka, A., Skoglund, A., Roth, G., de Pomereu, J., Griffiths, H., Headland, R., *et al.* 2021. *Quantarctica*, an integrated mapping environment for Antarctica, the Southern Ocean, and sub-Antarctic islands. *Environmental Modelling and Software*, **140**, 10.1016/j.envsoft.2021.105015.

Ochyra, R. 1999. *Schistidium halinae* (Grimmiaceae, Bryopsida), a new moss species from the Antarctic. *Annales Botanici Fennici*, **35**, 267–273.

Ochyra, R. 2003. *Schistidium lewis-smithii* (Bryopsida, Grimmiaceae) a new species from the maritime Antarctic, with a note on the Australian *S. flexifolium*. *Nova Hedwigia*, **77**, 10.1127/0029-5035/2003/0077-0363.

Ochyra, R. & Zander, R.H. 2002. The genera *Didymodon* and *Bryoerythrophyllum* (Pottiaceae) in Antarctica. *Journal of Bryology*, **24**, 10.1179/037366802125000331.

Ochyra, R., Bednarek-Ochyra, H. & Smith, R.I. 2008. *The illustrated moss flora of Antarctica*. Cambridge: Cambridge University Press, 704 pp.

Putzke, J., Athanásio, C.G., Pereira de Albuquerque, M., Victoria, F.C. & Pereira, A.B. 2015. Comparative study of moss diversity in South Shetland Islands and in the Antarctic Peninsula. *Revista Chilena de Historia Natural*, **88**, 10.1186/s40693-014-0033-z.

QGIS Development Team. 2020. *QGIS Geographic Information System*. Open Source Geospatial Foundation Project. QGIS Association. Retrieved from http://qgis.org

Roman, M., Nedbalová, L., Kohler, T.J., Lirio, J.M., Coria, S.H., Kopácek, J., *et al.* 2019. Lacustrine systems of Clearwater Mesa (James Ross Island, north-eastern Antarctic Peninsula): geomorphological setting and limnological characterization. *Antarctic Science*, **31**, 10.1017/S0954102019000178.

Sharp, A.J., Crum, H. & Eckel, P.M. 1994. *The moss flora of Mexico*. New York: New York Botanical Garden Press, 1113 pp.

Singh, J., Singh, R.P. & Khare, R. 2018. Influence of climate change on Antarctic flora. *Polar Science*, **18**, 94–101.

Sollman, P. 2015. The genus *Bryoerythrophyllum* (Musci, Pottiaceae) in Antarctica. *Polish Botanical Journal*, **60**, 10.1515/pbj-2015-0004

Stilwell, J.D. 2002. Geological exploration of Cockburn Island, Antarctic Peninsula. *Polish Polar Research*, **23**, 47–73.

Van Wessem, J.M., Reijmer, C.M., Van de Berg, W.J. & Van den Broeke, M.R. 2015. Temperature and wind climate of the Antarctic Peninsula as simulated by a high-resolution regional atmospheric climate model. *Journal of Climate*, **28**, 10.1175/JCLI-D-15-0060.1.